

**ANALYSIS REPORT ON
FIRE FIGHTER FATALITIES**

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

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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 by NFPA each year since 1974.

For more than 10 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 1990 and 1991 fire fighter fatalities and with lists of names and addresses of next of kin and of fire department chiefs for use in the Memorial Service in October 1991 and 1992.

In August, a briefing on the 1991 experience and three special analyses was presented by NFPA staff to USFA staff and guests 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 15 years of experience now classified in its 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 1991 in an attempt to identify potential means for reducing the number of deaths that occur each year. In addition to the 1991 findings, this study will also include special analyses of particular recurring scenarios, using NFPA's data base of fire fighter fatalities from 1982 through 1991.

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 wildland agencies; prison inmates serving on fire fighting 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; 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 in the line of 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 illness 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 that have occurred in the past 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 while working around the station, 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, a fire inspector who fell through a skylight, and a fire fighter killed when the aerial ladder he was strapped to collapsed as he was hanging a banner.

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, one who was kidnapped and

shot after responding to a verbal request for assistance, and one who was killed when a pipe bomb planted in his car exploded as he left the station.

Fatal injuries and illness 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 after years of recurring seizures resulting from a brain injury received in 1979 when he was struck by a hose coupling. Because his death was the direct result of his injury, and the injury occurred in 1979, he is counted as a 1979 fatality.

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. This creates an ambiguous picture on the issue of occupational versus other factors as causes of fire fighter deaths. This is recognized as a gap that cannot now be filled because of the limitations in tracking the exposure of fire fighters to toxic environments and substances and the potential long-term effects of such exposure.

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 wildland agencies.

The NFPA also receives 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 recorded in 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 1991 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. 1991 Findings

One hundred four fire fighters died while on duty in 1991, the lowest total in the 15 years that NFPA has done this study. As shown in Figure 1, this is a decrease of 2.8 percent from the year before, and a 23.5 percent decrease from 1988, the most recent peak year.* This third consecutive drop in fire fighter deaths indicates that the efforts made to improve fire fighter health and safety are beginning to take effect. However, these efforts need to be continued and extended throughout the fire service. 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 (48.1 percent).

Of the 50 fire ground deaths, 21 were due to heart attacks, 10 to asphyxiation, eight to burns, six to internal trauma, three to crushing injuries and one each to electric shock and stroke (CVA). Twenty-three of the victims were career fire fighters and 27 were volunteers.

The second largest category involved responding to and returning from alarms, which accounted for a quarter of the deaths -- a result consistent with the findings in previous years. Fourteen of these 27 deaths were due to heart attacks,

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

Figure 1
On-Duty Fire Fighter Deaths
1977 - 1991

Number of Deaths

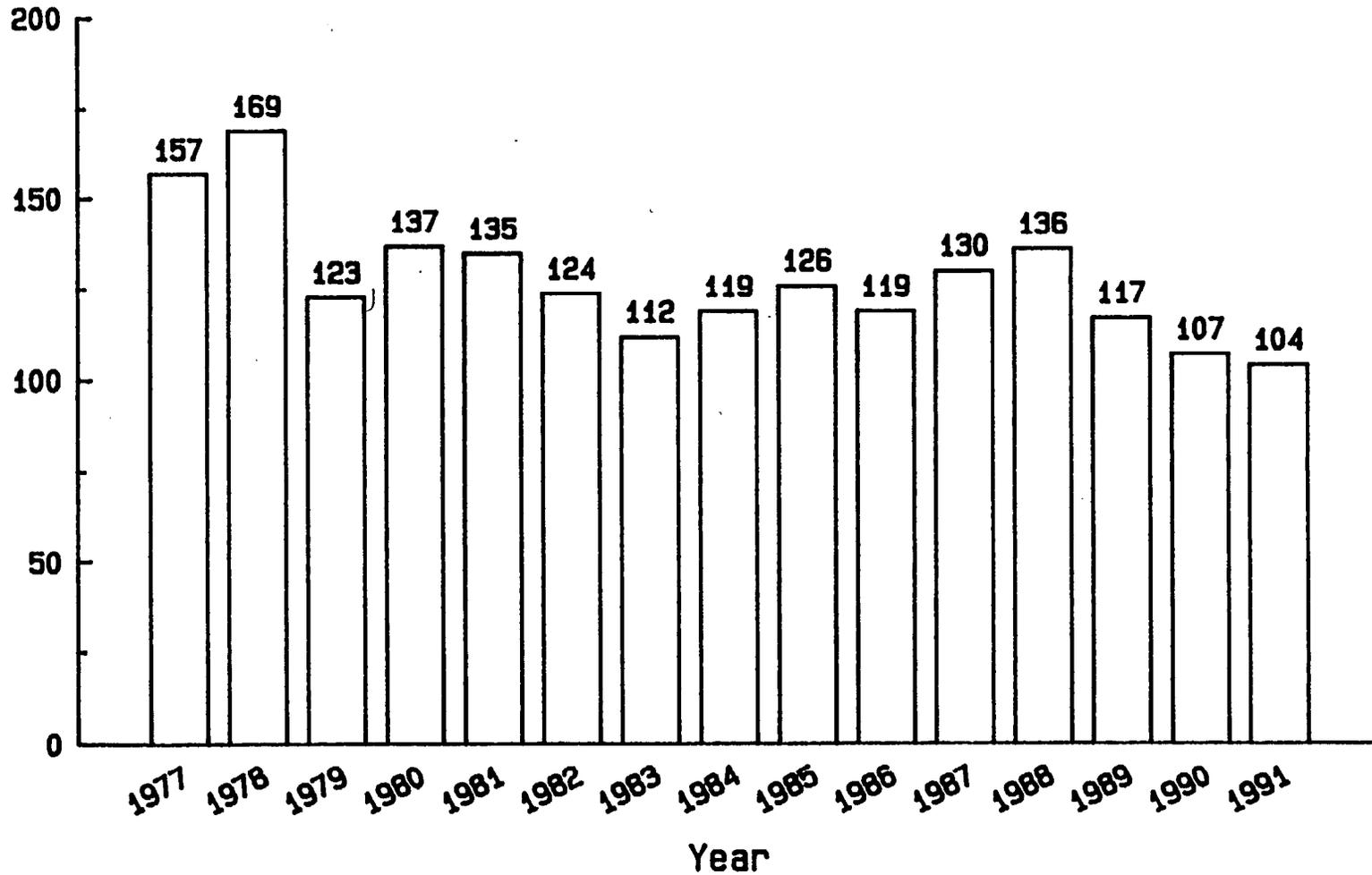
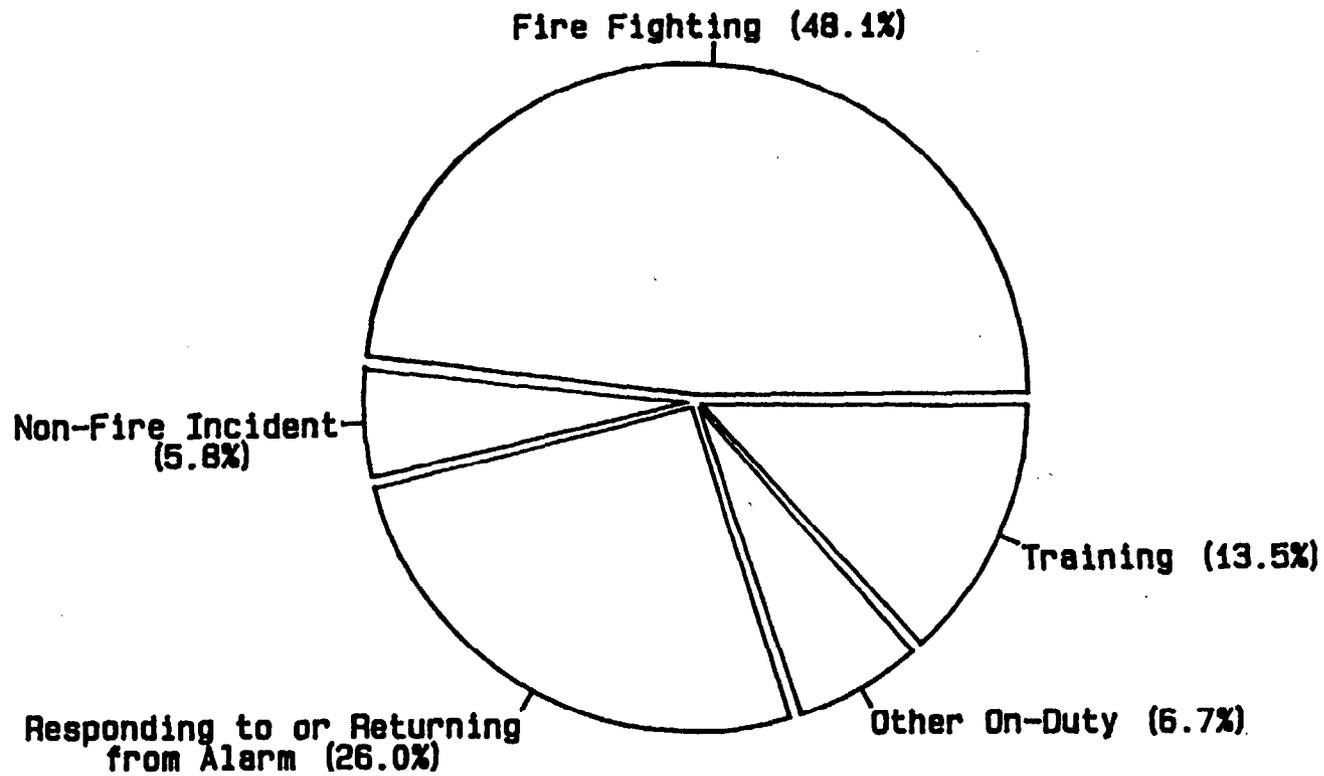


Figure 2
Fire Fighter Deaths 1991
by Type of Duty



one to a fall from the back step of a rescue truck, one to exposure to weather, one to a fall at home where he had been sent to change his clothes after a fire and the remaining 10 to collisions. Three were career fire fighters and 24 were volunteers. Two were killed while responding to or returning from false calls -- one had a heart attack at the station while responding and the other had a heart attack at the station after returning from a false alarm.

There were 14 deaths related to training activities. Of these, seven were due to heart attacks (one of these occurred at a live fire training exercise in a training tower) and one resulted from a stroke. Three were the result of collisions -- one in a personal vehicle en route to a training session and one in an ambulance helicopter during training. The third collision victim was training a fire fighter to tiller a tractor-drawn aerial ladder apparatus when the trailer section struck a power pole. A U.S. Forest Service fire fighter was killed during smoke jumper training when his parachute failed to open. One fire fighter died during training when he stepped from a moving apparatus, slipped and struck his head on the ground. Another was struck by a collapsing chimney during live fire training in a vacant dwelling.

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 and one struck by lightning while working at motor vehicle accidents, one fire fighter who suffered a heart attack while directing traffic during a power failure and one who suffered a heart attack while investigating a suspected fire.

The remaining seven deaths occurred while performing other duties -- three fire fighters who suffered fatal heart attacks during normal station and administrative duties, one from a heart attack at a state meeting, one from a heart attack while marching in a parade, one killed in a plane crash when flying to pick

up a piece of apparatus and one in a motor vehicle accident after refueling a tanker.

