ANALYSIS REPORT ON
FIRE FIGHTER FATALITIES

Prepared by

Fire Analysts and Research Division
National Fire Protection Association
Batterymarch Park
Quincy, MA 02269

Prepared for

Federal Emergency Management Agency
U.S. Fire Administration
Contract No. EMW-88-C-2868

August 1990

Any opinions, findings, conclusions or recommendations expressed in this publication do not necessarily reflect the views of the Federal Emergency Management Agency.

This document was scanned from hard copy to portable document format (PDF) and edited to 99.5% accuracy. Some formatting errors not detected during the optical character recognition process may appear.

ACKNOWLEDGEMENTS

This study was funded by the U.S. Fire Administration of the Federal Emergency Management Agency (FEMA). It would not have been possible without the cooperation and assistance of the U.S. fire service, the United States Fire Administration, the Public Safety Officers' Benefits Program of the Department of Justice, the National Wildfire Coordinating Group, the Bureau of Land Management of the Department of the Interior, the Bureau of Indian Affairs, the U.S. Department of Energy and the U.S. military, all of whom contributed data to this study.

The assistance of other NFPA staff members is also acknowledged: A. Elwood Willey, Assistant Vice President, Research and Fire Information Services; Dr. John Hall, Director, Fire Analysis and Research Division; William Neville, Assistant Vice President of External Affairs; Martin Henry, Assistant Vice President, Public Fire Protection; Kenneth Tremblay, Alison Miller, Michael Sullivan, Michael Karter, and Gary Stein, Fire Analysis and Research Division; and William Baden, Carl Peterson and Bruce Teele, Public Fire Protection Division.

The authors also wish to acknowledge the assistance of USFA staff, particularly John Ottoson, Project Officer, for their suggestions and support.

Special thanks go to Nancy Schwartz for typing the several drafts of this report.

Rita F. Fahy
Arthur E. Washburn
Paul R. LeBlanc
Project Staff

TABLE OF CONTENTS

LIST OF TABLES

BACKGROUND

For more than a decade, the National Fire Protection Association (NFPA) has developed the most complete records on U.S. fire fighter fatalities - both in breadth of coverage and depth of detail - of any organization. This data base has been used to support the fire fighter fatality studies produced each year by NFPA since 1974.

Over the past nine years, NFPA also has worked with FEMA's U.S. Fire Administration (USFA) to provide, in a timely manner, lists of fire fighter fatalities and their next of kin to support the National Fire Academy's annual Fire Fighter Memorial Service, analyses of each year's fire fighter fatalities, and briefings on the latest experience. Under the present contract, NFPA has provided the USFA with lists, both hand lettered and typed, of 1988 and 1989 fire fighter fatalities and with lists of names and addresses of next of kin and of fire department chiefs for use in the Memorial Services in October 1989 and 1990.

In August, a briefing on the 1989 experience and three special analyses was presented by NFPA staff to USFA staff in Emmitsburg, MD. Through the briefing and analysis, this contract continued the trend toward more extensive analysis of patterns and trends in specific parts of the fire fighter fatality problem. With over a decade of experience now classified in a computer data base, NFPA is able to provide increasingly detailed and focused examinations of the specific parts of the problem addressable by particular strategies.

The deliverables under this contract are (a) this analysis report, (b) the incident and casualty data on diskette in NFIRS Version 4.0 format, which is being delivered separately, (c) the various lists described above, and (d) the briefing provided in August.

I. INTRODUCTION

The purpose of this study is to analyze the circumstances surrounding fire fighter fatalities in the United States in 1989 in an attempt to identify potential means for reducing the number of deaths that occur each year. In addition to the 1989 findings, this study will also include special analyses of particular recurring scenarios, using NFPA's data base of fire fighter fatalities from 1980 through 1989.

A. Who Is a Fire Fighter?

For the purpose of this study, the term "fire fighter" covers all members of organized fire departments, whether career, volunteer or mixed; full-time public service officers acting as fire fighters; state and federal government fire service personnel; temporary fire suppression personnel operating under official auspices of one of the above; and privately employed fire fighters including trained members of industrial or institutional fire brigades, whether full- or part-time.

Under this definition, the study includes not just municipal fire fighters, but also seasonal and full-time employees of the U.S. Forest Service and state forestry agencies; prison inmates serving on state forest service crews; fire fighters for the Bureau of Land Management, the Bureau of Indian Affairs, the Bureau of Fish and Wildlife, the National Park Service, and the U.S. Department of Energy; military personnel performing assigned fire suppression activities; civilian fire fighters working at military installations; and members of industrial fire brigades.

B. What Constitutes an On-Duty Fatality?

The term "on-duty" refers to being at the scene of an alarm, whether a fire or non-fire incident; being en route while responding to or returning from an alarm; performing other assigned duties such as training, maintenance, public education, inspection, investigations, court testimony and fund raising; performing non-fire duties on official assignment; and being on call, under orders or on stand-by duty other than at home or at the individual's place of business.

On-duty fatalities include any injury sustained while on duty that proves fatal, any illness that was incurred as a result of actions while on duty that proves fatal, and fatal mishaps involving occupational hazards that occur while on duty. The types of injuries included in the first category are mainly those that occur on the fire ground, in training, or in accidents while responding to or returning from alarms. The most common examples of fatal illnesses incurred on duty are fatal heart attacks. Another example is a fire fighter who contracted hepatitis when a victim being transported by ambulance pulled out his intravenous needle and stuck the fire fighter. A few examples of fatal occupational mishaps include fire fighters who died of asphyxiation while working on fire apparatus in closed garages, a fire fighter who fell through a slide pole hole, a fire fighter electrocuted while raising a banner for a town event, a volunteer fire fighter who was fatally injured when he fell down a flight of stairs in his home while responding to an alarm, and a fire inspector who fell through a skylight.

Also included in the file are fire fighters who were murdered while on duty. These include fire fighters shot by snipers while on the fire ground,, fire fighters shot in the station by off-duty or former fire fighters, and one in 1988 who was kidnapped and shot after responding to a verbal request for assistance.

Fatal injuries and illnesses are included even in cases where death is considerably delayed. When the onset of the condition and death occur in different years, the incident is counted on the basis of the former. For example, a Michigan fire fighter died in 1986 of a brain injury received in 1979 when he was struck by a hose coupling, resulting in recurring seizures. Because his death was the direct result of his injury, and the injury occurred in 1979, he is counted as a 1979 fatality. Two of the 1989 fatalities were injured in 1989 and died in 1990.

The NFPA recognizes that these definitions should include chronic illnesses (such as cancer) that prove fatal and that arise from occupational factors. In practice, there is as yet no mechanism for identifying fatalities that are due to illnesses that develop over long periods of time and that thereby present an ambiguous picture on the issue of occupational versus other factors as causes. This is recognized as a gap that cannot now be filled because of the limitations of the state of the art in tracking and analysis.

C. Sources of Initial Notification

As an integral part of its ongoing program to collect and analyze fire data, NFPA solicits information on fire fighter fatalities from the U.S. fire service and a wide range of other sources. These include the U.S. Fire Administration and the Public Safety Officers' Benefits Program (PSOB). Both are organizations with whom NFPA has maintained long-standing cooperative efforts in collecting and analyzing fire fighter fatality data. Other contacts include federal agencies such as the U.S. Forest Service of the

Department of Agriculture, the Bureau of Indian Affairs and the Bureau of Land Management of the Department of Interior, the U.S. military, the Department of Energy, and the Occupational Safety and Health Administration (OSHA). In recent years, significant assistance has been received from the National Wildfire Coordinating Group, an organization made up of representatives of state and federal forestry agencies.

We also receive notification from fire service organizations such as the International Association of Fire Fighters, state fire associations, state training organizations, state and local fire marshals, and fire service publications. A network developed over the years of individuals interested in the area of fire fighter fatalities also assists in identifying incidents, especially those that occur outside of large urban areas or that involve non-fire-incident-related fatalities. Among these individuals are fire fighters, photographers, fire buffs, and members of the insurance industry.

Notification of fatal incidents also comes from NFPA members and staff and through the use of a newspaper clipping service that reads all daily and weekly newspapers in the country.

D. Procedure for Including a Fatality in the Study

After initial notification of a fatal incident is received, contact with the local fire department is made by telephone to verify the incident, its location and the fire department involved. Data collection forms for the fatality and the fire, if it was a fire incident, are sent to the responsible local official identified during the telephone follow-up. After the forms are returned to NFPA, a final decision is made to include or exclude the fatality, based on the inclusion criteria described previously. In order to make a

final determination, additional information is sometimes sought, either by contacting the fire department directly to clarify some of the details or by obtaining data elsewhere, such as medical documentation frequently available from PSOB.

Some of the material that might be received to document an incident includes casualty forms, both NFPA fire fighter fatality study reporting forms and NFIRS-type forms; NFPA's Fire Incident Data Organization (FIDO) major-fire report form or the department's own incident reporting form, if a fire incident was involved in the fatality; medical data such as death certificates or autopsy reports; special investigation reports from other agencies; police and motor vehicle accident reports, if applicable; photographs and diagrams; and additional newspaper accounts. Incidents to be included in the study are then coded into NFPA's FIDO system, which includes both incident and casualty information. By mutual agreement of the USFA and NFPA project staff, the same inclusion criteria were used for the USFA study as are used in the NFPA study.

Work described to this point was done as part of NFPA's ongoing program of data collection and analysis in the area of fire fighter fatalities and was completed at no cost to FEMA.

E. Additional Data Collection Completed for the Contract

To meet FEMA's request for a list of the next-of-kin of the 1989 fatalities and the names and addresses of the fire chiefs, a follow-up mailing was sent to all departments asking them to verify the victims' names and dates of fatal injury, the names and addresses of the departments and chiefs, and the names and relationships of the next of kin. Telephone calls were made to non-responding fire departments to obtain the information.

II. 1989 FINDINGS

One hundred thirteen fire fighters died in the line of duty in 1989, the second lowest total in the 13 years that NFPA has done this study. As shown in Figure 1, this is a decrease of 16.3 percent from the year before.* After several years of an upward trend (the totals for 1987 and 1988 were the highest since 1981, this is a welcome development; however, it would be premature to read too much into one year's results. Efforts to further reduce the death toll need to continue. This study will report some of the most frequently occurring scenarios and will present some conclusions and recommendations to address the problem.

A. Type of Duty

The distribution of deaths by type of duty being performed is shown in Figure 2. The largest proportion of deaths occurred during fire ground operations.

Of the 57 fire ground deaths, 26 were due to heart attacks, 10 to asphyxiation, seven to internal trauma, SiX to burns, three to crushing injuries, two to electrocution, and one each to bleeding, gunshot and stroke (CVA). Twenty-four of the victims were career fire fighters and 33 were volunteers.

* The totals for some earlier years have been adjusted to reflect new information received since the earlier studies.

Figure 1
Line of Duty Fire Fighter Deaths
1980 - 1989

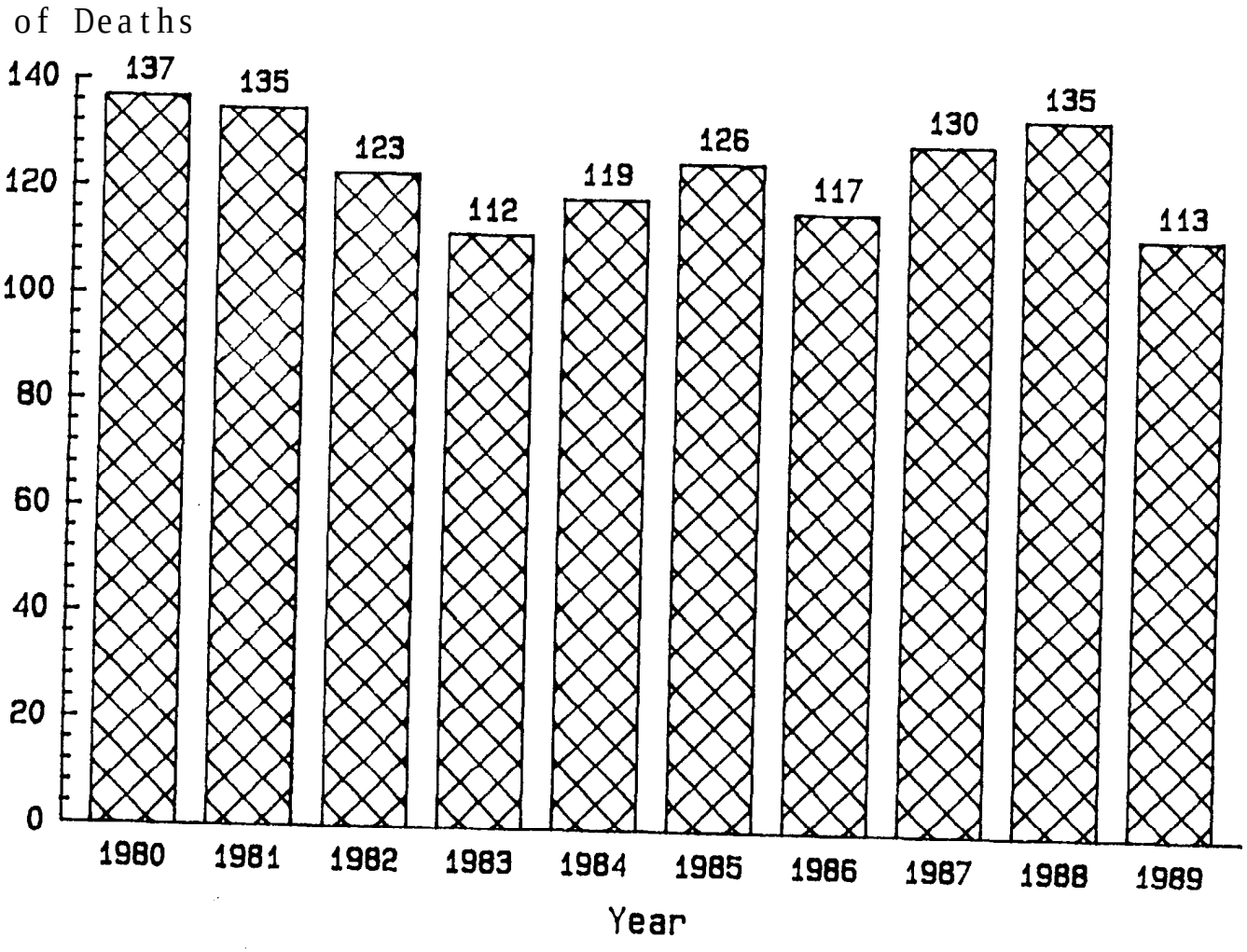
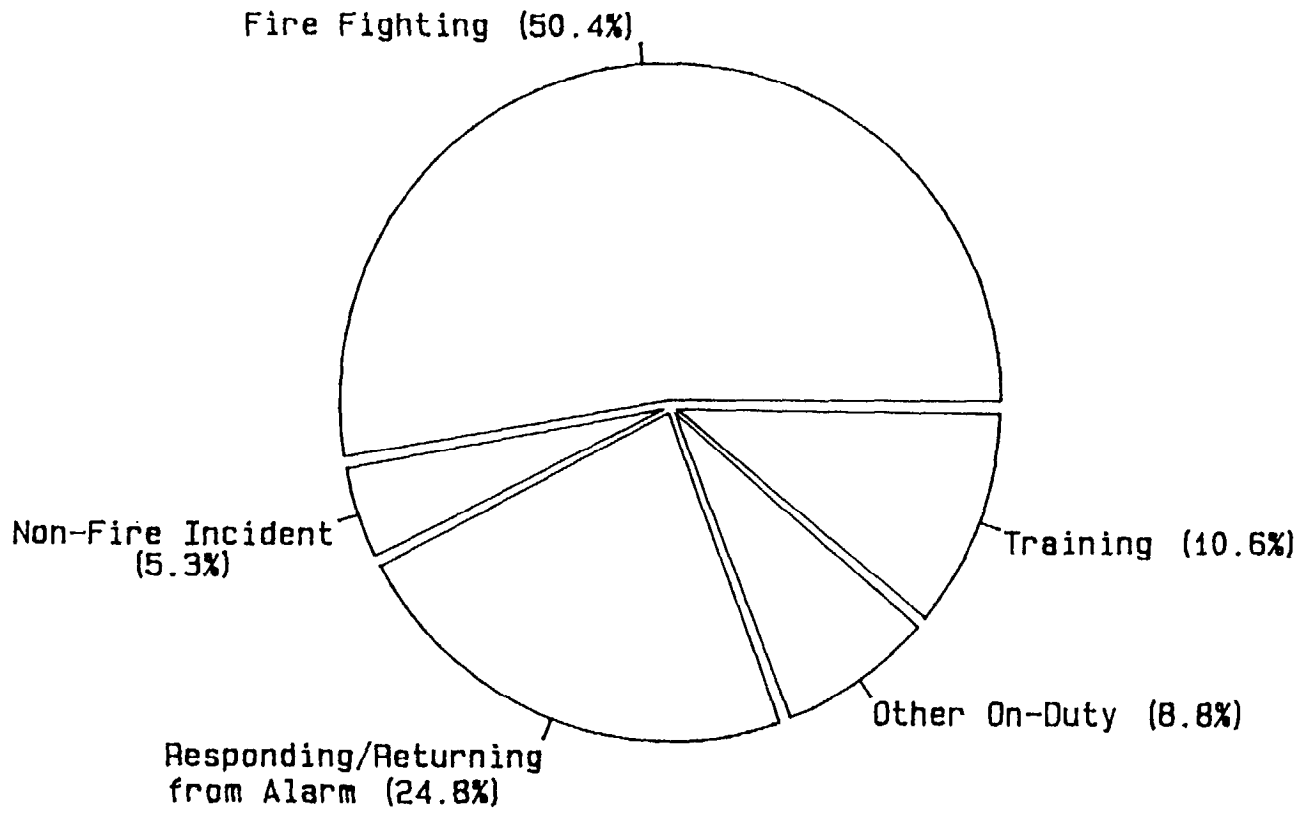


Figure 2
Fire Fighter Deaths 1989
by Type of Duty



The second largest category involved responding to and returning from alarms, which accounted for approximately a quarter of the deaths -- a result consistent with the findings in previous years. Eighteen of these 28 deaths were due to heart attacks, one to a fall from apparatus, one to being struck by apparatus, and the remaining eight to collisions.

There were 12 deaths related to training activities. Eight of the deaths were due to heart attacks -- five while at seminars or classes and three during physical fitness training. Another fire fighter damaged a muscle while jogging and died several months later due to a resulting embolism. Two fire fighters were killed in motor vehicle accidents while driving to or returning from seminars or drills. One fire fighter was run over during driver training.

There were six deaths while working at non-fire incidents. These included two fire fighters who suffered heart attacks while working at motor vehicle accidents, one fire fighter struck by a passing vehicle while working at a motor vehicle accident, one electrocuted while investigating an electrical hazard during a snowstorm, one drowned while diving to recover a body, and one death due to carbon monoxide poisoning while attempting to rescue two workers from a 50-foot water well.

The remaining 10 deaths occurred while performing other duties -- six fire fighters who died during normal station and administrative duties, one struck by a vehicle while directing traffic for a disabled motorist, one killed in a motor vehicle accident en route to a fire fighter parade and competition, one shot while following an alleged arsonist from the scene of a fire, and one drowned at a wildland fire base camp.

Fire fighter deaths over the past ten years that occurred during search and rescue activities are discussed in detail in a separate section of this report.

B. Cause and Nature of Fatal Iniury or Illness

As used in this study, the term "cause" refers to the action, lack of action, or circumstances that directly resulted in the fatal injury while the term "nature" refers to the medical nature of the fatal injury or illness or what is often referred to as the cause of death. Often, the fatal injury is the result of a chain of events, the first of which is recorded as the cause. For example, if a fire fighter is struck by a collapsing wall, becomes trapped by the debris, runs out of air before being rescued and dies of asphyxiation, the cause of fatal injury recorded is "struck by collapsing wall" and the nature of fatal injury is "asphyxiation."

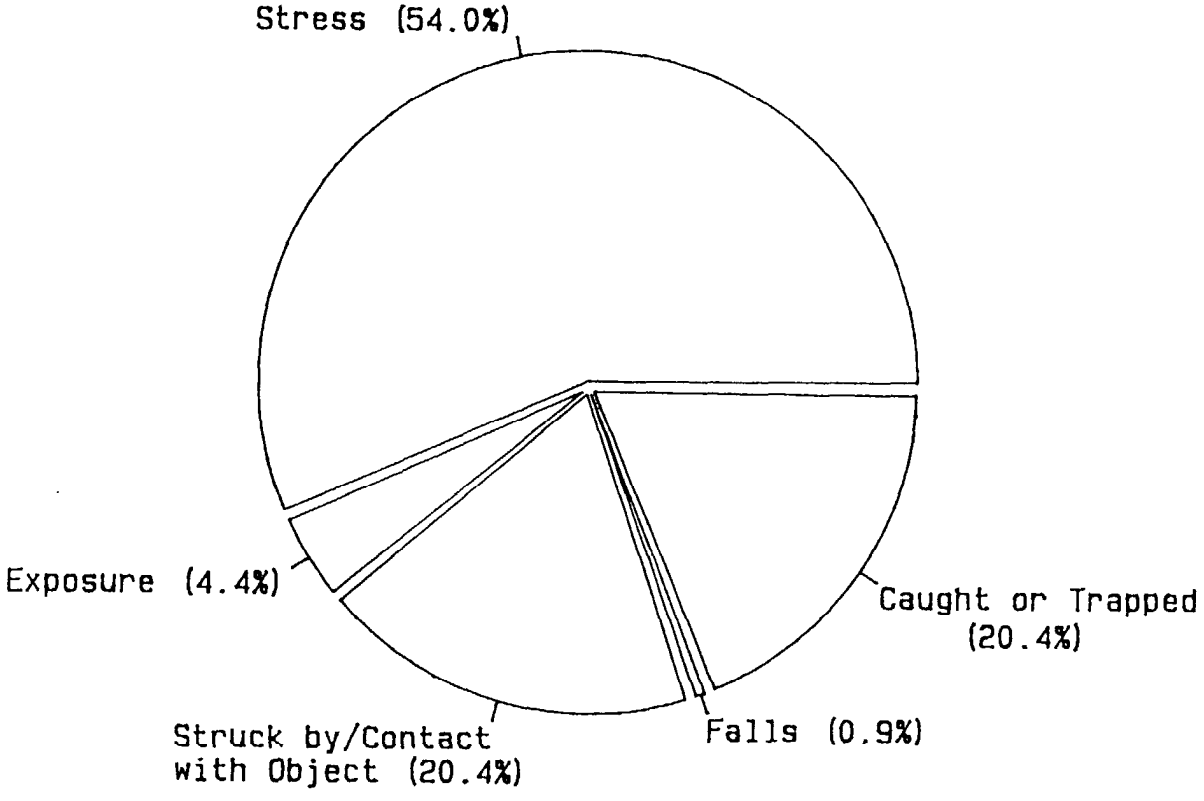
Figure 3 shows the distribution of deaths by cause of fatal injury or illness. As found in most previous years, the largest proportion of deaths were due to stress or overexertion. Eight of these 61 deaths were specifically attributed to strenuous physical activities.

Another major category was struck by or contact with objects. These 23 deaths included 20 motor vehicle accidents, two fatal shootings (one by an alleged arsonist and one by a motorist who refused to leave the scene of a fire) and one case of being struck by a fire-weakened redwood tree at a wildland fire.

Twenty-three fire fighters were caught or trapped -- eight by roof collapses; seven by rapid fire progress or flashover; three by being lost inside buildings; two as a result of floor collapses; two underwater, where they drowned; and one in an explosion as the result of the BLEVE of a propane cylinder.

One fire fighter fell from the back step of an engine while responding to a fire. Two fire fighters were electrocuted when they came in contact with

Figure 3
Fire Fighter Deaths 1989
by Cause of Injury



power lines. Another was struck by lightning. One fire fighter-was overcome by carbon monoxide during a well rescue and another suffered a heat-induced. heart attack.

Fire fighter deaths over the past ten years that occurred as a result of rapid fire progress in structures or as a result of drowning are discussed in more detail in separate sections of the report.

Figure 4 shows the distribution of deaths by the medical nature of the fatal injury or illness. The largest proportion of deaths were due to heart attacks. Of these 60 deaths, medical documentation indicated that 16 of the victims had prior heart problems, either previous heart attacks or bypass surgery; and six others had severe arteriosclerotic heart disease (defined for this study as arterial occlusion of at least 50 percent). One other victim suffered from hypertension and four were diabetics. One victim was taking medication for blood clotting. Medical documentation was not available for the other 32 heart attack victims.