B. Cause and Nature of Fatal Injury 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.”

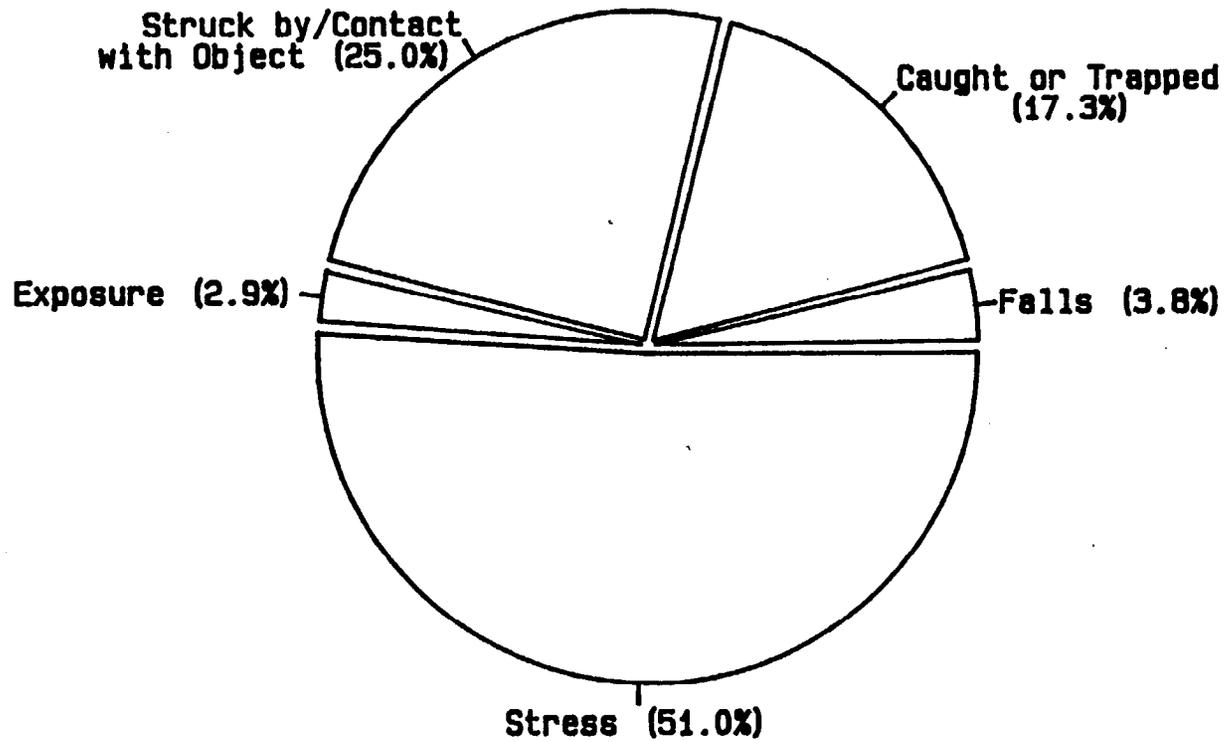
Figure 3 shows the distribution of deaths by cause of fatal injury or illness. As found in most previous years, the largest proportion of deaths (in this case, just over half) were due to stress or overexertion. Five of these 53 deaths were specifically attributed to strenuous physical activities. Stress deaths usually result in heart attacks or strokes.

The next major category was struck by or contact with objects. These 26 deaths included 19 from motor vehicle accidents, two by collapsing walls and one each by a collapsing ceiling, a hose coupling, a falling power pole, a collapsing chimney and a falling tree limb.

Eighteen fire fighters were caught or trapped -- seven by structural collapses; five by rapid fire progress; five by being lost inside buildings; and one by a garage door that closed automatically.

Fire fighter deaths over the past 10 years that resulted from becoming lost inside structures are discussed in more detail in a separate section of this report.

Figure 3
Fire Fighter Deaths 1991
by Cause of Injury



Four fire fighters were killed as a result of falls -- two from apparatus, one down a flight of stairs and one whose parachute failed to open.

Three fire fighters died of various types of exposure. Of the three, one came in contact with a downed power line, one was struck by lightning and one was exposed to severe weather and developed pneumonia.

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 51 deaths, medical documentation indicated that 15 of the victims had prior heart problems, either previous heart attacks or bypass surgery; and eight others had severe arteriosclerotic heart disease (defined for this study as arterial occlusion of at least 50 percent but usually found to be in excess of 70 percent). Three other victims suffered from hypertension. Medical documentation was not available for the other 25 heart attack victims.

The other categories of nature of fatal injury were internal trauma (24 deaths), asphyxiation (10 deaths), burns (nine deaths), crushing (five deaths), strokes (two deaths), electrocution (two deaths) and pneumonia (one death]. The 10 asphyxiation deaths included five disoriented inside buildings until their air supplies were depleted, three trapped by structural collapses in buildings, one trapped when a garage door closed and one at a wildland fire.

C. Ages of Fire Fighters

The ages of fire fighters who died in 1991 ranged from 18 to 75 years with a median age of 43 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. But fatal heart attacks occur even among younger fire fighters -- the

Figure 4
Fire Fighter Deaths 1991
by Nature of Injury

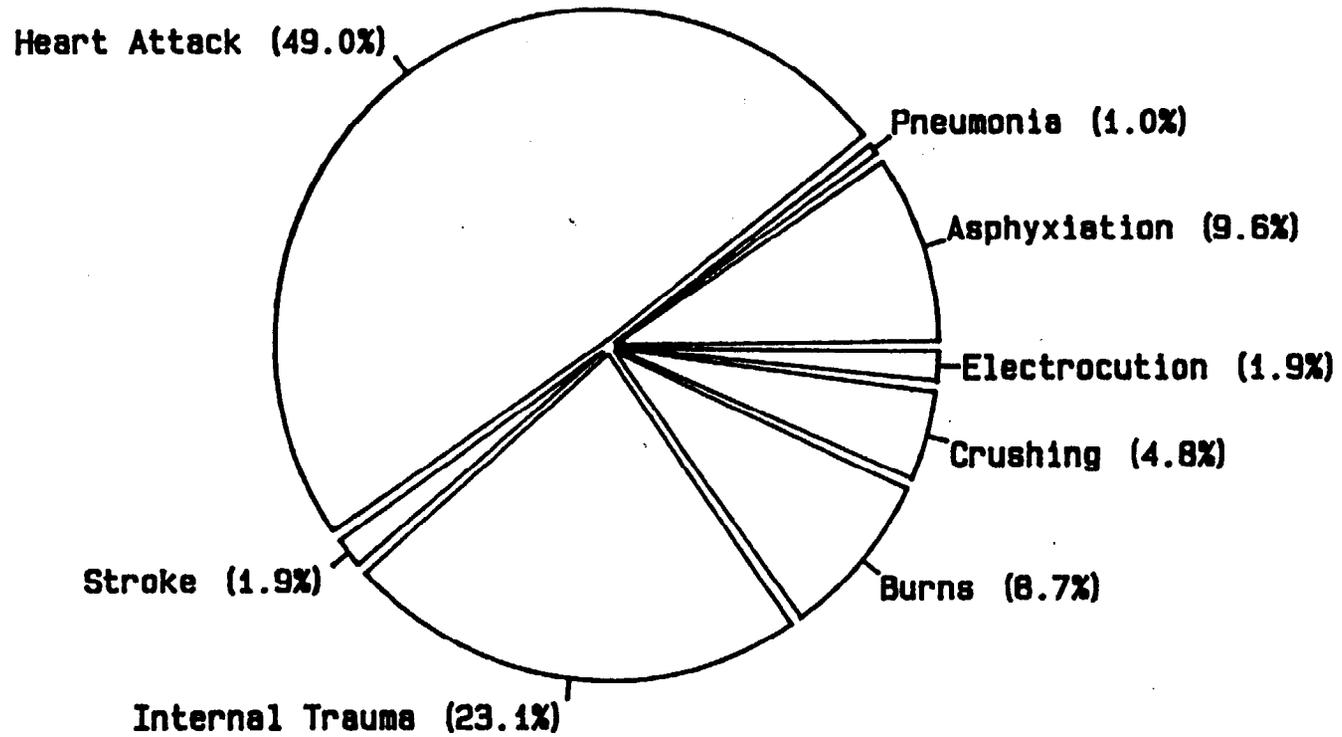
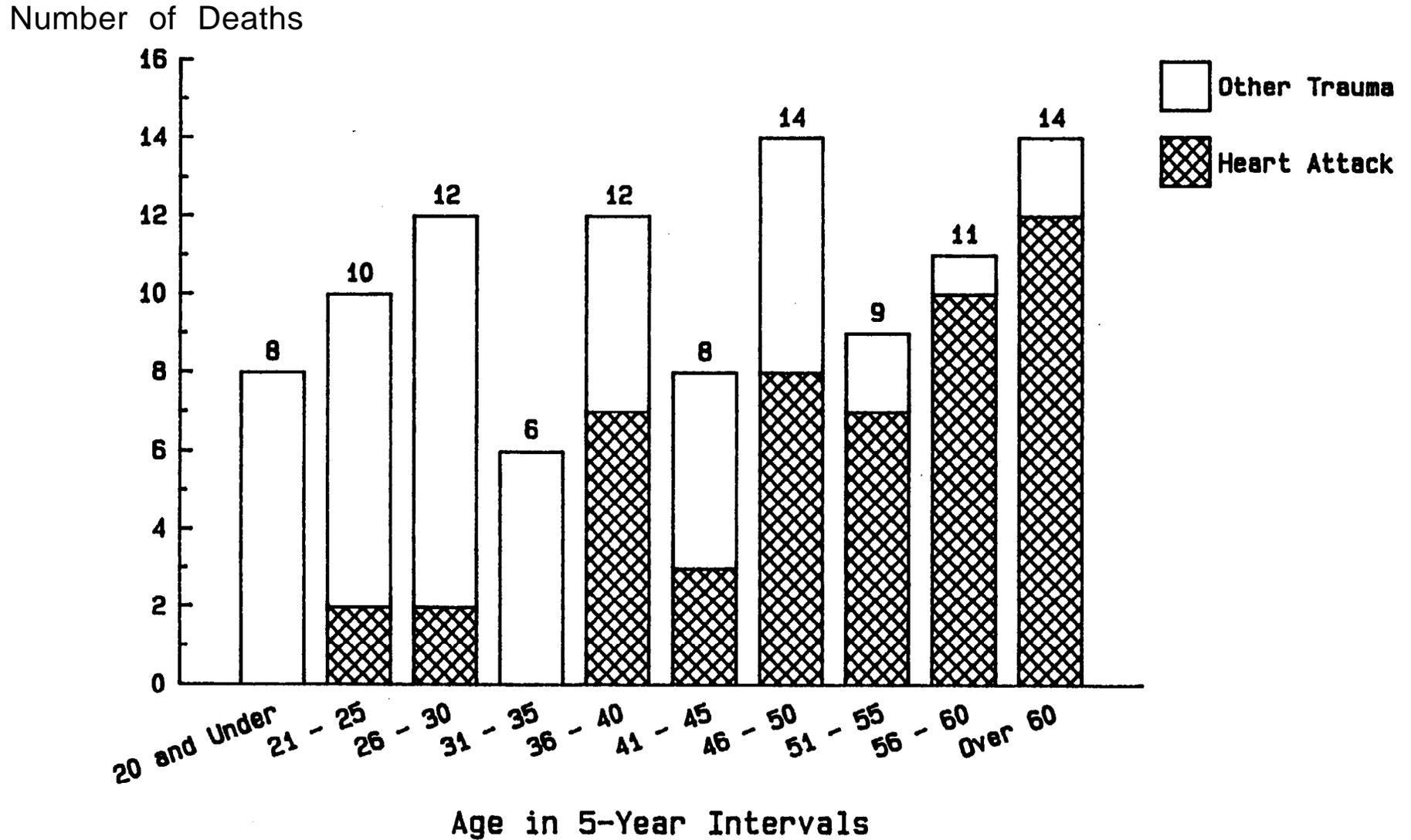


Figure 5
Fire Fighter Deaths 1991
by Age and Cause of Death



two youngest victims were 24 and 25. The younger fire fighter suffered a heart attack while attending a training seminar. He had had a liver transplant 13 years earlier which may have been a contributing factor in his death. The other young victim had severe, progressive heart disease and had suffered an earlier heart attack.

Figure 6 shows the death rates by age categories using estimates of the number of fire fighters in each age group from NFPA's- 1989 profile of fire departments and the fatality data from 1987 through 1991¹. 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 only 14 percent of all fire fighters are over age 50, that age group accounted for 40 percent of the deaths from 1987 through 1991, including 60 percent 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 2 1/2 times the average.

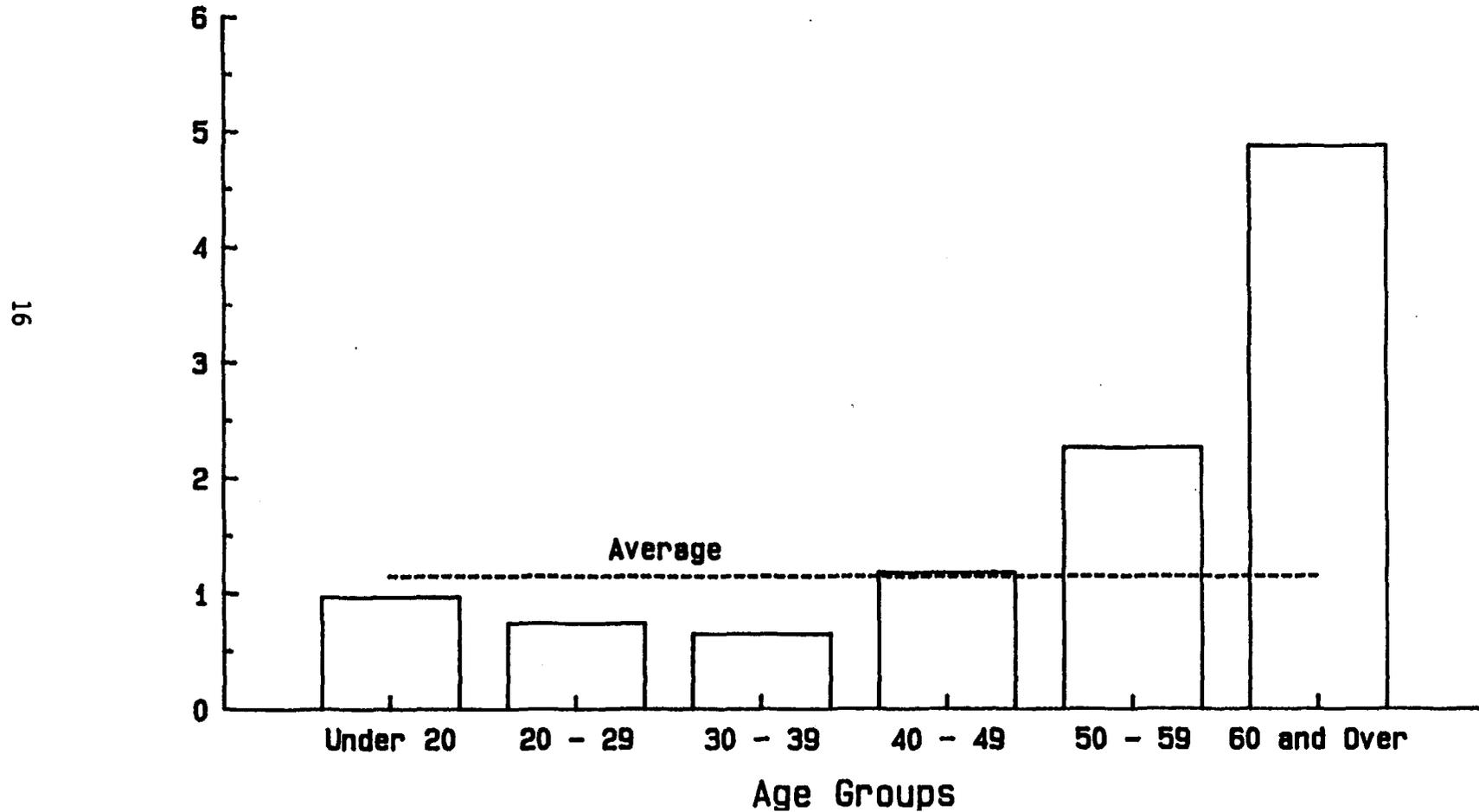
D. Fire Ground Deaths

The distribution of the 50 fire ground deaths by fixed property use is shown in Figure 7. The largest share of fire ground deaths (32.0 percent) occurred at residential structure fires. These 16 deaths included 14 in one- and two-family dwellings and two in apartment buildings. This is a substantial increase over the seven deaths in residential structure fires in 1990, but in line with the annual average of 19 deaths per year over the last 10 years.

There were nine deaths at fires in stores and offices. This includes the three deaths that occurred in a high-rise office building in Philadelphia. There were

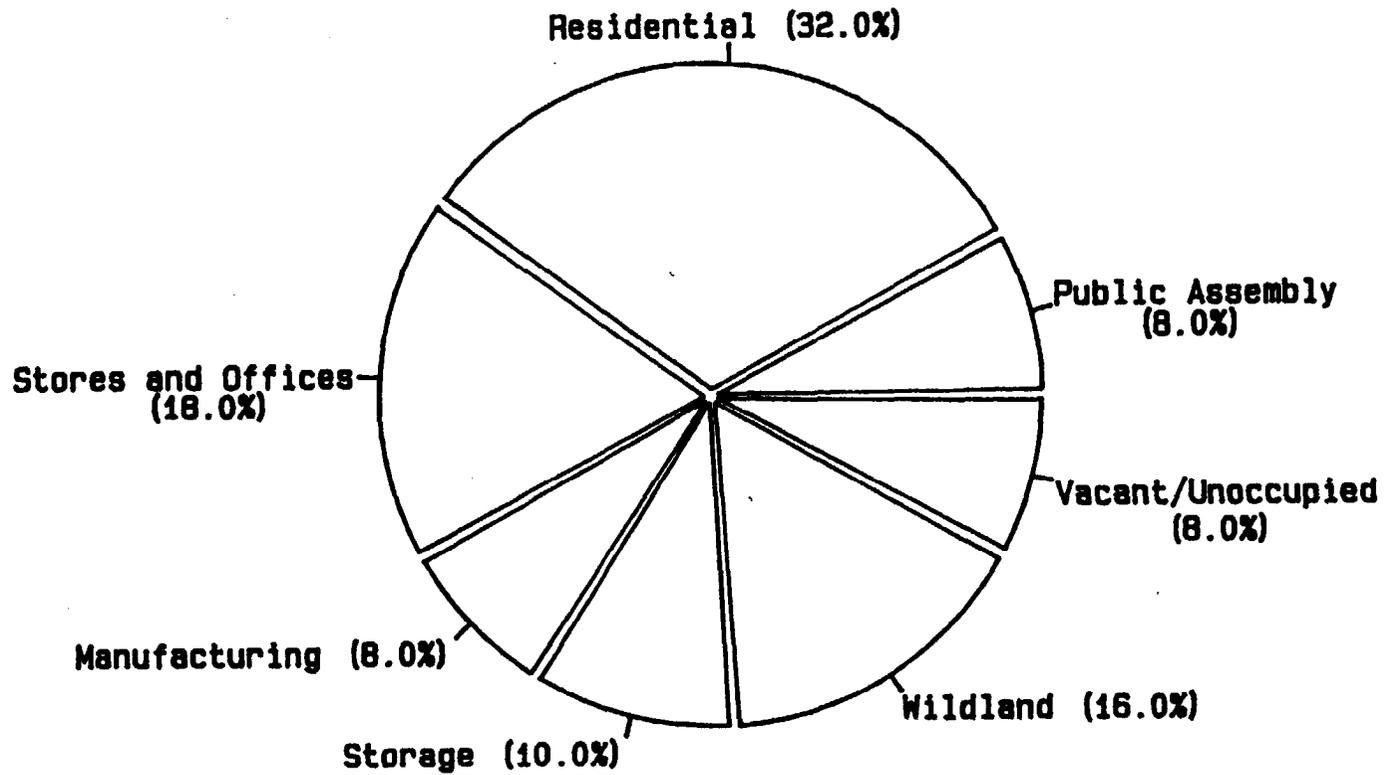
Figure 6
On-Duty Death Rates per 10,000 Fire Fighters
1987-1991

Deaths per 10,000 Fire Fighters



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

Figure 7
Fire Ground Deaths in 1991
by Fixed Property Use



eight deaths in wildland fires in 1991 -- a sharp drop from the 19 deaths reported in 1990 and an improvement on the annual average of 11 deaths.

There were five deaths in storage properties, one of which was a dwelling garage. Four deaths occurred in one incident at a furniture refinishing business in Brackenridge, Pennsylvania. Four deaths occurred in public assembly buildings -- two in a restaurant, one in a lounge and one in a church. There were three deaths due to fires in vacant buildings and one in a building undergoing renovations.

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 1991 fire loss study². There were 3.4 fire fighter deaths per 100,000 residential structure fires, compared to 16.0 deaths per 100,000 nonresidential structure fires. Although 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.

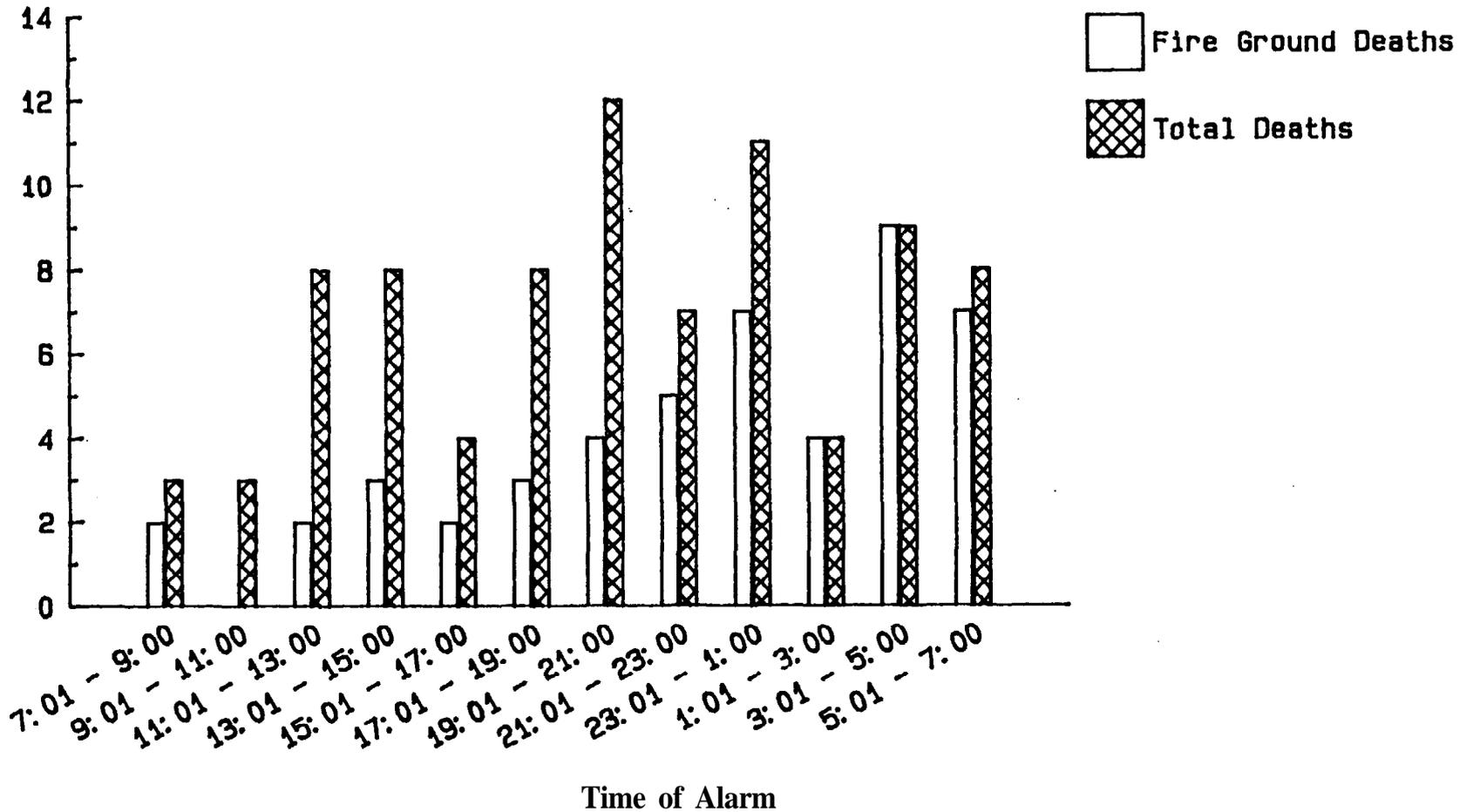
E. Time of Alarm

The distributions of 1991 fire ground deaths and total deaths by time of alarm are shown in Figure 8. The highest number of fire ground deaths occurred for alarms between 11 pm and 7 am. The seven deaths in the two largest multiple-fatality incidents (Brackenridge and Philadelphia) occurred in this time period. The distributions of deaths by time of alarm over a ten-year period are shown in Figure 9. The number of deaths in both categories was at the highest level for alarms between 1 and 9 pm and dropped to the lowest level in the early morning hours.