The other categories of nature of fatal injury were internal trauma (18 deaths), asphyxiation (11 deaths), crushing (8 deaths), burns (6 deaths), electrocution (3 deaths), gunshot wounds (2 deaths), drowning (2 deaths) and one each due to bleeding, stroke and embolism.

C. Ages of Fire Fighters

The ages of fire fighters who died in 1989 ranged from 18 to 75 years with a median age of 45 years.

The distribution of fire fighter deaths by age and cause of death is displayed in Figure 5. Over two-thirds of the fire fighters over age 40 who died were killed by heart attacks. The youngest heart attack victim was 19 years old -- he had had heart surgery at age 11.

Figure 4
Fire Fighter Deaths 1989
by Nature of Injury

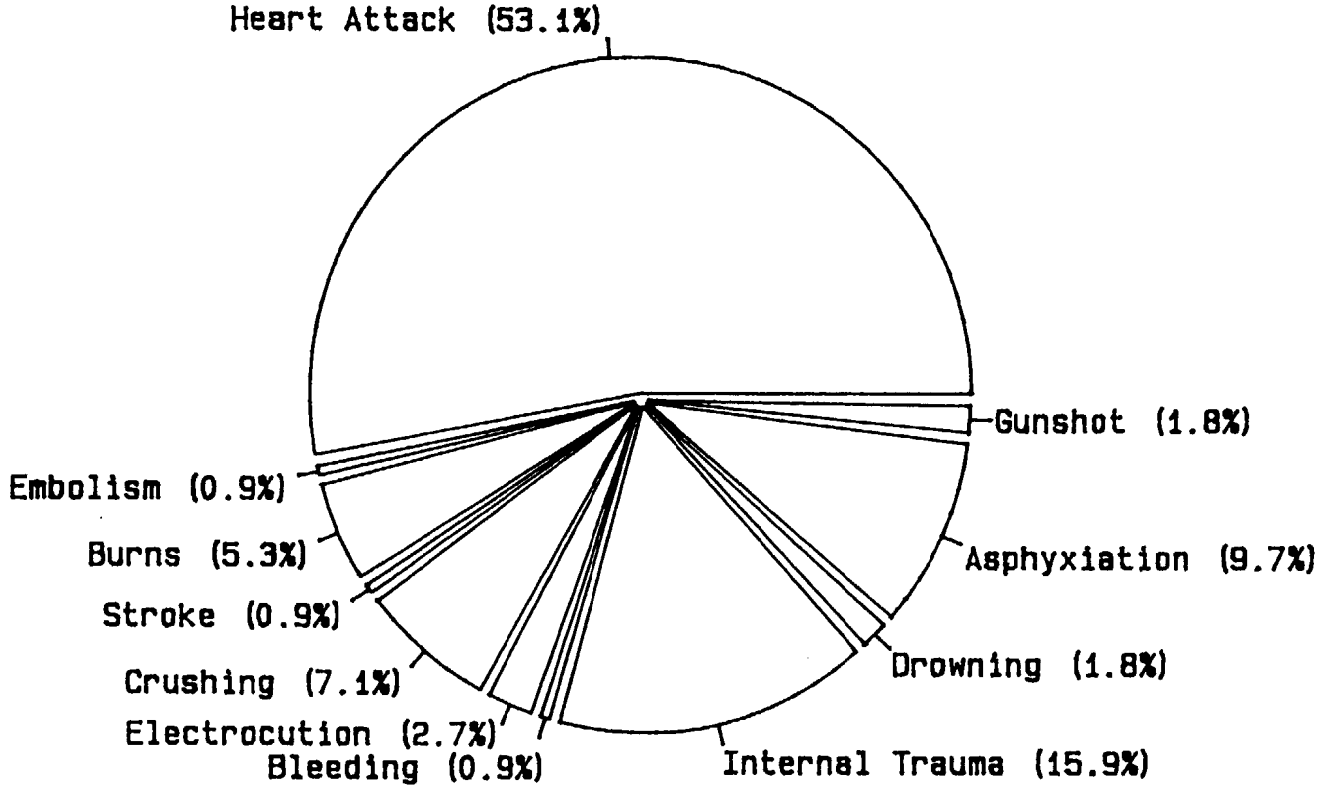


Figure 5
Fire Fighter Deaths 1989
by Age and Cause of Death

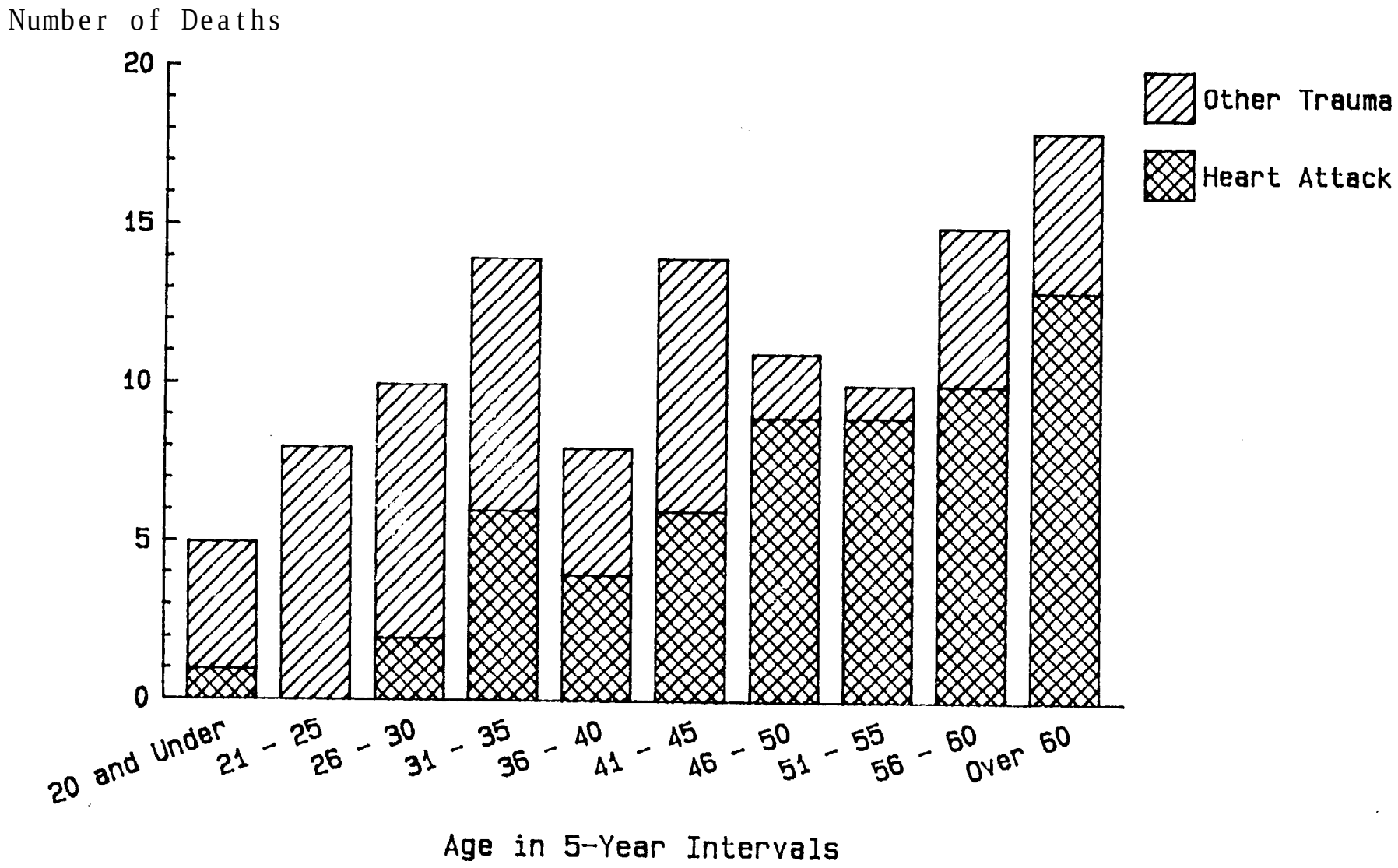


Figure 6 shows the death rates by age categories using estimates of the number of fire fighters in each age group from NFPA's 1987 profile of fire departments and the fatality data from 1985 through 1989'. As the graph shows, the death rate is lowest for fire fighters aged 20 to 39, slightly above the average rate for those aged 40 to 49, and much higher than average for fire fighters aged 50 and over. This is a reflection of the fact that although fewer than 15 percent of all fire fighters are over age 50, that age group accounted for over a third of the deaths from 1985 through 1989 and over half of all heart attack deaths. When the rates are calculated for non-heart-attack deaths, fire fighters aged 60 and over have a rate more than twice the average.

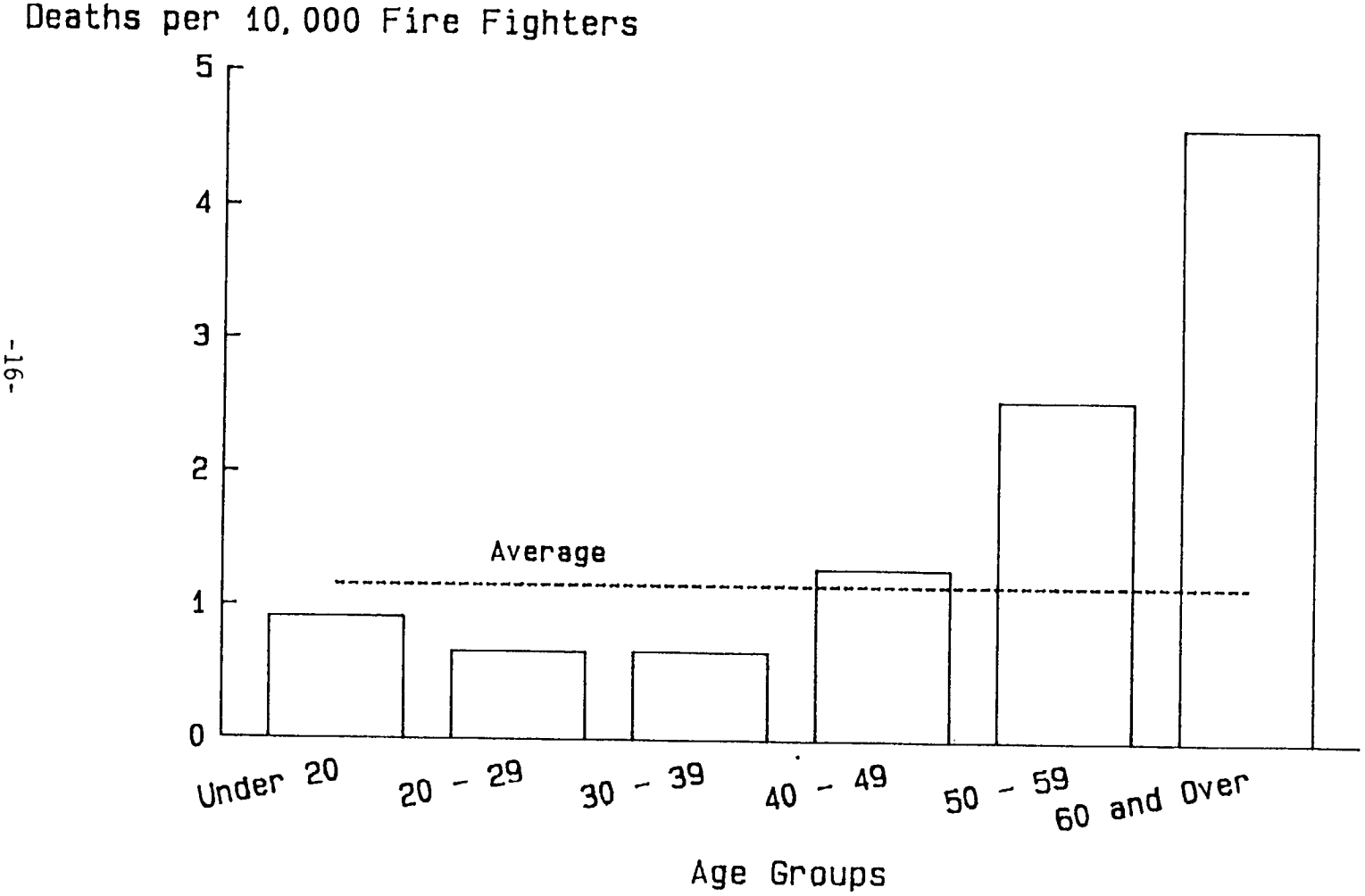
D. Fire Ground Deaths

The distribution of the 57 fire ground deaths by fixed property use is shown in Figure 7. As has been the case every year except 1987, the largest proportion of fire ground deaths occurred in residential properties - 21 deaths in 1989, including 12 deaths in one- and two-family dwellings, five in apartment buildings, two in a residential hotel and one each in a rooming house and a fraternity house.

Eight deaths occurred in wildland fires. Four fire fighters died of heart attacks -- one due to heat exposure, the other three due to stress. One fire fighter was killed when he was struck by a falling tree section. One fire fighter was struck by lightning. Another fire fighter died of smoke inhalation after being caught by rapid fire progress caused by ignition of methane gas escaping from an abandoned mine.

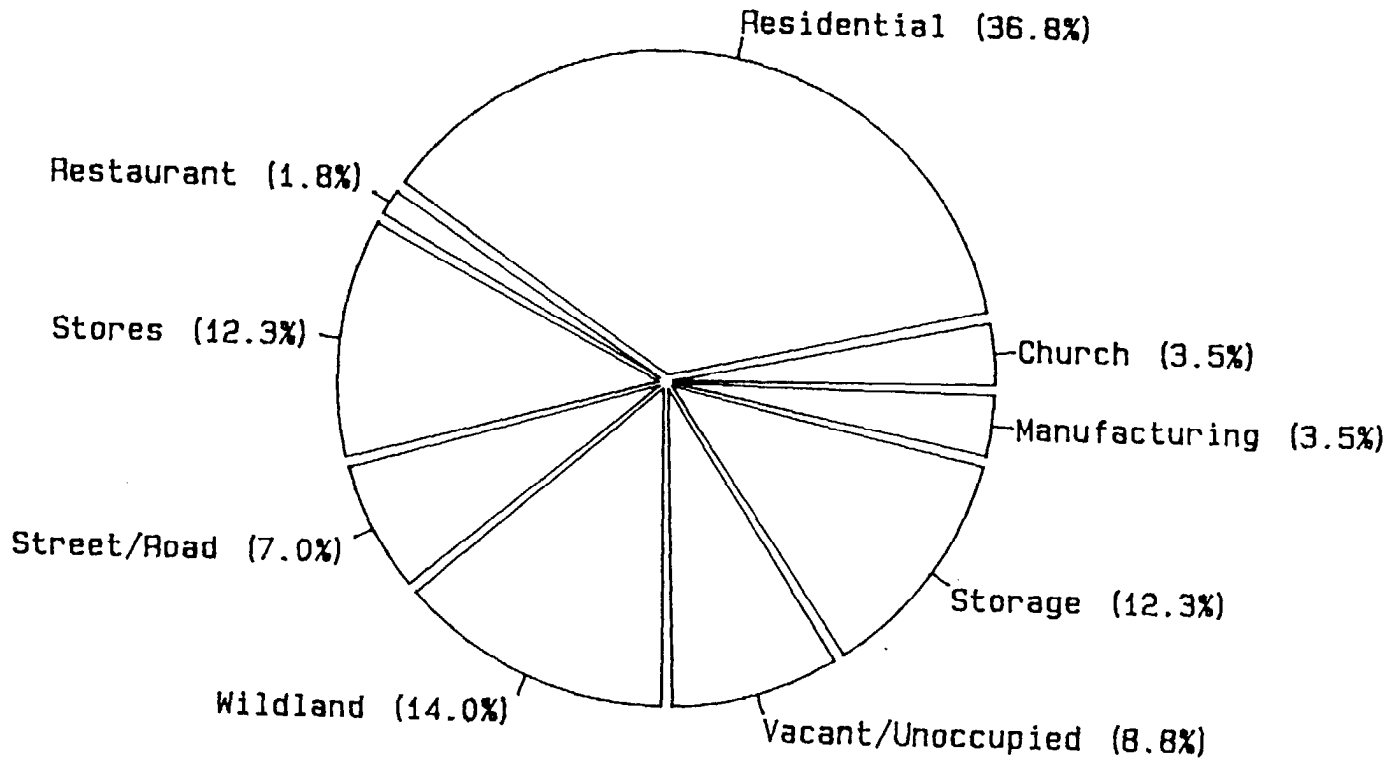
There were seven deaths each in stores and storage properties. Four deaths resulted in fires on or along streets and highways. Two fire fighters were killed in fires in manufacturing properties and two others were killed -in

Figure 6
Average Death Rates per 10,000 Fire Fighters
1985 - 1989



Note: These figures combine career and volunteer
The two groups may have very different age distr
which are not reflected here.

Figure 7
Fire Ground Deaths in 1989
by Fixed Property Use



church fires. One fire fighter was killed in a restaurant fire. Four fire fighters were killed in fires in vacant buildings -- three of those fires were of incendiary origin. Another fire fighter was killed in a fire in a building under renovation.

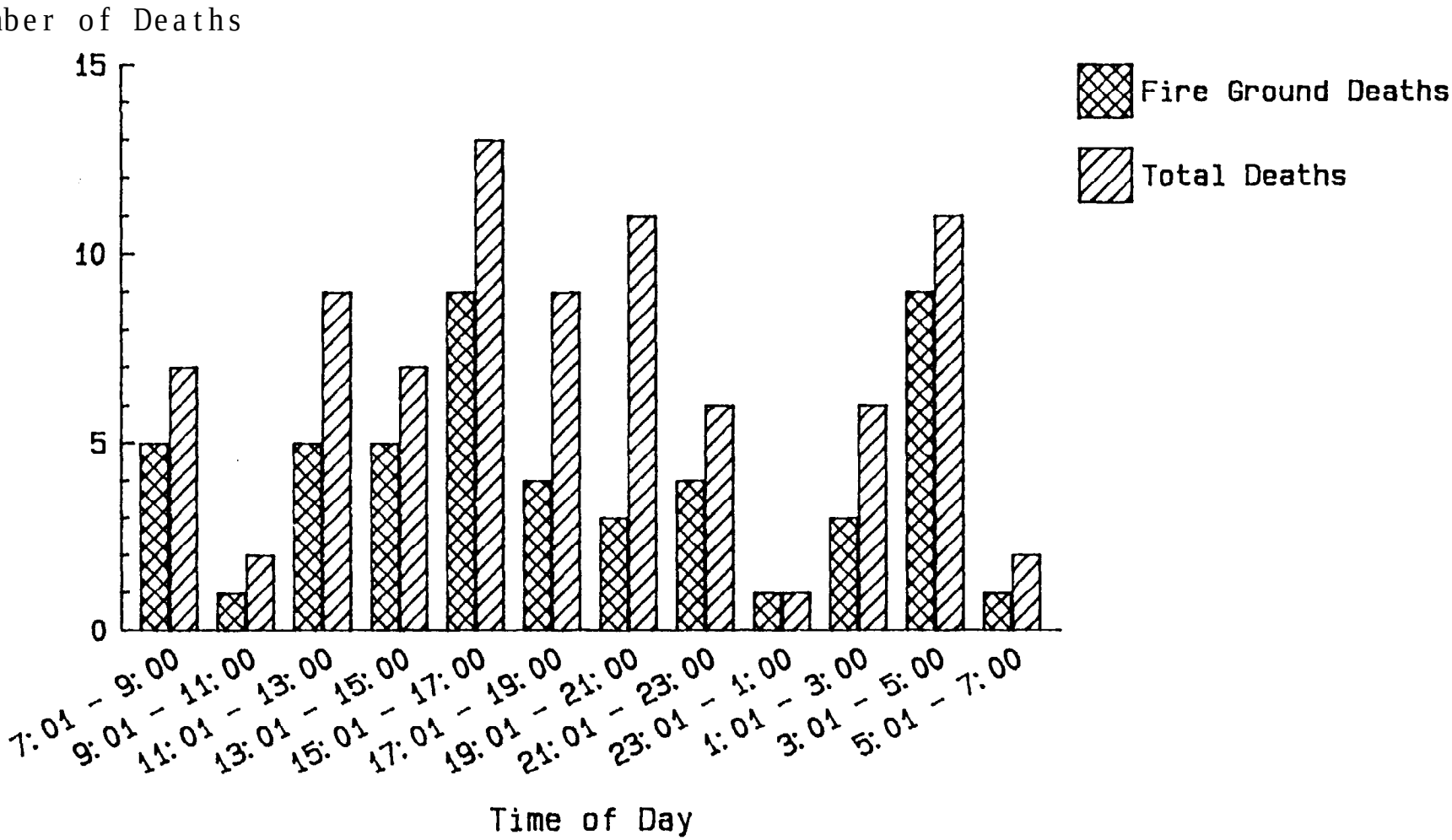
In all, 10 fire fighters died at the scene of incendiary or suspicious fires. Eight of these deaths were at structure fires and two were at wildland fires. (Four other fire fighters were killed en route to incendiary or suspicious fires and another was shot by a suspected arsonist as he followed him from the scene.>

To put the hazards of fire fighting in various types of occupancies into perspective, the number of deaths per 100,000 structure fires was examined by fixed property use. The rates were calculated using the estimates of fire experience from NFPA's 1989 fire loss study[2]. There were 4.1 fire fighter deaths per 100,000 residential structure fires, compared to 13.8 deaths per 100,000 nonresidential structure fires. Although almost three times as many fires occurred in residential structures, the size, complexity and special hazards often associated with nonresidential structures result in a much greater risk at such fires.

E. Time of Day

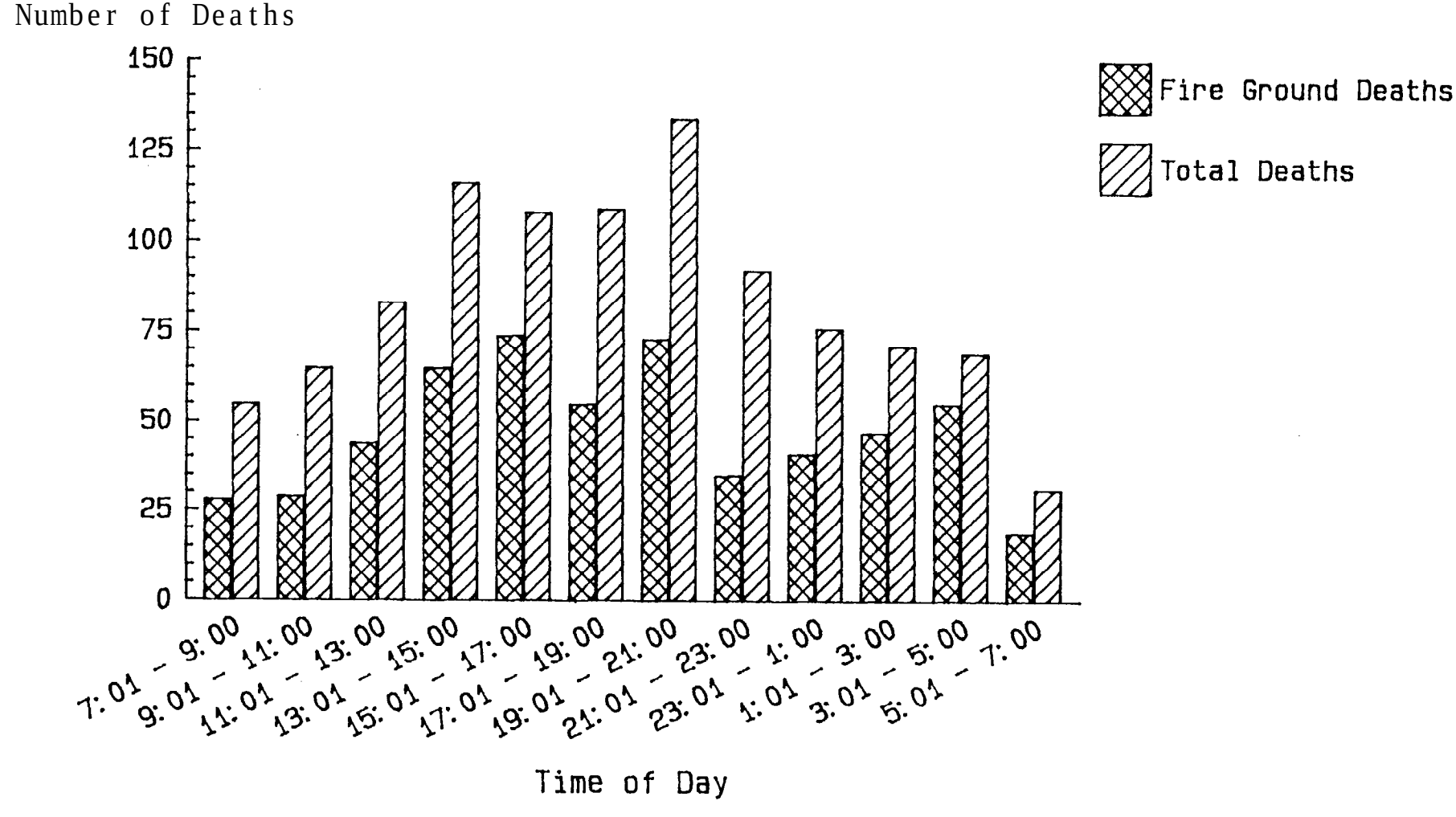
The distribution of 1989 fire ground deaths and total deaths by time of alarm is shown in Figure 8. The highest number of deaths occurred between 3 and 5 pm. The distribution of deaths by time of day over a ten-year period is shown in Figure 9. The number of deaths in both categories was at the highest level between 1:00 and 9:00 pm and drops to the lowest level in the early morning hours.