Figure 8 Fire Fighter Fatalities 1991 by Time of Alarm

Number of Deaths

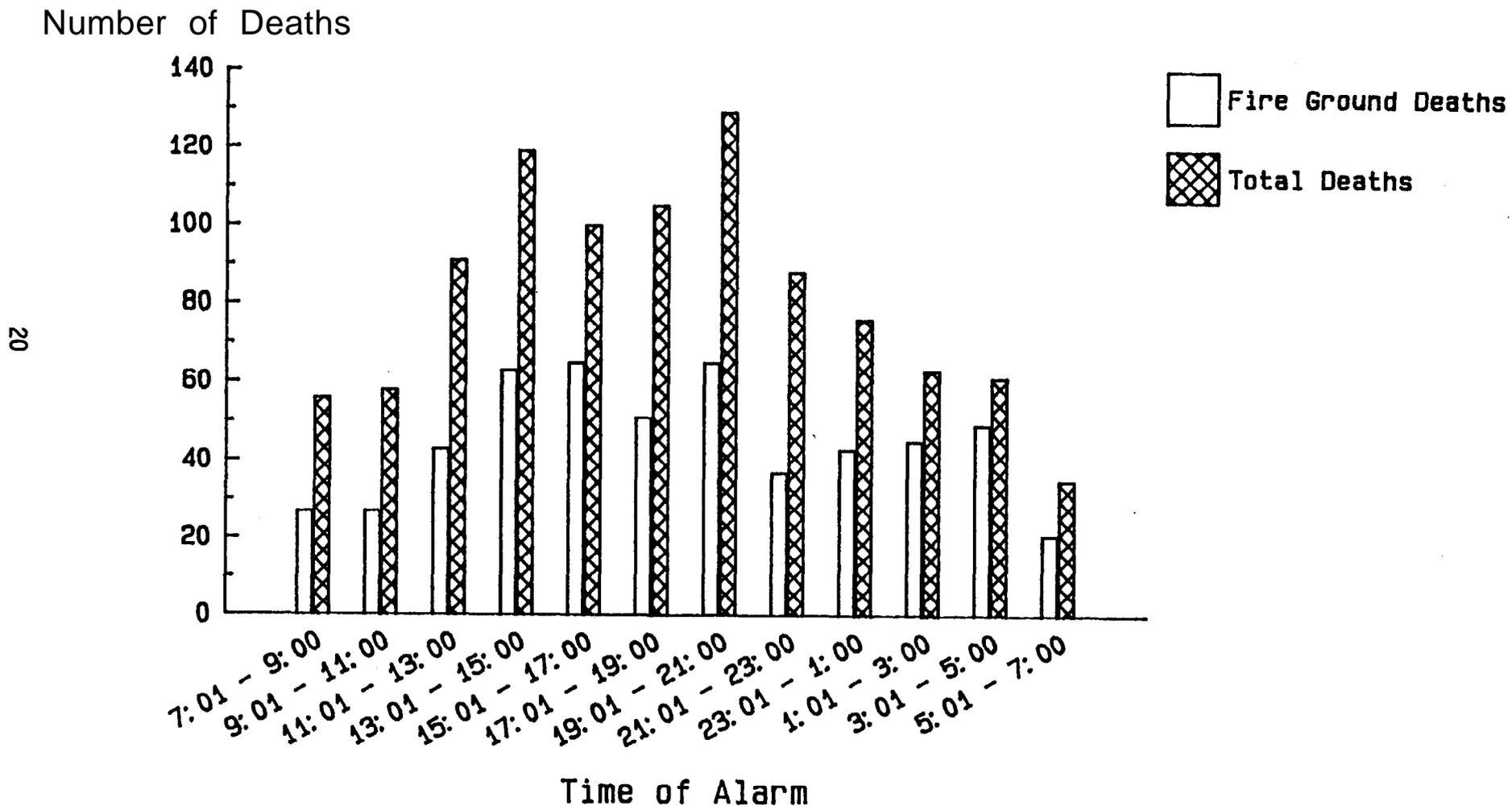
19



Based on 48 fire ground fatalities and 85 total fatalities for which alarm time was reported.

Figure 9

Fire Fighter Fatalities 1982 - 1991 by Time of Alarm



Based on 536 fire ground fatalities and 981 total fatalities for which alarm time was reported.

F. Month of the Year

Figure 10 shows the distribution of 1991 fire fighter deaths by month. The same information for 1982 through 1991 is shown in Figure 11. The ten-year analysis shows that fire ground deaths are highest in the winter months and in July.

G. State and Region

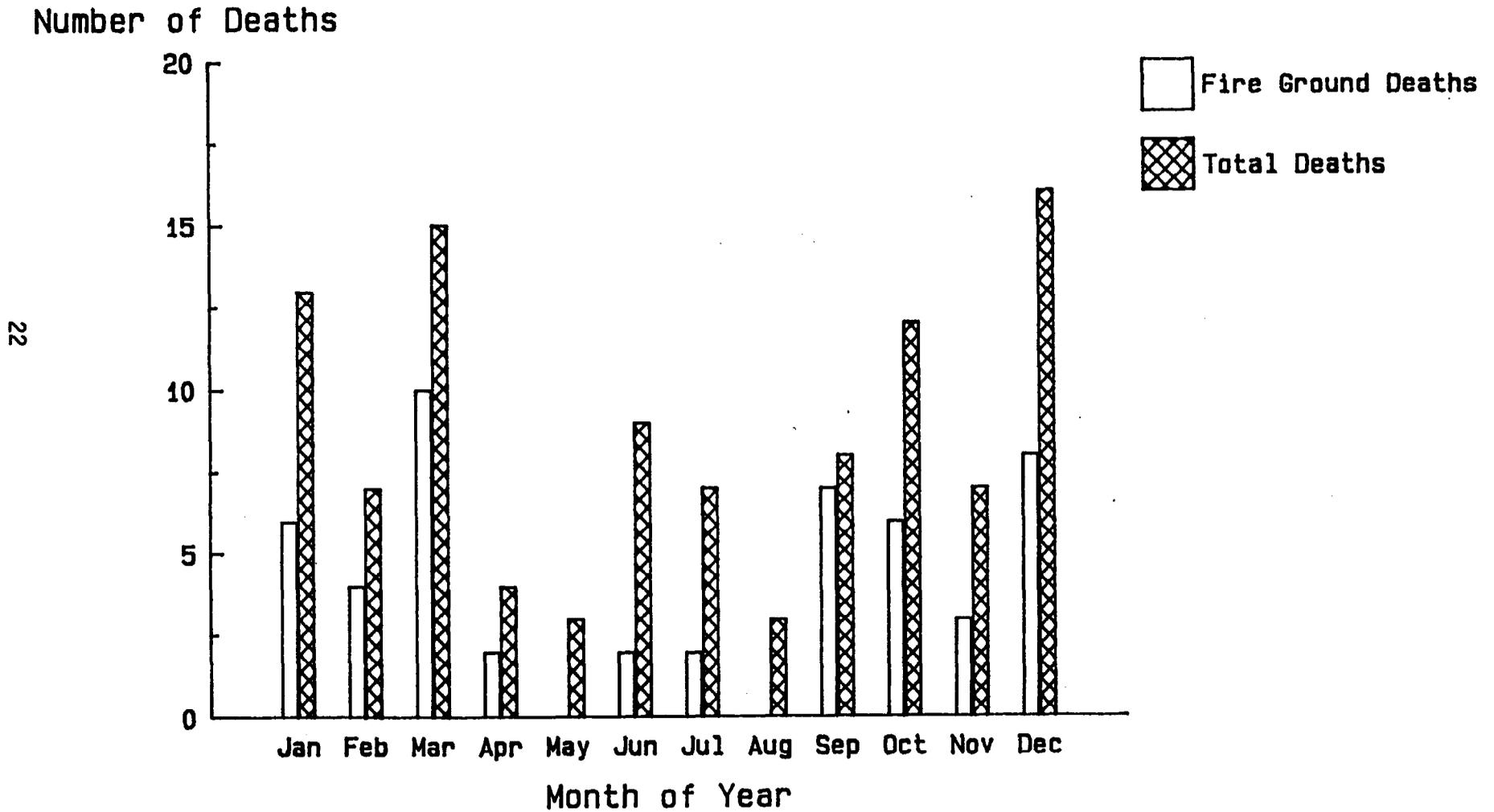
The distribution of fire fighter deaths by state is shown in Table 1. Thirty-six states are represented on the list, led by New York with 17 deaths and Pennsylvania with 14. The experience by region³ is displayed in Table 2 and Figure 12. The Northeast lost the largest number of fire fighters (42), followed by the South (26), the Northcentral region (20) and the West (16). Only the Northeast had a higher than average fire ground death rate. At 4.67 deaths per 100,000 fires, the death rate for the Northeast was almost twice the national average.

H. Analysis of Urba/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 organized by counties or special fire protection districts may have both urban and rural sections, and there are

Figure 10
Fire Fatalities 1991
by Month of Year

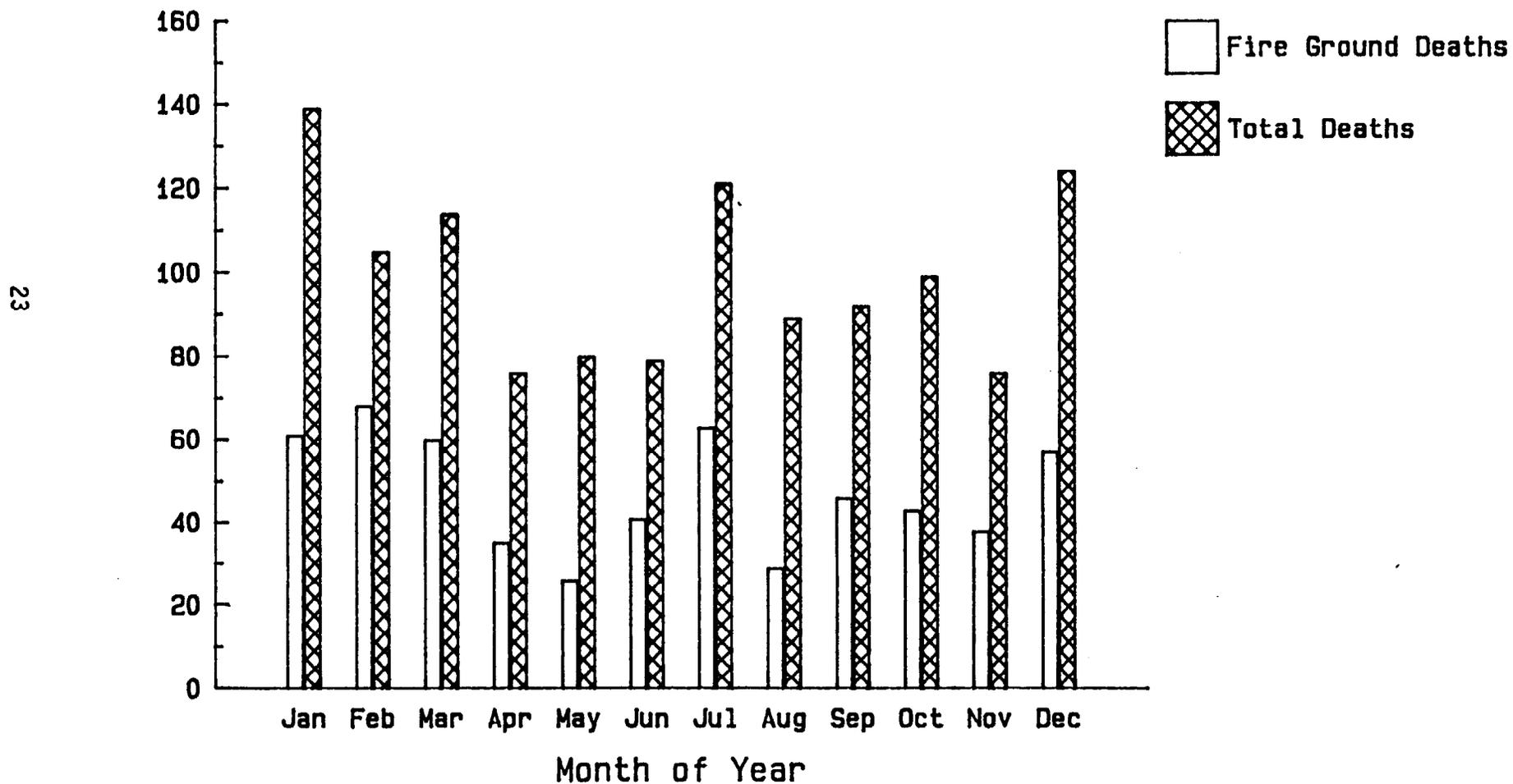


Based on 50 fire ground fatalities and
104 total fatalities.