Figure 8
Fire Fighter Fatalities 1989
by Time of Day



Based on 50 fire ground fatalities and 84 total fatalities for which time was reported.

Figure 9
Fire Fighter Fatalities by Time of Day
1980 - 1989



Based on 565 fire ground fatalities and 1009 total fatalities for which time was reported.

F. Month of the Year

Figure 10 shows the distribution of 1989 fire fighter deaths by month. The same information for 1980 through 1989 is shown in Figure 11. The ten-year analysis shows that fire ground deaths are higher in the winter months and in midsummer.

G. State and Region

The distribution of fire fighter deaths by state is shown in Table 1. Thirty-four states are represented on the list, led by New York with 12 deaths. The experience by region' is displayed in Table 2 and Figure 12. The South lost the largest number of fire fighters (43), followed by the Northeast (32), the Northcentral region (20) and the West (18). When looking at fire ground deaths, we see that the Northeast and South regions both have higher than average death rates.

H. Analysis of Urban/Rural/Suburban Patterns in Fire Fighter Fatalities

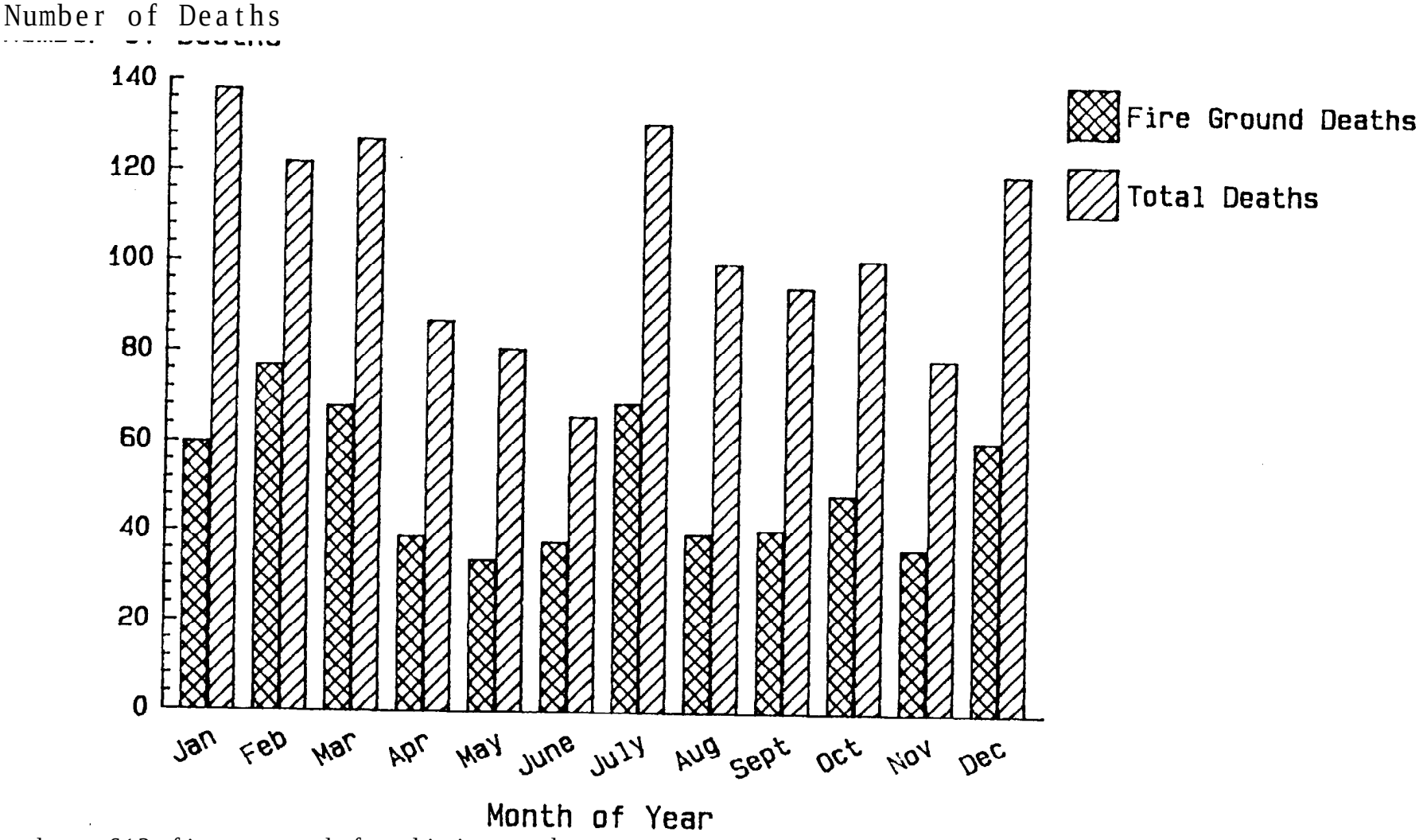
The U.S. Bureau of the Census defines "urban" as a place having at least 2,500 population or lying within a designated urbanized area. "Rural" is defined as any community that is not urban. "Suburban" is not a Census term but may be taken to refer to any place, urban or rural, that lies within a metropolitan area defined by the Census but is not one of the designated central cities of that metropolitan area.

Fire department coverage areas do not always conform to the boundaries of Census places. For example, fire departments defined by counties or special fire protection districts may have both urban and rural sections, and there

Figure 10
Fire Fighter Fatalities 1989
by Month of Year

Based on 57 fire ground fatalities and
113 total fatalities.

Figure 11
Fire Fighter Fatalities by Month of Year
1980 - 1989



Based on 613 fire ground fatalities and
1247 total fatalities.

Table 1
1989 Line of Duty
Fire Fighter Fatalities

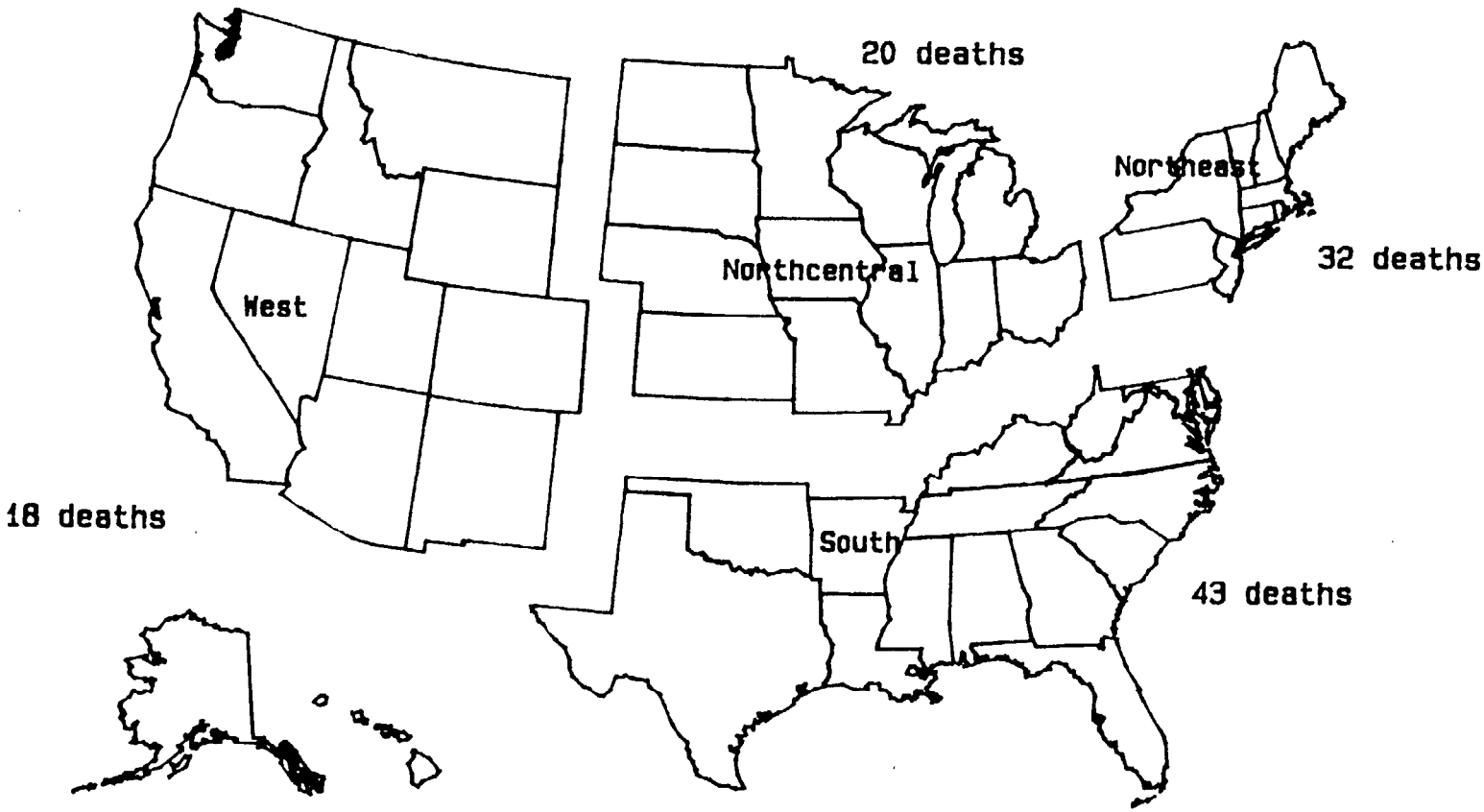
State	Number of Deaths	State	Number of Deaths
Alabama	4	Nebraska	1
Arizona	2	Nevada	1
Arkansas	2	New Jersey	5
California	5	New Mexico	2
Colorado	1	New York	12
Connecticut	1	North Carolina	5
Florida	4	Ohio	2
Illinois	5	Oklahoma	7
Indiana	1	Oregon	1
Kansas	1	Pennsylvania	9
Kentucky	1	South Carolina	1
Maine	2	Tennessee	3
Massachusetts	3	Texas	8
Michigan	3	Virginia	3
Minnesota	3	Washington	4
Mississippi	4	Wisconsin	2
Missouri	2	Wyoming	1
Montana	2		

TOTAL: 113

Table 2
Fire Fighter Death Rate by Region
1989

Region	Number of Fatalities	Number of Fire Ground Deaths	Fire Ground Death Rate per 100.000 Fires
Northeast	32	16	3.57
Northcentral	20	10	2.02
South	43	25	3.13
West	18	6	1.61
Nationwide	113	57	2.70

Figure 12
Fire Fighter Fatalities 1989
by Region



are Federal, state, and private fire fighters. In such cases, it may not be possible to characterize the entire coverage area of a fire department as rural or urban, and one must assign a fire fighter death as urban or rural based on the particular community in which he was operating when fatally injured.