Figure 11

Fire Fighter Fatalities 1982 - 1991 by Month of Year

Number of Deaths



Based on 567 fire ground fatalities and
1194 total fatalities.

Table 1
1991 On-Duty
Fire Fighter Fatalities

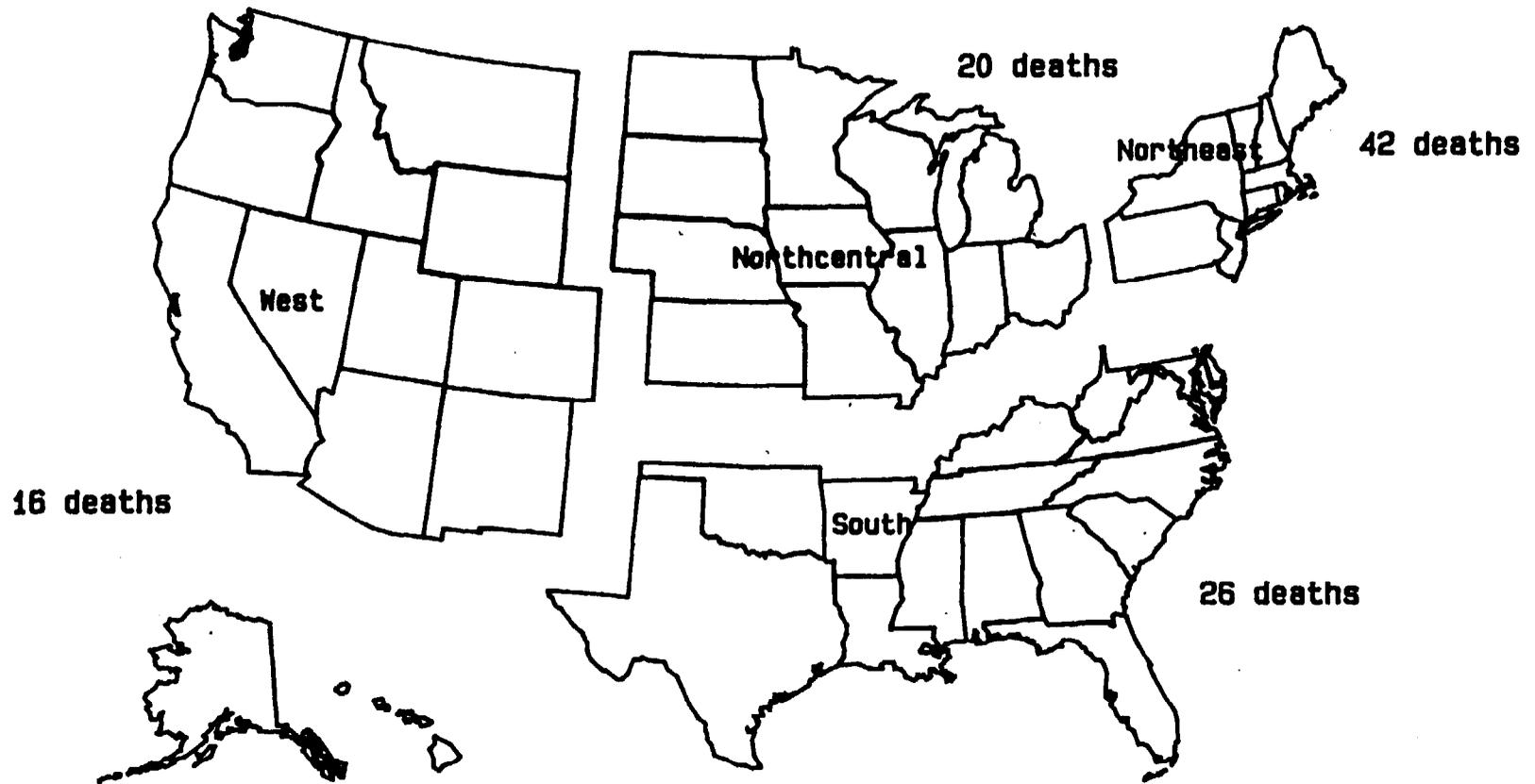
State	Number of Deaths	State	Number of Deaths
Alabama	1	Mississippi	3
Alaska	1	Missouri	1
Arizona	2	Montana	3
California	7	New Jersey	5
Colorado	1	New Mexico	1
Connecticut	4	New York	17
Florida	2	North Dakota	1
Georgia	2	Ohio	5
Illinois	3	Pennsylvania	14
Indiana	1	South Carolina	2
Iowa	1	South Dakota	1
Kansas	2	Tennessee	1
Kentucky	3	Texas	2
Louisiana	2	Vermont	1
Maine	1	Virgini a	2
Maryland	4	West Virginia	2
Michigan	3	Wisconsin	1
Minnesota	1	Wyoming	1

TOTAL: 104

Table2
Fire Fighter Death Rates by Region
1991

Region	Number of Fatalities	Number of Fire Ground Deaths	Fire Ground Death Rate per 100,000 Fires
Northeast	42	21	4.67
Northcentral	20	9	1.94
South	28	13	1.68
West	16	7	1.98
Total	104	50	2.45

Figure 12
Fire Fighter Fatalities 1991
by Region



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 the fatal injury occurred.

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 1991 fire fighter fatalities	68 (65%)	36 (35%)	104 (100%)
Suburban location	25	13	38
Local fire department only**	67 (68%)	31 (32%)	98 (100%)
U.S. population (1980)	74%	26%	100%
U.S. fire fighters (1990), total***	60%	40%	100%
U.S. fire fighters (1990), career***	98%		100%
U.S. fire fighters (1990), 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 departments, suggesting that urban fire fighters faced a greater risk of dying than rural fire fighters. In 1988 and 1990,

* 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 other community boundaries. 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.

** Excludes one federal fire fighter killed in an urban location and 5 federal fire fighters killed in rural locations.

*** *U.S. Fire Department Profile Through 1990*, Quincy, Massachusetts: National Fire Protection Association, Fire Analysis and Research Division, November 1991. All percentages are for fire fighters in local fire departments.

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 and 1991, the distribution of local fire fighter fatalities fell between the two other distributions.

Since the results fluctuate back and forth each year, it is not advisable to read too much into them. We can conclude though that urban fire fighters face at least as great a risk as rural fire fighters. But, more importantly, our analyses of fire fighter deaths over the years have indicated that fire fighter safety can be more reliably attributed to proper training, equipment and incident management than to geographical location.

III. Comparison of Volunteer and Career Municipal Fire Fighters, 1982 - 1991

In previous years, and in this report to this point, we have divided fire fighters into just two categories -- career and volunteer. The term career is used to describe all full-time paid members of fire departments. The term *volunteer* is used to describe all other fire fighters. The volunteer category thus includes seasonal workers, contract pilots and others who may be paid for the time of the year that they actually work as fire fighters but whose regular full-time employment is not fire fighting.

Over the past year, NFPA has refined its data collection system to record the type of fire department or agency each victim reported to, so that we could more accurately depict the relative experience of members of municipal paid and unpaid departments while isolating non-municipal fire fighters*. The results of this data collection effort are detailed in this section.

Before looking at the municipal breakdown by career vs. volunteer, it's interesting to see how the numbers break down by type of agency. There were 1,194 fire fighter fatalities in the U.S. from 1982 through 1991. Of these, 1,076 (or 90.1 percent) of the victims were members of municipal fire departments. Federal forestry personnel made up the next largest category (35 fire fighters or 2.9 percent). There were 22 private contractors and 22 members of industrial fire brigades (1.8 percent each). The remaining groups were non-forestry federal employees (14 fire fighters or 1.2 percent), state forestry personnel (13 fire fighters or 1.1 percent) and prison crew members (12 fire fighters or 1.0 percent).

* For this report, the term *municipal fire fighters* refers to members of city, town, county and township fire departments, members of independent volunteer fire departments providing primary protection to a municipality and contract fire departments providing primary fire protection. It excludes federal and state employees and contractors and members of prison and industrial fire brigades.

The 1,076 municipal fire fighters included 35 fire police, three junior fire fighters, three members of student fire brigades, and one public safety officer. The 35 Federal forestry personnel included 23 employees of the US Forest Service, eight employees of the Bureau of Land Management, and four employees of the Bureau of Indian Affairs. Of the 22 private contractors, 16 were working for federal agencies and six were employed by state agencies. Eleven of the 12 prison crew members were inmates from state prisons. The twelfth was a supervisor. The 14 non-forestry federal employees included seven civilian employees of the military, five full-time military personnel, one National Guard member and an employee of the Department of Energy.

Figure 13 compares municipal career and volunteer fire fighter deaths over the past 10 years. Career fire fighter deaths have been following a generally downward trend. The two lowest numbers of career fire fighter deaths occurred in the two most recent years -- 1990 when 25 fire fighters died and 1991 when 35 died. The highest number of deaths in a year was 54, which occurred in 1983 and 1985.

The trend for volunteer fire fighters has not been so clear and might best be called level. If three-year and five-year averages are examined, the trend over the decade is slightly upward, with some improvement since the 1988 high of 81 deaths.

Figure 14 shows the types of duty during which municipal fire fighter deaths occurred over the 10-year period. For both career and volunteer fire fighters, the largest share of fatal injuries occurred on the fire ground (50.1 percent for career fire fighters, 42.5 percent for volunteer fire fighters). However, over a third of all deaths of municipal volunteer fire fighters occurred while responding to or returning from alarms. This one type of duty can explain nearly the entire difference between career and volunteer municipal fire fighters.