Based on these rules, the following patterns were found and are shown with available patterns for the general population and for the population of fire fighters specifically in local fire departments:

	Urban***	Rural	Total
Total 1989 fire fighter fatalities	73 (65%)	40 (35%)	113 (100%)
Suburban location	17	15	32
Local fire department only*	69 (67%)	34 (33%)	103 (100%)
U.S. population (1980)	74%	26%	100%
U.S. fire fighters (1988), total**	60%	40%	100%
U.S. fire fighters (1988), career**	97%	3%	100%
U.S. fire fighters (1988), volun.**	48%	52%	*100%*

In 1987, we reported that the distribution of fire fighter fatalities from local fire departments was closer to the distribution of the whole U.S. population than to the distribution of fire fighters from local fire

---

* Excludes two fire fighters employed by the military killed in urban locations, one prison inmate killed in an urban location, one industrial fire brigade member killed in an urban location, and 6 federal, state and inmate fire fighters killed in rural locations.

** "U.S. Fire Department Profile Through 1988," Quincy, Massachusetts: National Fire Protection Association, Fire Analysis and Research Division, November 1989. All percentages are for fire fighters in local fire departments.

*** Note that the classification of fire fighters into urban and rural is based strictly on the population protected by the fire department and not on metropolitan area considerations. However, if fire fighter fatalities were similarly classified, the distribution would shift by at most two percentage points, so the points here are not affected.

departments, suggesting that urban fire fighters faced a greater risk of dying than rural fire fighters. In 1988, we reported that the distribution of local fire fighter fatalities was closer to the distribution of local fire fighters, suggesting a similar risk of dying for urban and rural fire fighters. In 1989, the distribution of local fire fighter fatalities fell exactly between the two other distributions.

Since the results fluctuate back and forth each year, it is not worthwhile to read too much into them. It will be necessary to collect several years worth of data and do a multi-year analysis before any firm conclusions can be drawn.

III. FIRE FIGHTER DEATHS DUE TO DROWNINGS

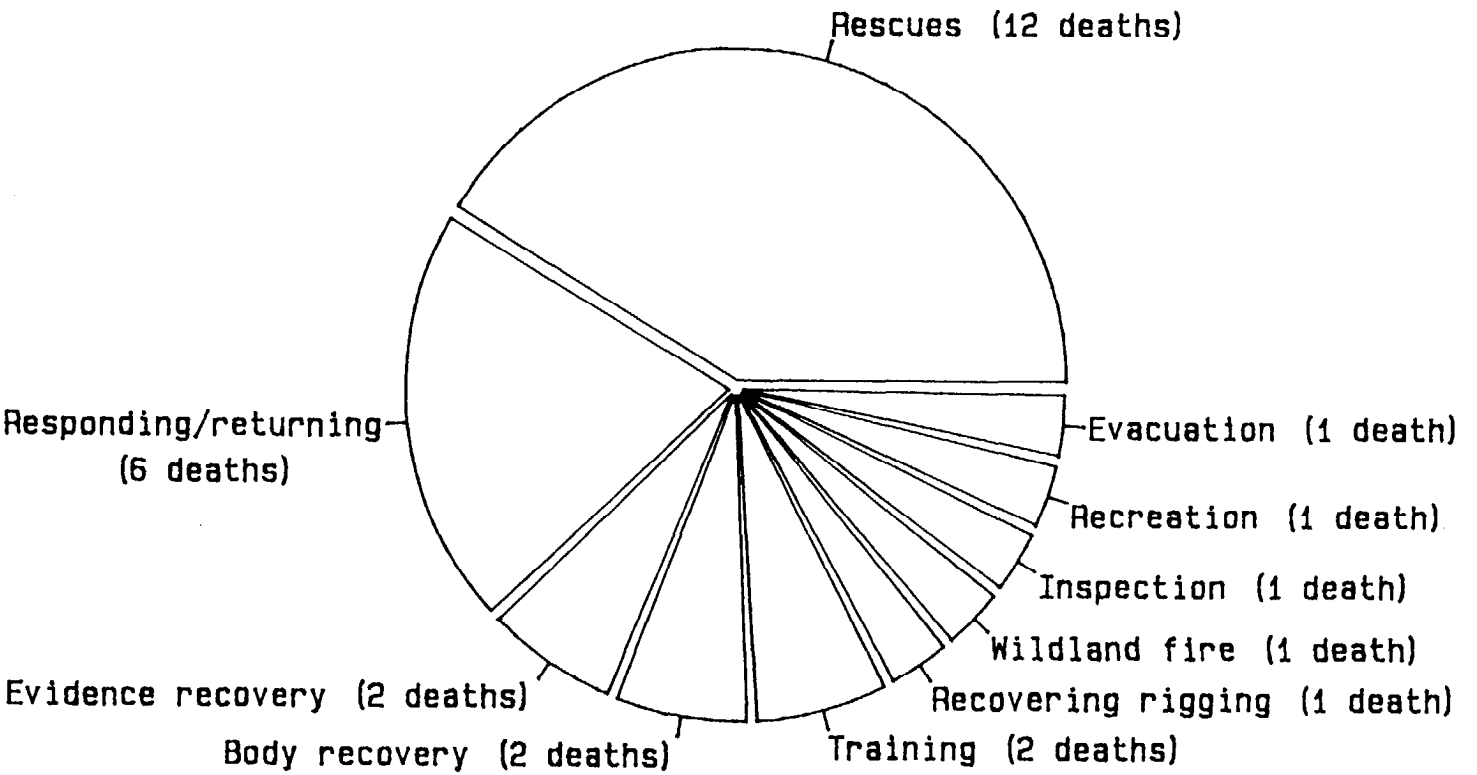
1980-1989

From 1980 through 1989, 29 fire fighters drowned in 25 separate incidents while on duty. Although this is a fairly small portion of deaths over the lo-year period, such deaths do occur almost every year and so they merit a closer look.

Type of Activity

The distribution of deaths by the type of activity the fire fighter was engaged in is displayed in Figure 13. As might be expected, the largest proportion of deaths occurred while performing rescues (41 percent). Two of these 12 fire fighters were killed in one incident when the first attempted to swim across a river to assist a fire fighter giving CPR to a child pulled from the river. When the cold water caused his muscles to cramp, the second fire fighter swam out to help him, but both drowned. Three fire fighters were killed when they went to the assistance of people who they observed falling into rivers or other water. (In one case, the rescued child was the victim's own daughter.) Another fire fighter waded into an overflowed leaching pond with other fire fighters to assist people whose cries for help they heard. The deceptive stillness of the water's surface hid the presence of a storm drain until the fire fighter was pulled to the drain by the current. Two other people, the victims whose calls they had heard, were swept through the 150-yard-long drain and pulled to safety from the pond at the other end, but the fire fighter drowned when he became entangled in a reinforcing rod gate that was supposed to cover the drain.

Figure 13
Fire Fighter Fatalities Due to Drowning by Type of Activity 1980 - 1989



Three fire fighters drowned while rescuing children from a river or canal. One child was being rescued from a vehicle underwater in a canal, when the designated backup rescuer went into the water unobserved to assist, and drowned. Another fire fighter was attempting to free a child from a hole in a dam through which he had been swimming with friends when planks in the dam gave way and the fire fighter became trapped underwater against the dam and lost the mouthpiece to his SCUBA gear. In the third incident, the fire fighter attempted to rescue two boys stranded on a rock in a river when he was swept away by the current. In separate incidents, two fire fighters were also swept away by rapid currents while attempting to rescue victims of floods, as was a third fire fighter attempting to rescue victims of a boating accident in a creek.

Six fire fighters were drowned while responding to or returning from emergencies. In one incident, three fire fighters were killed when their aircraft crashed into Lake Erie in bad weather as they returned from a medical emergency. Two other deaths were due to motor vehicle accidents on roadways along rivers -- both drivers had been drinking, and one had a blood alcohol level of 0.21%. The sixth fire fighter was returning in a boat with three other fire fighters from a structure fire in a flooded area when the steering on the boat malfunctioned and it began to drift. The four fire fighters grabbed onto a bridge as they passed beneath it but the boat was swept away from under them. Three of the four were swept away by the current. All but one of the fire fighters were rescued.

Four of the drownings occurred during recovery activities -- two in one incident while attempting to recover evidence for the police and two while attempting to recover bodies. In the first incident, two divers entered the

water at a quarry to search for guns that had been thrown there. When they did not resurface after 20 minutes, the two surface observers went down to get them out. A postmortem determined that all equipment was functional and proper procedures had been followed. One fire fighter was working to recover a body when his boat overturned and was pulled under by the current at the base of a dam. Another fire fighter searching for the victims of a parasailing accident became caught underwater by parachute cords and drowned.

The remaining seven victims were involved in a variety of activities. One was swimming for recreation at the base camp during a 24-hour rest break during a wildland fire. He was considered by his department to be on-duty at the time of the drowning. One fire fighter was swimming during a water drafting drill. One fire fighter was evacuating a shore area during a storm when a prop pin sheared, causing his boat to drift toward open water. The boat flipped over when he and the other fire fighters tried to get out of it, and he was swept out to sea. Another fire fighter fell into a drainage ditch and drowned in 2 l/2 feet of water. He was last seen setting up flares along a highway during a brush fire. Another fire fighter was doing a fire prevention inspection at a public fireworks display. As he stood on the ramp between the barge and the shore, the barge moved, disengaging the ramp and throwing the fire fighter into the water where he was struck by the ramp and drowned. A fire fighter recovering the rigging of a shrimp boat became entangled In the lines and drowned. And finally, a fire fighter participating in underwater search and rescue training drowned.

Type of Equipment Used

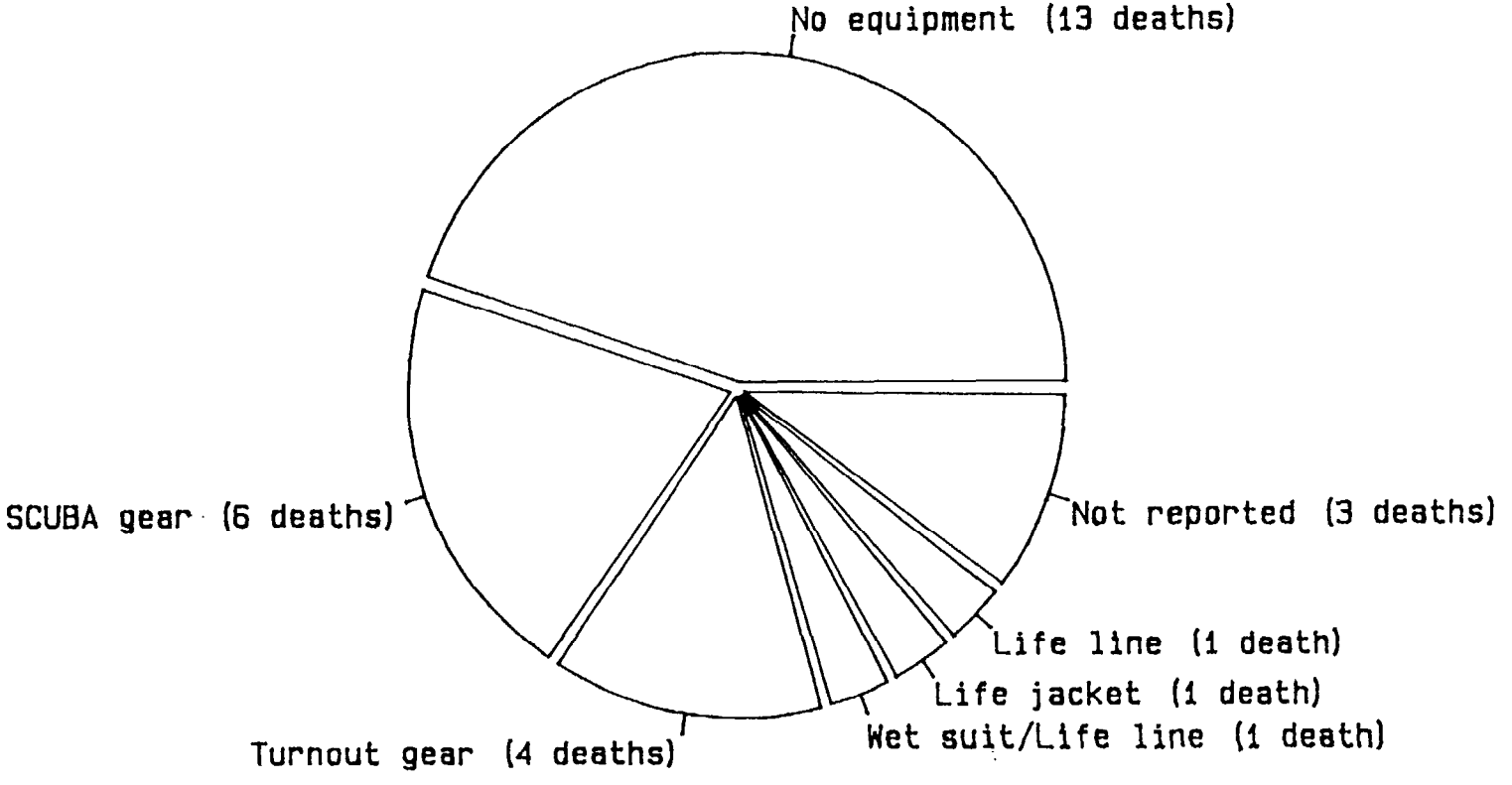
The type of protective or diving equipment worn by the fire fighters who drowned is shown in Figure 14. Almost half of the victims were not wearing any protective or diving equipment when they drowned. This includes eight of the rescuers, the two involved in motor vehicle accidents, the recreational swimmer, the fire fighter at the water drafting drill, and the fire prevention inspector. It was not reported what type of equipment, if any, was worn by the three victims who drowned in Lake Erie.