Figure 13
Municipal Fire Fighter Deaths
Career vs. Volunteer

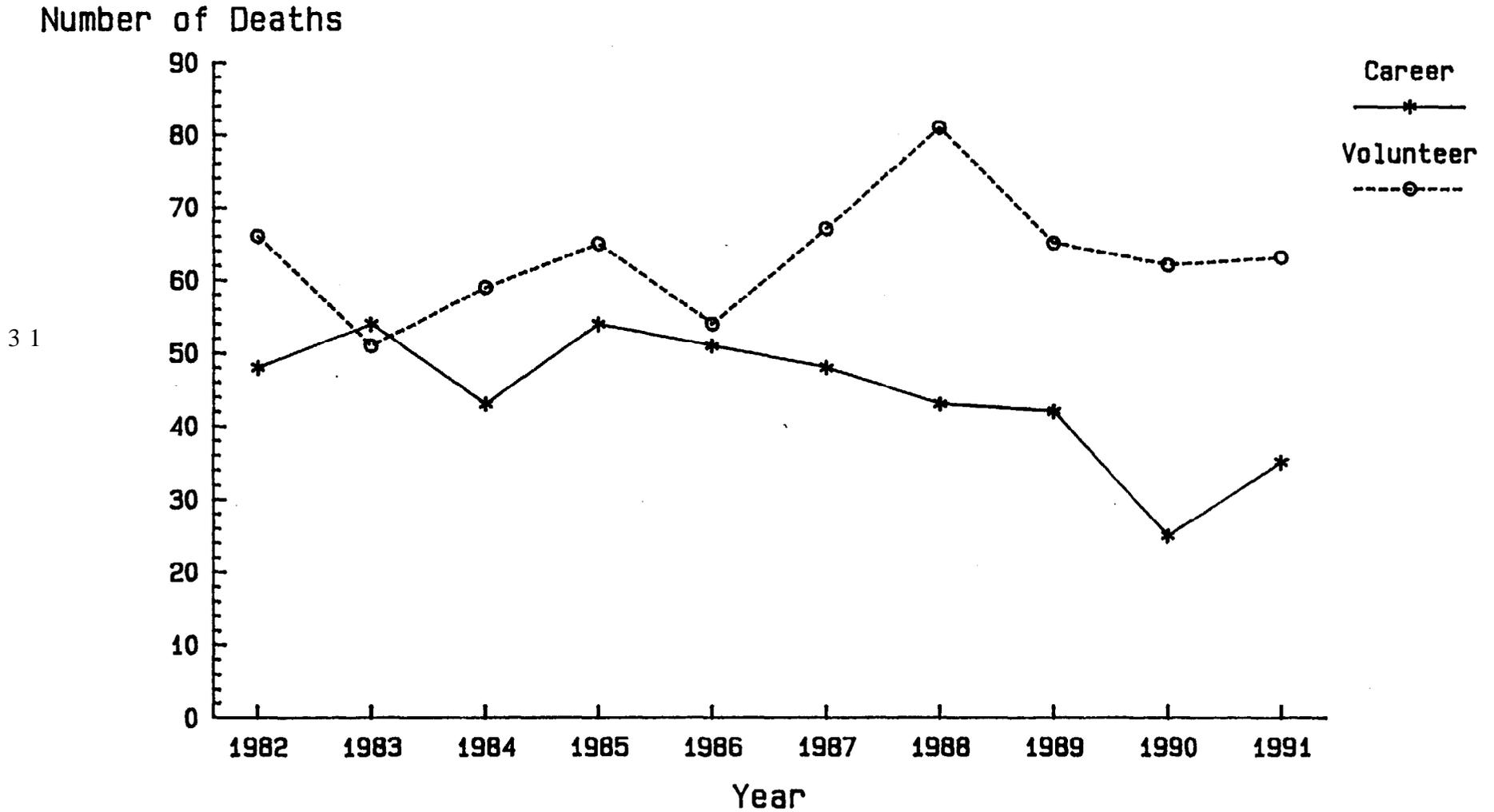
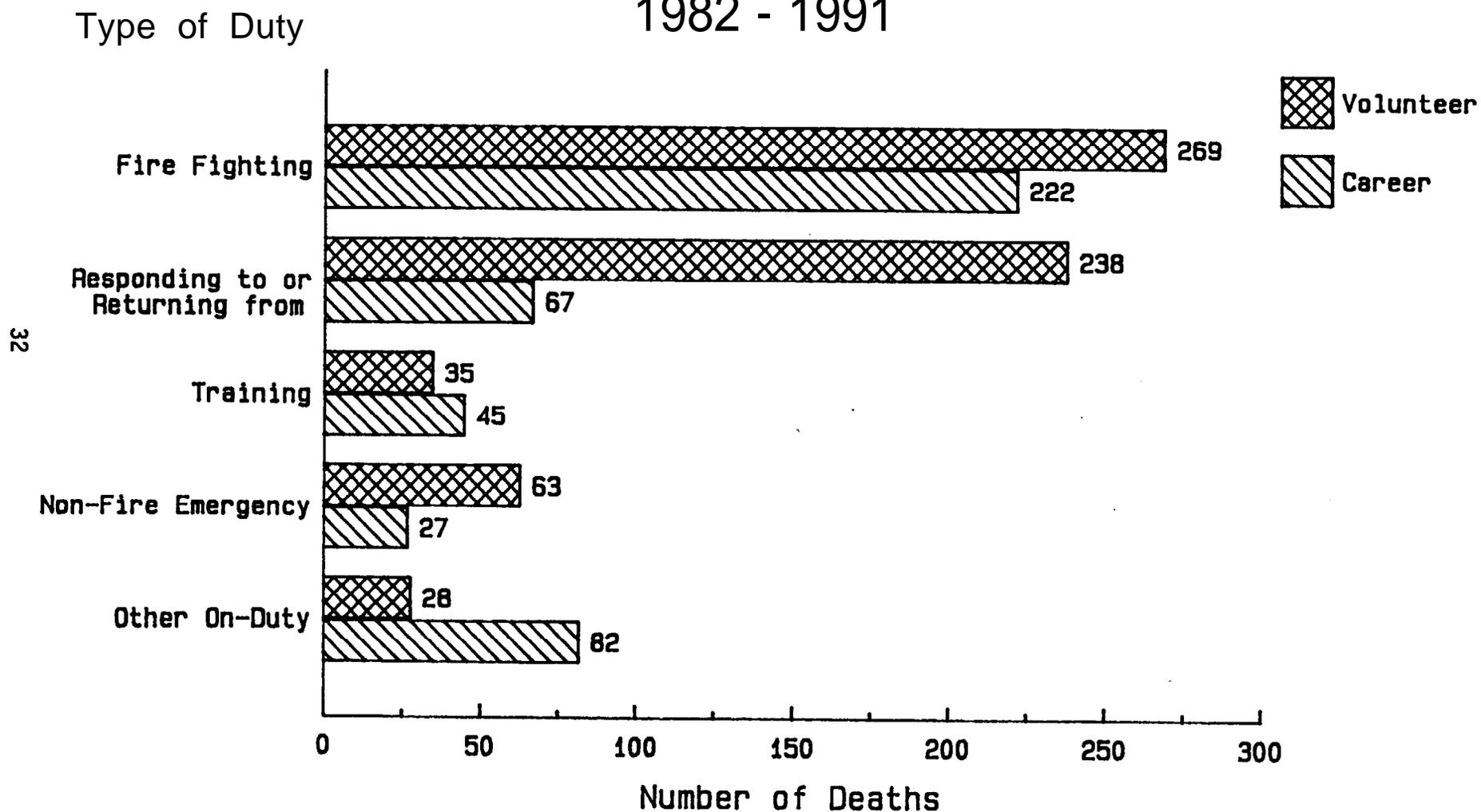


Figure 14
Comparison of Experience for
Municipal Fire Fighters
1982 - 1991



Without them, volunteer deaths have been only 5 percent higher than career deaths. With them, volunteer deaths have been 43 percent higher. The 238 deaths among volunteers included 109 resulting from stress, 105 in motor vehicle accidents and 11 in falls from apparatus. The 67 deaths among career fire fighters included 29 resulting from stress, 17 in motor vehicle accidents and 17 in falls from apparatus.

The second largest category for career fire fighters was *other on-duty* (18.5 percent), the category where normal station activities and other non-emergency activities other than training fall. This was also the duty category where career deaths most exceeded volunteer deaths.

As shown in Figure 15, the largest share of deaths for both career and volunteer fire fighters resulted from stress or overexertion (47.4 percent and 50.6 percent, respectively). In most of these cases, the medical cause of death was heart attack. Some resulted in strokes. Of the 309 volunteer fire fighters who suffered fatal heart attacks, 90 had had prior heart attacks or surgery and 37 had severe arteriosclerotic heart disease. Of the 194 career heart attack victims, 33 had had prior heart attacks or surgery and 41 had severe arteriosclerotic heart disease.

For career fire fighters, the only other category of injuries that resulted in over 10 percent of the deaths was *caught or trapped* (25.7 percent). This category includes 49 deaths as the result of rapid fire progress, 38 deaths due to structural collapses and 20 deaths resulting from fire fighters becoming lost inside buildings. For volunteer fire fighters, there were three other categories of injuries that resulted in over 10 percent of the deaths. These were collisions (16.4 percent), struck by or contact with object (10.3 percent), and caught or trapped (10.1 percent).