Six of the victims were wearing SCUBA gear. For three of the victims, no reasons for their drownings were reported. In each case their equipment was operational and proper procedures had been followed. In two other incidents, the divers had become entangled in lines. In one of those incidents and in the incident where the fire fighter became trapped in a hole in a dam, the divers lost their mouthpieces when they became trapped.

Four of the victims were wearing structural fire fighting protective clothing when they drowned. One of them was placing flares along a roadway when he apparently fell into a drainage ditch. Another was assisting motorists whose vehicle had been washed off the road in torrential rains when he himself was swept away. Another was one of the fire fighters returning in a boat from a structure fire. The fourth fire fighter was evacuating residents of a coastal area during a storm. He ignored orders to put on a life jacket at least four times. He had also been told to remove his coat and boots since they would act like anchors if he fell into the water.

The remaining three victims, wearing life jackets or using life lines, were caught in undertows or rapid currents.

Figure 14
Fire Fighter Fatalities Due to Drowning by Type of Equipment Worn 1980 - 1989



Findings

The 29 drowning victims ranged in age from 16 to 57 years. Twenty-one were volunteer fire fighters, seven were career and one was a seasonal fire fighter.

Severe weather conditions, swift currents, undertows and cold water were cited as factors in many of the drownings. Two of the victims had been drinking prior to their accidents -- they had blood levels of 0.09 and 0.21. Two of the victims became entangled in lines while working underwater.

IV. FIRE FIGHTER DEATHS DURING RESCUES
1980-1989

From 1980 through 1989, 79 of the 699 fire fighters who were killed at the fire ground or during non-fire emergencies died while performing search and rescue activities. This analysis includes only those incidents where fire fighters were working to free victims who were trapped and will describe what activities the fire fighters were involved in and the cause and nature of the fatal injuries they sustained. It does not include fire fighters who were responding to or returning from such emergency calls or the 20 fire fighters who suffered heart attacks or were struck by vehicles while providing emergency medical care.

Type of Activity

Of the 79 fire fighters killed during search and rescue activities, 44 were on the fire ground and the other 35 were at EMS or other non-fire emergency calls. The distribution of these 79 deaths by type of activity is shown in Figure 15.

The distribution of cause of fatal injury for the 44 victims involved in search and rescue activities on the fire ground is shown in Figure 16. Twelve of the victims were caught or trapped by rapid fire progress -- seven of them died of burns and five of smoke inhalation. Eight fire fighters were lost tion. inside the buildings -- all died of smoke inhalation. Seven fire fighters were killed in structural collapses. Six fire fighters died of heart attacks due to overexertion -- two of them were pulling or carrying victims to safety at the time. Four of the fire fighters died as a result of falls -- two from the structure, one from a ladder and one through an opening in the floor. Four deaths resulted from exposure to smoke -- two were asphyxiated and two

Figure 15
Fire Fighter Deaths During Search and Rescue by Type of Activity 1980 - 1989

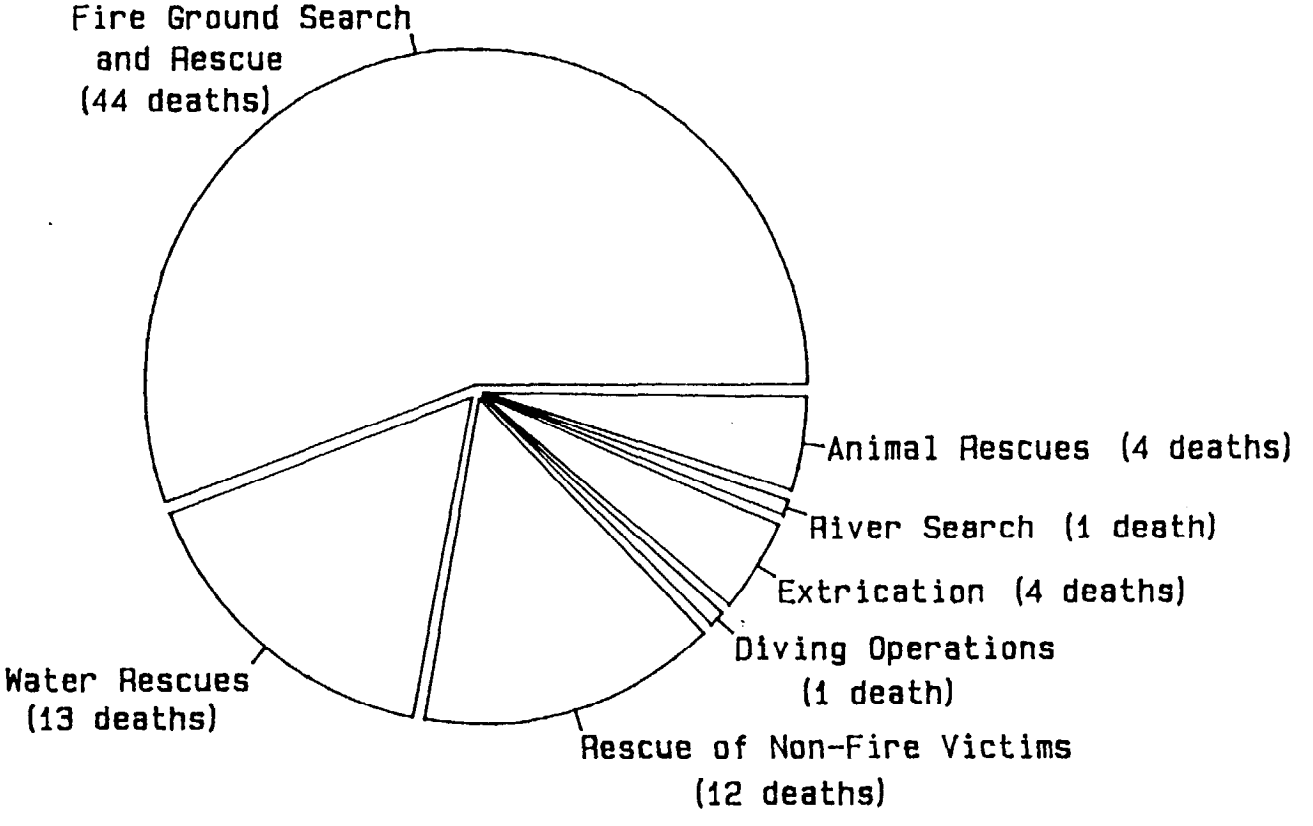
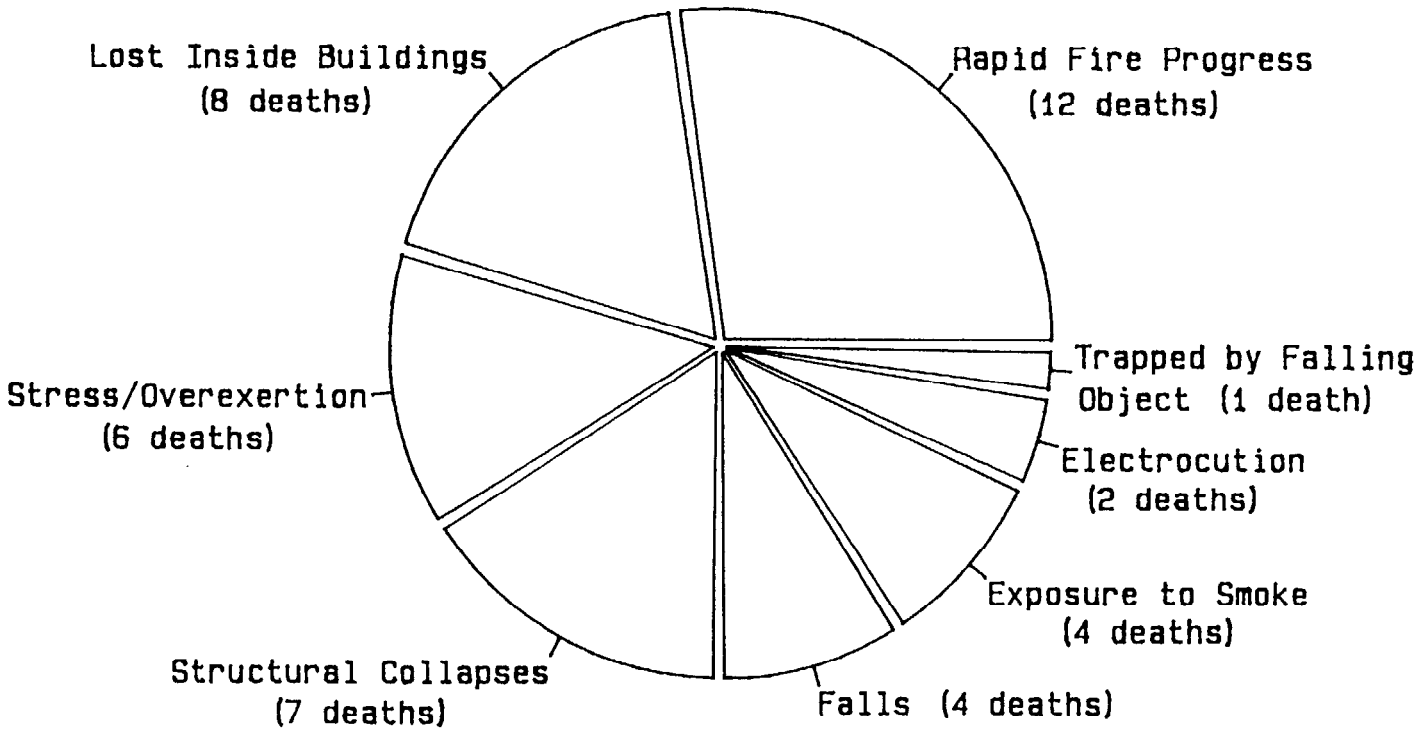


Figure 16
Fire Fighter Deaths During Search and Rescue on the Fire Ground by Cause of Fatal Injury 1980 - 1989



suffered heart attacks. Two of the victims were electrocuted. And finally, one was caught in a collapse of bales of tissue in a warehouse fire and died of asphyxiation.

Thirteen fire fighters were killed while involved in water rescues. Twelve of the victims drowned. The circumstances of their deaths are discussed in the previous section of this report. The remaining victim suffered a fatal heart attack following pneumonia contracted while involved in a cold water river rescue a week earlier.

Twelve fire fighters died while attempting to rescue non-fire victims. Four of the fire fighters were overcome by fumes -- one in a storm sewer under construction while rescuing a worker who had been overcome, one attempting to rescue a worker from the tank of a ship, one attempting to rescue two workers from a 50-foot water well and one attempting to rescue two paramedics overcome while rescuing a child from a septic tank. One fire fighter suffered a heart attack while climbing a cliff overlooking a beach and trying to find an access route to a victim trapped on the beach at high tide. One fire fighter was struck by a train while trying to evacuate elderly flood victims. Another drowned while evacuating a flooded coastal area. One fell from a cliff during the rescue of a boy trapped on a ledge in a canyon. And finally, one fire fighter mistakenly dove into an empty pool to rescue a victim lying at the bottom of the pool. Another was electrocuted as he administered CPR to a truck driver whose vehicle was energized by contact with high tension power lines. And in two separate incidents, fire fighters were slain as they tried to assist victims of their assailants -- one was struck by an ax and the other was shot.