Figure 15
Municipal Fire Fighter Deaths
by Cause of Fatal Injury
1982 - 1991

Cause of Injury

 Career
 Volunteer

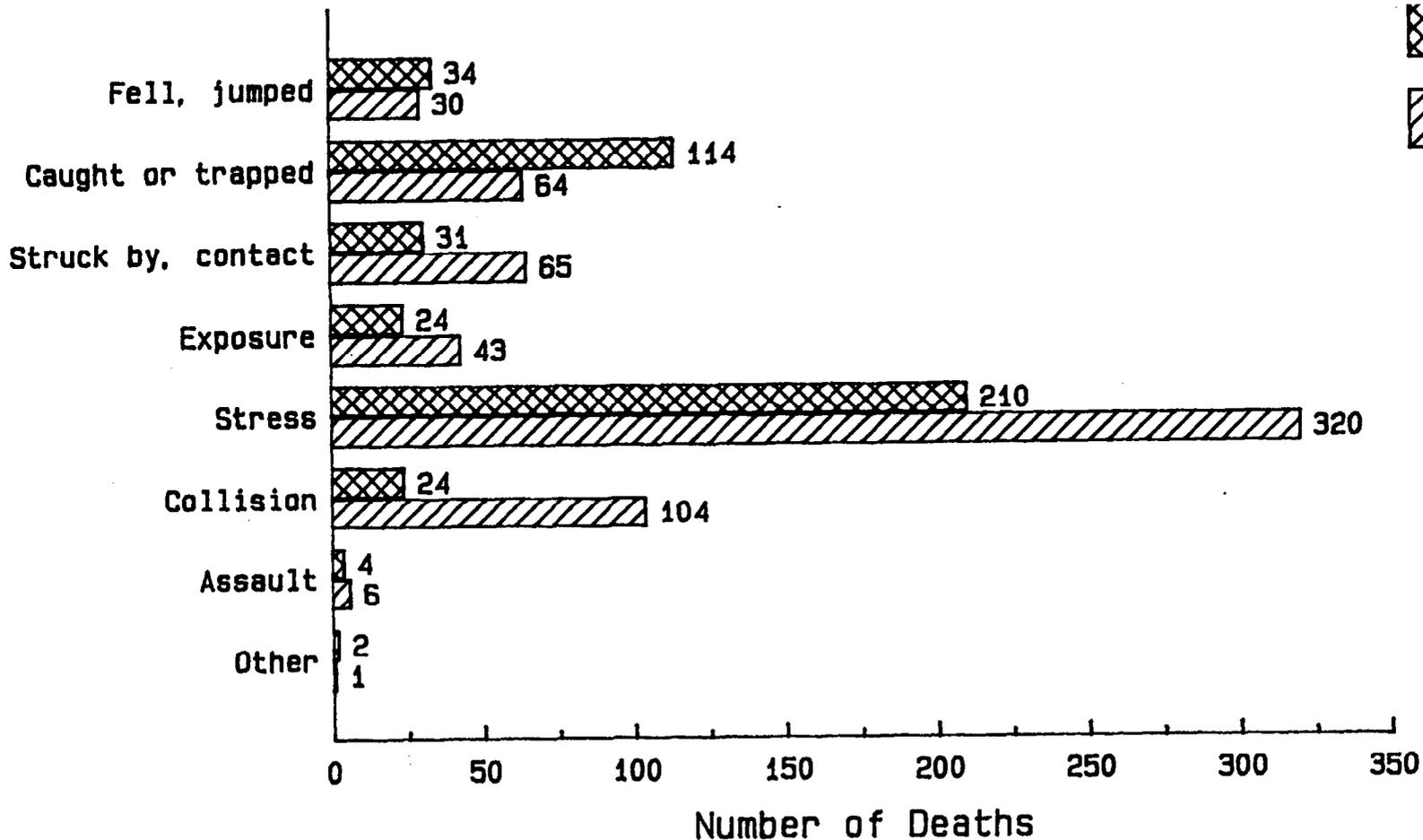
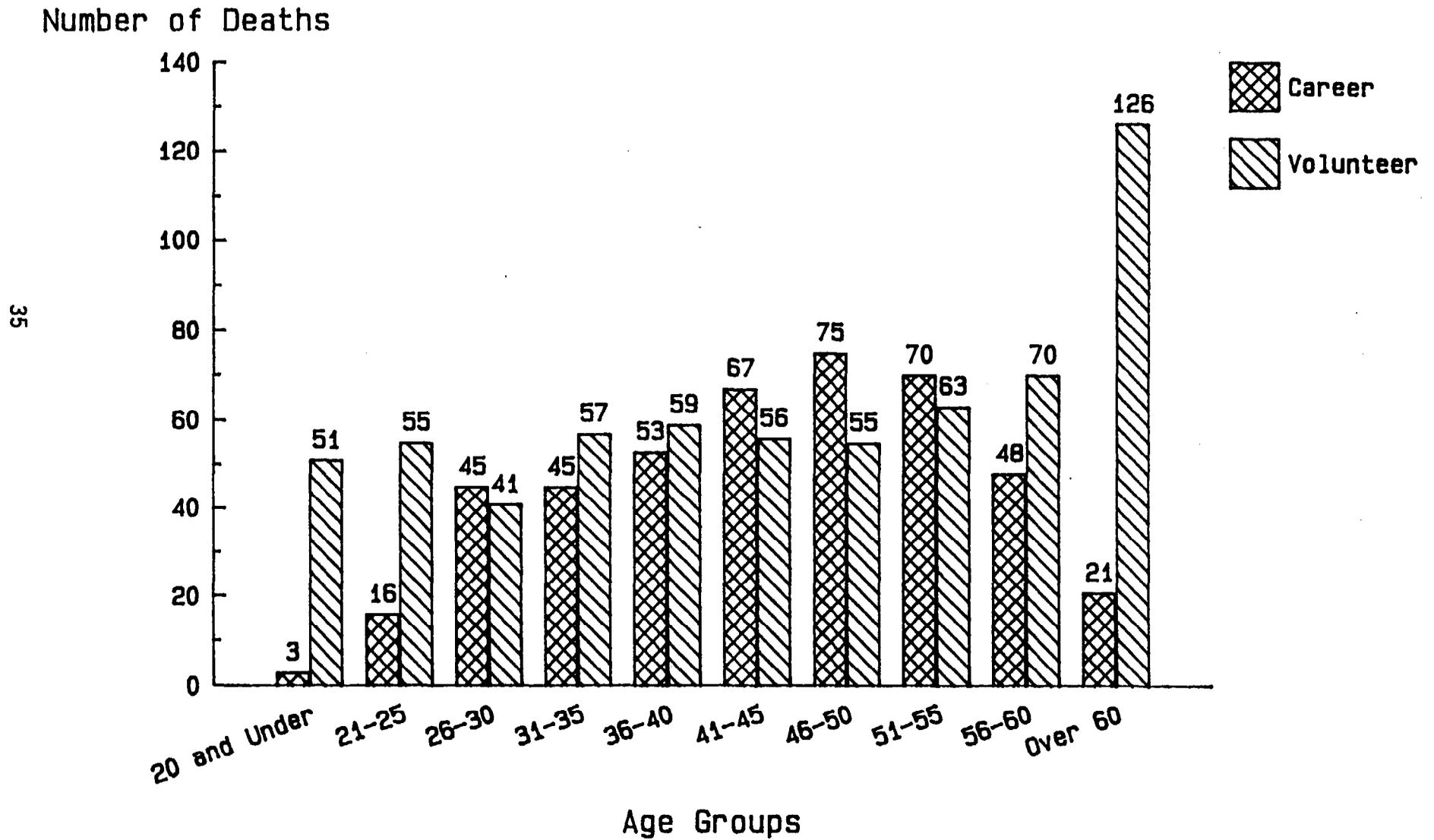


Figure 16
Municipal Fire Fighter Deaths
by Age 1982 - 1991



Although the median age for career and volunteer municipal fire fighter fatalities is the same (45 years), the distribution of the ages of the victims is very different (Figure 16). Career fire fighters ranged in age from 19 to 76 years, with the lowest number of fire fighter fatalities in the extreme age categories. For volunteer fire fighters, the ages of victims ranged from 16 to 81, but in each category there were usually between 50 and 60 deaths, resulting in a fairly level distribution with a sharp rise in the over-60 category.

Emergency duty (fire ground, non-fire emergencies and responding to and returning from alarms) accounted for 316 career fire fighter deaths and 570 volunteer fire fighter deaths over the 10-year period. Of the emergency-duty deaths, 21.2 percent of the career deaths and 41.8 percent of the volunteer deaths occurred while responding to or returning from alarms. Many of these deaths were the result of heart attacks. As was shown earlier in this report, heart attacks are the leading cause of on-duty deaths among fire fighters. For the emergency-duty deaths, over a third of the career deaths and half of the volunteer deaths were due to heart attacks. When emergency-duty deaths due to heart attacks are excluded, we find that 16.9 percent of the career fire fighter deaths are the result of motor vehicle accidents while responding to or returning from alarms, but 41.7 percent of the volunteer fire fighter deaths occurred while responding or returning. This is partly due to the need for volunteer fire fighters to respond to the incident or the station in their own vehicles, thereby increasing the number of vehicles on the road to a single incident.

Before this analysis was completed, there had been some concern on the part of the municipal volunteer fire service that using *volunteer* as a category to cover all non-full-time, paid fire fighters unfairly increased their apparent share of the fire fighter fatality problem. Interestingly, we found, using the simple career/volunteer split, that 40.5 percent of the deaths fell in the career category,

and 59.5 percent were in the volunteer category. When we removed non-municipal fire fighters from both sides, we found that the split for municipal fire fighters only was 41.2 percent career and 58.8 percent volunteer. Although the total number in each category declined, the relative shares remained nearly the same.

The analysis of experience of municipal fire fighters provides an opportunity to identify more specifically the areas where fire fighter fatality problems persist, enabling fire departments to target training and operational strategies to address those areas.

IV. Multiple Fire Fighter Fatalities, 1982 - 1991

There have been several fires in this century where over a dozen fire fighters were killed in one incident. The worst was a wildland fire in 1910 that resulted in the deaths of 78 fire fighters. Although such large-scale losses have not occurred in recent years, multiple-death incidents (defined here as incidents where three or more fire fighters are killed) do still occur. These incidents were analyzed to see if they shared any traits that differentiate them from single-fatality incidents or any factors that could provide a key to their prevention.

From 1982 through 1991, there were 21 incidents in which three or more fire fighters died. These multiple-death incidents resulted in a total of 86 fire fighter deaths. Although these 21 incidents accounted for only 3.8 percent of the incidents where a non-stress-related death occurred, they accounted for 13.3 percent of the non-stress deaths. Overall, one in 14 fire fighters killed while on duty has been killed in an incident where at least three fire fighters were killed.

These incidents are of interest not only because they had such catastrophic consequences, but because we found in the analysis that so frequently they involved the same circumstances or sequence of events as incidents where only one life was lost, or where, through sheer luck, no one was killed or even seriously injured.

The 21 incidents occurred on the fire ground (14 incidents, 61 deaths), while responding to or returning from incidents (five incidents, 19 deaths), during training (one incident, three deaths) and at a public service response (one incident, three deaths).

In the training incident, the three victims died as a result of rapid fire development during a poorly executed live fire training exercise in a vacant farmhouse. Flammable liquids had been used inside the building to start the fire

and the trainees were trapped on the second floor. All three deaths were due to soot and smoke inhalation. In the public service incident, one fire fighter was fatally overcome while attempting to pump out a well and three others were also overcome (two fatally) when they tried to rescue him. It was the fifth fire fighter to enter the well who finally donned SCBA before making his rescue attempt.

All five of the incidents that occurred while responding to or returning from alarms were single-vehicle accidents. Four of the accidents occurred during response. One of the four was an aircraft crash during a mutual aid EMS response in heavy fog. Another involved a helicopter that struck high-tension wires while responding to a wildland fire with three fire fighters aboard. The two other accidents while responding and the one accident while returning occurred on streets or highways when drivers lost control of their vehicles on curves. The victims in one of the accidents were members of a student fire brigade. Alcohol was believed to be a factor in that accident but no charges were brought.

The fire ground deaths involved five scenarios: explosions, structural collapses, rapid fire progress, being lost inside and collision. The largest loss-of-life incident in the 10-year period was the result of an explosion in a petrochemical plant where 10 fire fighters and seven employees were killed. The 10 fire fighters were members of the company's industrial fire brigade. There were three other incidents that were the result of explosions. These explosions claimed an additional 14 lives. The first was an arson fire that caused the detonation of a blasting agent stored in trailers at a highway construction site, resulting in the deaths of six fire fighters. The decision of the chief on the scene to hold another company back in case of subsequent explosions saved the lives of that crew when a second explosion did occur. In another incident, five fire fighters were killed when a leaking 500-gallon propane tank exploded just as fire fighters

arrived at the scene. And finally, an oxygen-limited silo exploded after 3,000 gallons of water had been applied to it, killing three fire fighters on its roof.

Fourteen of the deaths were the result of four fires where structural collapses occurred. In one incident, five fire fighters advancing a hose line and searching for the seat of the fire were killed when the structure's truss roof collapsed. In a 1991 fire, the floor of the structure collapsed, exposing fire fighters to the flames from below and killing four. In another fire, the roof of a store collapsed, dropping four of the fire fighters on the roof into the flames below. One of the four fire fighters was able to pull himself out onto the roof and survived severe burns. And in an unusual situation, two fire fighters attempting extinguishment were killed in a structural collapse hours after another fire fighter had been killed as the result of rapid fire progress while he and others tried to find the location of the fire.

In three other fires, an additional 12 fire fighters were killed as the result of rapid fire development, backdraft or flashover. In one incident, five inmates and their supervisor, working as volunteer fire fighters at a wildland fire, were unable to fully deploy their fire shelters before they were overrun by the fire and suffered fatal smoke and burn injuries. Rapid fire development in a single-family dwelling resulted in the deaths of three fire fighters as they operated a handline in the living room of a dwelling. And finally, rapidly developing fire in the space above the heads of three fire fighters resulted in the collapse of the ceiling and their entrapment.

Seven fire fighters lost inside structures were killed in two separate incidents. In the first fire, four members of the manufacturing plant's fire brigade were trapped and disoriented by rapidly developing severe smoke conditions. None was equipped with self-contained breathing apparatus. In 1991, three fire fighters were killed when they ran out of air on the 28th floor of a

Philadelphia high-rise while trying to reach the roof. They radioed for assistance but did not know their correct location and died of asphyxiation before they could be located.

And in the final fire ground scenario, three fire fighters were killed when their aircraft crashed after dropping fire retardant at a wildland fire.

Of the 86 victims, 51 were volunteer fire fighters and 35 were career. They included 52 municipal fire fighters, 17 members of industrial or student fire brigades, seven employees of forestry agencies, **six** members of a prison crew and four contractors to forestry agencies.

As was mentioned above, these incidents are noteworthy not only because of the high loss of life that resulted from each, but because they involve circumstances that frequently occur in fires that do not have such tragic results. Fire fighter deaths are a relatively rare occurrence, given the number of fires that are responded to each year. But often there is no perceptible difference between tragically fatal incidents and those where sheer luck prevents deaths.

But fire fighters have to depend on more than luck to prevent similar tragedies. Proper training and equipping of members of industrial fire brigades, as well as other fire fighters, is essential in preventing unnecessary deaths. Standards exist for the safe conduct of live fire training drills that could prevent the occurrence of events such as the one described above. Proper incident management must be practiced at all fires to ensure the safety of fire fighters operating throughout the fireground.