Four fire fighters died while extricating victims. Two of them suffered fatal heart attacks while working at motor vehicle accidents. One was

electrocuted while he worked with others to lift a vehicle that had struck a utility pole and knocked down power lines. The fourth victim died of blast' injuries suffered when flammable liquid vapors exploded as he was cutting a hole in a toluene tank to free a worker trapped inside.

One fire fighter drowned during diving operations while searching for a body. Another fire fighter drowned when his boat overturned while he was assisting in a river search for the body of a drowning victim.

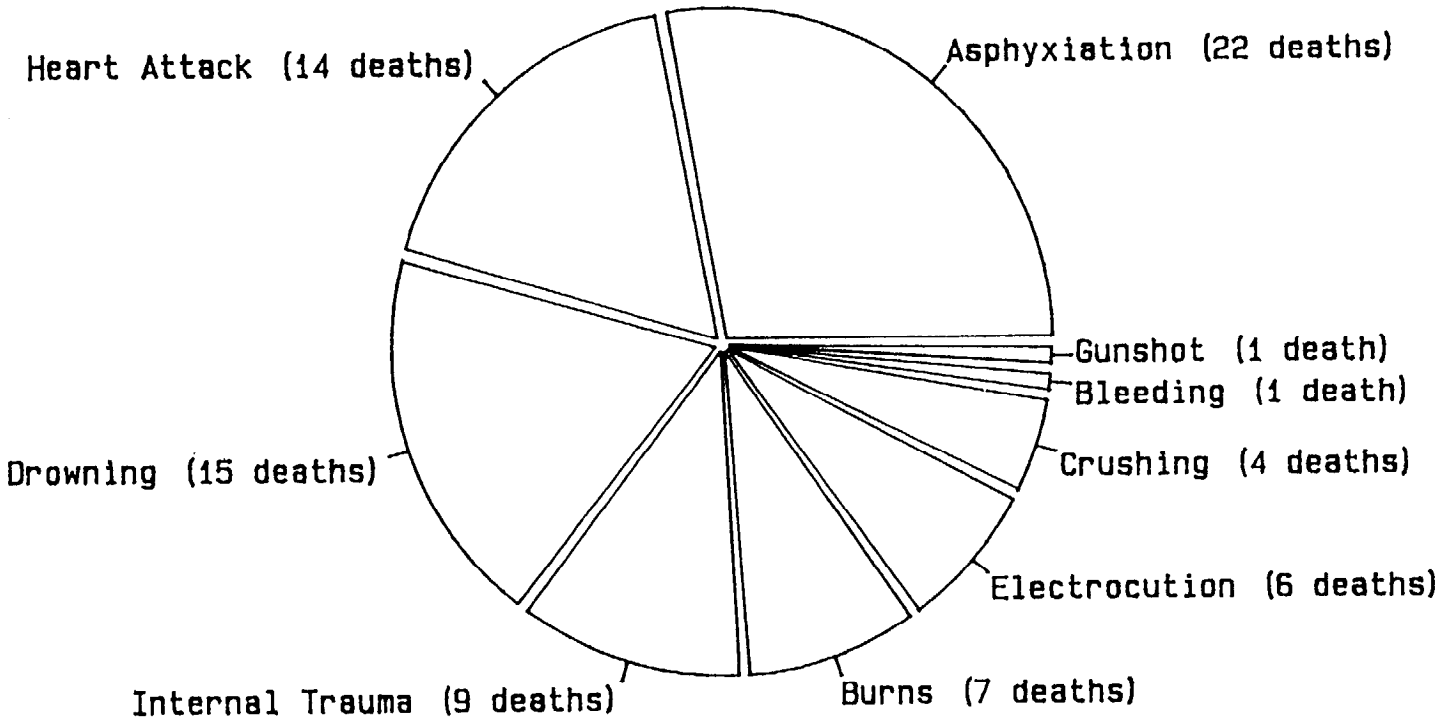
Four fire fighters were killed in separate animal rescues. Two were attempting to retrieve cats from power poles when they were electrocuted. One fire fighter suffered a heart attack when trying to free a dog from a hole in the ice. The fourth had a heart attack while trying to free a heard of cows trapped when the roof of their barn collapsed under a heavy snowfall.

Findings

Forty-five of the victims were career fire fighters and thirty-four were volunteers. As shown in Figure 17, the most frequent nature of fatal injury (medical cause of death) was asphyxiation, followed by heart attack and drownings. Burns and electrocutions also accounted for a large number of deaths.

Deaths during search and rescue activities accounted for 11.3 percent of all deaths at fire and emergency scenes, and 6.3 percent of the total deaths.

Figure 17
Fire Fighter Deaths During Search and Rescue by Nature of Fatal Injury 1980 - 1989



V. FIRE FIGHTER DEATHS AS A RESULT OF RAPID FIRE PROGRESS IN STRUCTURES

1980 - 1989

One of the dangers fire fighters face while operating inside structures is being caught in the rapid development of the fire, which can trap and fatally injure them. The types of rapid fire growth included in this analysis are flashover, backdraft and ignition of fire gases.

Flashover is defined as the stage of a fire at which all surfaces and objects in a room or area are heated to their ignition temperature and all contents and combustible surfaces ignite at once. Backdraft is defined as the burning of heated gaseous products of combustion when oxygen is introduced into an environment that has a depleted supply of oxygen due to fire. This burning often occurs with explosive force.[4] We use the term "ignition of fire gases" to cover other phenomena reported as "rollover," "flameover," "flare-up," "flashback," etc.

Distinguishing among these specific phenomena can be difficult for observers outside the building or observers inside the building but removed from the involved area. For this reason, the following analysis will not deal with which phenomenon was involved, but with the circumstances that led to the fatalities in all fires where any of these phenomena led to deaths.

From 1980 through 1989, 456 fire fighters (36.6 percent of all line of duty deaths> were killed while operating at structure fires. Of these deaths, 45 were the result of some sort of rapid fire development. Not included in this analysis are seven fire fighters killed under similar circumstances during live fire training, and 13 fire fighters caught by rapid fire spread at wildland fires.

Three possibilities were examined in the analysis of the circumstances of these 45 fatalities: 1) fire fighters did not recognize the signs of flashover or backdraft conditions developing; 2) the suppression approach which was used made rapid fire development more likely; and 3) fire fighters were not adequately protected.

In general, no obvious signs of backdraft and flashover (e.g., the puffing of smoke out any opening in the building that makes the building appear to be breathing; thick smoke and heat with no visible fire; rolling flames across the bottom of a heavy smoke layer) were reported. In several cases, fire fighters specifically reported that smoke was only light as they moved through the building.

Although no warning signs were reported, that does not mean that flashover and backdraft occur without any indication of, or buildup to, a sudden change. The victims themselves may have observed the signs but were unable to react in time. Other fire fighters on the scene may have been unobservant, or may have failed to recognize and understand warning signs that did occur. Understanding fire behavior is of critical importance to all fire fighters. It is also possible that the signs were present beyond the view of the other fire fighters on the scene.

Whenever a fire has been smoldering or burning in an oxygen-starved atmosphere for a long time, there is potential for large quantities of carbon monoxide and other unburned products of combustion to be present. These may not evidence themselves as thick smoke. In larger areas, these dense concentrations of gases and potential fuel could extend a considerable distance from the seat of the fire, where they would have been cooled by the atmosphere. Under the right conditions, they can be ignited and flash across an area, creating tremendous radiant heat, generally from the ceiling downward. This type of phenomenon has led to a number of fire fighter deaths over the years.

The second hypothesis, that the suppression approach made rapid fire development more likely, may have been confirmed in a few incidents where there was inadequate ventilation. In one incident, two fire fighters were killed during overhaul of a fire in a clothing store which had not been ventilated either horizontally or vertically. The roof had not been opened and the windows were left intact. It was about 45 minutes after the alarm, and the fire was thought to have been knocked down, when the area where the fire fighters were working suddenly became involved in an intense fire. It may have been due to a buildup of heat and unburned products of combustion above the false ceiling or a sudden introduction of air into an area of the building where there was still some burning and an accumulation of unburned gases. In other cases, the directing of a hose stream into an unventilated space, such as a basement or attic, appears to have introduced oxygen and provided the mixing needed to create a backdraft.

The third hypothesis, that fire fighters were not adequately protected, was not supported by the incident reports. In every incident but two, fire fighters were reportedly wearing protective clothing and using SCBA. In one incident, the fire fighter was attempting to extinguish a fire in his own home. In the other, the fire fighter was not using the facepiece of his SCBA and suffered burns to his face and head as well as significant respiratory damage. For the other victims, specifics about what type of protective clothing was worn and whether the clothing met NFPA standards were not generally available. Equipment or clothing may indeed have been damaged or overwhelmed by these severe fire conditions in some cases, but failures of clothing or equipment within their design limits were not reported as factors in any deaths.

What can be done to prevent such fatalities as these? Ventilation of involved structures is essential in limiting risk to fire fighters operating inside, but the process of doing it can expose fire fighters to the very dangers they are trying to reduce. Fire fighters and fire officers must recognize conditions that could cause backdraft, flashover, or other ignition of fire gases and endanger fire fighters operating inside the structure. The film, "Countdown to Disaster," can be used in training to educate fire fighters about flashover hazards.'

It is also possible that these fire development phenomena are not factored into local fire fighting operations planning and decision-making as universally as the special hazard would warrant. A careful and thorough investigation of all abnormal situations should be initiated, whether there are deaths and injuries or not. When fire fighters encounter unusual heat, smoke, or burning at locations remote from the main fire area, these also could be indicators of problems. Fire fighters should use care when dealing with them at the time of the fire and attempts should be made after the fire to understand why the conditions existed. Additional fire research may be necessary to gain an understanding of how some materials burn in actual building fires, how some of these unexpected situations occurred, and how fire command and attack procedures might be better designed to reduce this risk.

VI. CONCLUSIONS AND RECOMMENDATIONS

The number of fire fighter deaths in 1989 was the second lowest since NFPA's first study of fire fighter fatalities was done in 1977. Almost all of the decrease was accounted for in the experience for volunteer fire fighters, after two years of increases for them. The death toll for career fire fighters was the second lowest since 1977 but the death toll for volunteers was only the fourth lowest and followed the two highest years in the 1980s.

The 1989 decrease for volunteer fire fighters was led by reductions in heart attacks and in internal trauma and crushing injuries, both on the fire ground and while responding to and returning from alarms. Unfortunately, the decrease in heart attack deaths among volunteer fire fighters was offset by a slightly larger increase in heart attacks in the career fire service. In 1989, heart attacks accounted for more than half of the total deaths and, as we find each year, most of the victims with known medical histories had suffered previous heart attacks, had had bypass or other heart surgery or had had severe, detectable heart disease.

This year's report focused on three special areas: deaths due to drowning, deaths during rescue activities, and structure fire deaths that resulted from rapid fire progress. The latter analysis was prompted to some degree by the three-fatality incident that occurred in Oklahoma City, Oklahoma. The other analyses address areas where attention is needed in order to reduce fatalities.

Drownings claim an average of 3 deaths per year, not the largest share of deaths by any means, but an indication of a significant problem faced by the fire service. Proper training in water rescues and proper precautions while working in flooded areas are essential to holding down the death toll in such incidents.

Deaths during search and rescue are another small but important part of the fire death problem. Such incidents result in an average of eight deaths' per year. Fire fighter health screening can limit the number of heart attack deaths. Proper precautions while working inside structures and around downed power lines are necessary to protect the safety of fire fighters at emergency scenes.

Basic guidelines for sound practices need to be well-distributed throughout the fire service. One example is NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, which provides the framework and objectives for a comprehensive program to reduce and eliminate fire fighter deaths and injuries.

Further reductions in fire fighter deaths can be accomplished if changes in operating procedures and attitudes are made in order to improve fire fighter safety.

REFERENCES

1. Michael J. Karter, Jr., "U.S. Fire Department Profile through 1988," Quincy, MA: National Fire Protection Association, Fire Analysis and Research Division, November 1989.

2. Michael J. Karter, Jr., "U.S. Fire Loss in.1989," Fire Journal, Vol. 84, No. 5, (September 1990).

3. The four regions as defined by the U.S. Census Bureau include the following 50 states and the District of Columbia:

   Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

   Northcentral: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

   South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia.

   West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washingon, and Wyoming.

4. Ralph W. Burklin and Robert G. Purington, Fire Terms: A Guide to Their Meaning and Use, National Fire 'Protection Association, 1980.

5. "Countdown to Disaster," National Fire Protection Association, 1984.