There have been several massive loss-of-life incidents in this century. Current codes and standards regarding the design and use of apparatus, SCBA and other equipment, protective clothing, training procedures, incident management systems and the like have been very effective in reducing the number and severity of such incidents. Further vigilance on the part of fire

fighters and officers today is still required in order to keep these incidents to an absolute minimum.

V. Deaths While Lost Inside Structures

From 1982 through 1991, there were 134 traumatic fire fighter deaths inside structure fires. Of these, 33 deaths (24.6 percent) involved victims who were lost inside the buildings and died of asphyxiation. It is possible that there were even more such incidents. Fire fighters who die of a depleted air supply or whose movements show signs of disorientation can be readily categorized as deaths due to being lost. But, some of the fire fighters killed after being trapped by structural collapse or by rapid fire progress may also have been lost inside the building when the more identifiable phenomenon, not tied to being lost, caused fatal injury. The incidents detailed in this special analysis, then, may actually describe a more frequently occurring scenario. The share of the overall structure fire ground fatalities known to have resulted from being lost inside is shown in Figure 17.

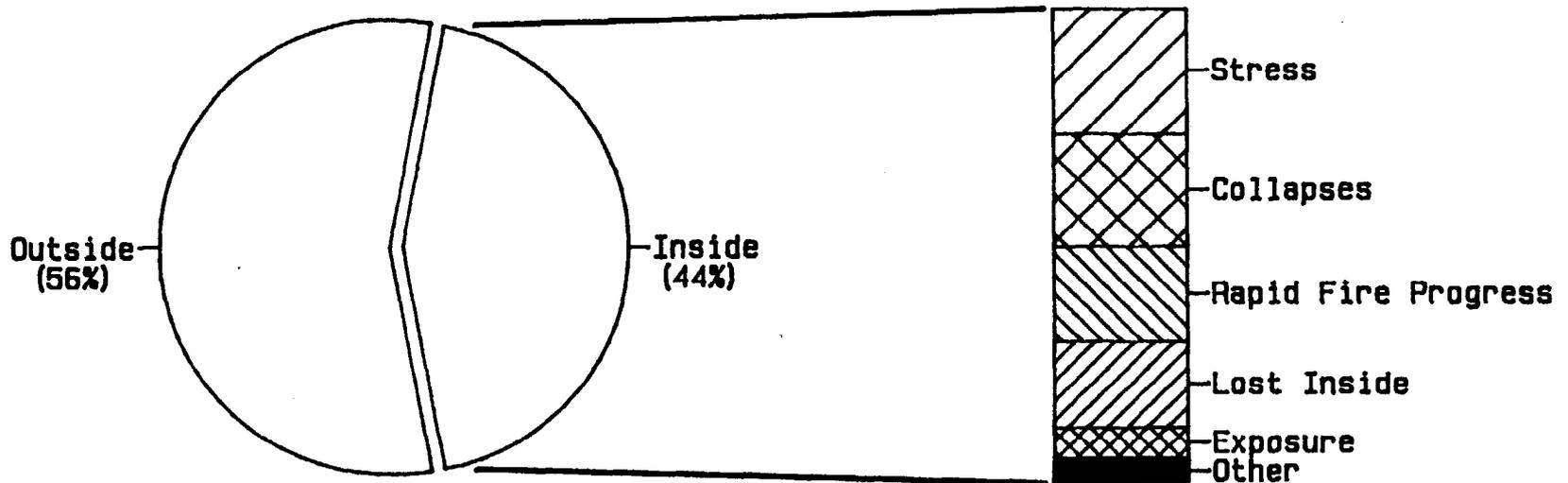
The nature of the 33 “lost inside” deaths makes details on their circumstances difficult to come by. Most were the result of fire fighters becoming separated from the rest of their crew or from their hose line. Others reentered the structure with no one’s knowledge or were left alone while their partners went out to replace their depleted SCBA cylinders. With no witnesses, it is impossible to know exactly how these deaths occurred, but important lessons can be learned even from these incidents and also from those where the victims were not alone and the chain of events surrounding their deaths could be related by a surviving partner. A brief overview of the circumstances in the deaths is shown in Table 3 and described below.

Lost While Leaving Structures

Sixteen of the 33 fire fighters became lost while attempting to leave structures. Five of the 16 lost the hose line they were using when leaving the

Figure 17
 Fire Fighter Deaths at Structure Fires
 1982 - 1991

44



Structural Fire
 Ground Deaths
 (413 Deaths)

Deaths Inside
 Structures
 (182 Deaths)

Table 3
Fire Fighters Lost Inside Buildings
Summary

Lost While Leaving Structure

- 5 Lost hose line while leaving due to low air or deteriorating conditions
- 3 Accompanied others to exit but did not make it out themselves
- 1 Buddy-breathing and was overcome
- 7 Others known to be leaving structure but no additional details were available

Separated During Operations

- 3 Left alone while others left because of low air
- 3 Separated in building or working separately and did not exit
- 1 Reentered after others were ordered out
- 1 Reentered alone but never seen by others
- 5 Others separated while working but no additional details were available

Other lost Inside

- 3 Were mistaken as to what floor they were on
- 1 Lost hose line, may have been alone inside

building because of smoke or fire conditions or because their low air alarms were -sounding. (In one of these five incidents, the victim had a blood alcohol level of 0.197 percent; smoke and clutter were cited as factors in other incidents.) In one of the five fires, the five surviving fire fighters operating inside with the victim reported that they did not attempt to follow the line in their rush to exit the building. In another of the five incidents, the victim shouted for assistance in finding the basement stairs after he lost the hose line. He was seen on the stairs and was thought to be able to make his way out of the building safely, but he was found later in a ground floor utility room adjacent to the stairs with the door closed.

In separate incidents, three of the 16 fire fighters accompanied others to the exit of the structure, but somehow did not make it out the door themselves. In another incident, four members of an industrial fire brigade became disoriented in intensifying smoke and were unable to exit the building. None was wearing self-contained breathing apparatus. In another fire, one of two fire fighters sharing one air supply was overcome and the other became disoriented. They were rescued, but the collapsed fire fighter could not be revived. In separate incidents, three fire fighters became separated from their partners and headed in the wrong direction while attempting to leave the building. All were overcome.

Separated During Operations

Of the 33 fire fighters killed when they became lost inside, 13 became separated from their partners or the rest of their crew during operations. Three of these 13 victims remained behind in the building while their partners left to replace their SCBA cylinders. In each case, conditions deteriorated while they remained inside, and they were unable to escape. In a fourth incident, a fire fighter reentered the building unbeknownst to other fire fighters after changing

his SCBA cylinder, apparently unaware that all fire fighters had been ordered out of the building.

Another three of the 13 fire fighters were killed while working separately from their partners inside the building. Of these three, one separated from the rest of his crew on entering the building and was left behind when extreme heat forced the others from the building; and one was using a forklift to move stored materials in a warehouse and was not able to reach the exit with the rest of his crew. The third victim's partner went to check the story above for fire and was unable to find his officer when he returned to the nozzle. When he did find him, the officer was too weak to make his way to the door. A series of miscommunications resulted in delays in rescue attempts and the officer depleted his air supply and died.

In another incident, a fire fighter who had been working in the basement and then on the second floor was seen leaving the building when his low air alarm sounded and then later he was seen reentering the front of the building. He was later found calling for help in the basement, but rescue attempts were unsuccessful in the intense heat. No details are known on what he was doing from the time he reentered the building to the time he was heard calling for help.

Details surrounding the deaths of the remaining five of the 13 victims who became separated from their crews while operating are very limited. One was possibly checking for fire extension or a means for additional ventilation when he became lost in a maze of aisles until he ran out of air. Another became separated from his partner while they searched for occupants reportedly trapped on the second floor. His partner jumped out a window to escape deteriorating conditions. In another incident, two fire fighters left the nozzle of their hose line within two minutes of entering the building and were found 30 feet from the nozzle after the fire was controlled. Another fire fighter became separated from

his two partners while operating a handline on the second floor. No one knows how he became lost or what he was doing before he depleted his SCBA cylinder and his body was found 45 minutes later.

Other Deaths While Lost Inside

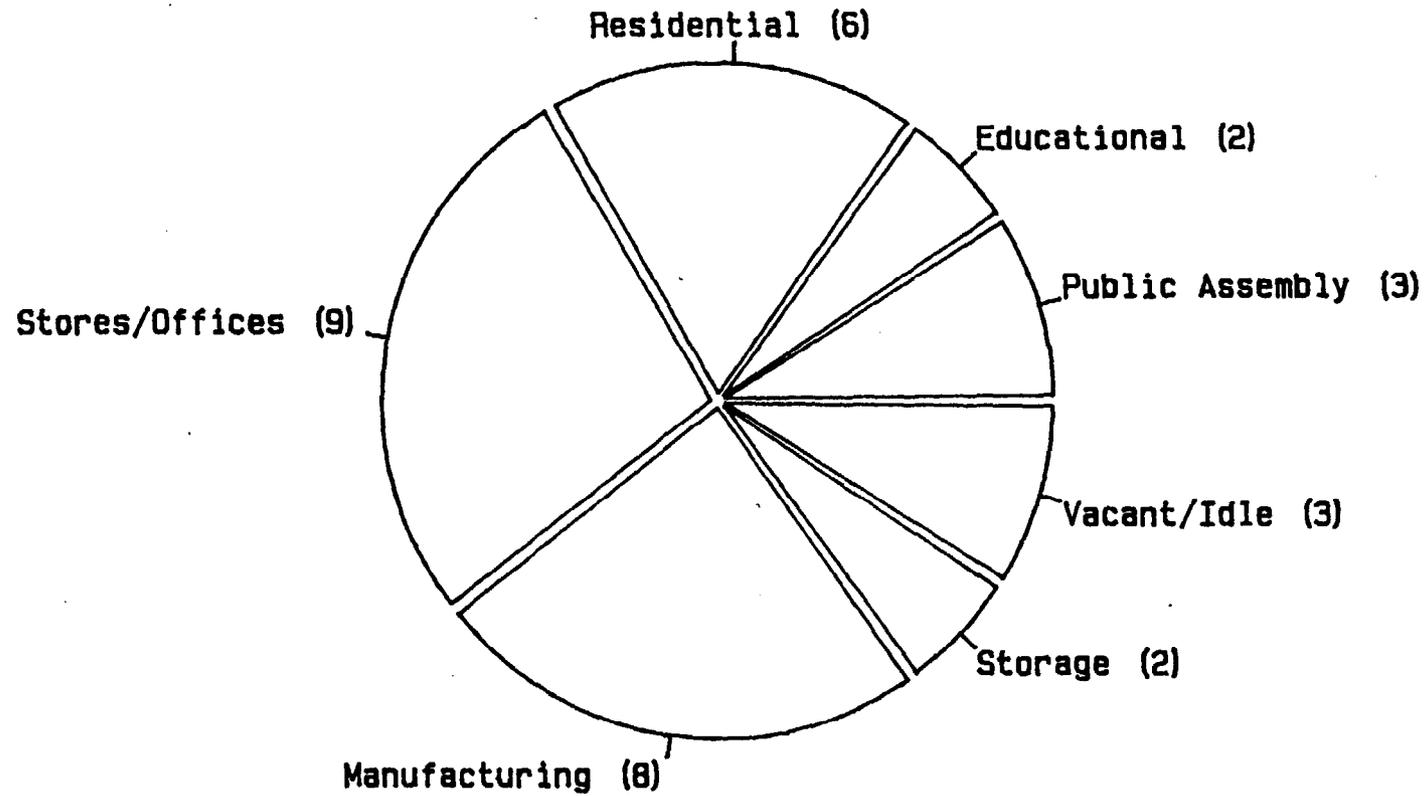
In a separate incident, a fire fighter who may have been operating a handline alone inside a structure somehow became separated from it. There were no details on what he was doing while he was inside the building.

In one of the worst incidents in 1991, three Philadelphia fire fighters were on the 28th floor on their way to the roof when they apparently ran out of air. They radioed for assistance, reporting that the officer was down, but reported, mistakenly, that they were on the 30th floor. They were not found in time.

As shown in Figure 18, these fatal incidents occurred in a variety of occupancy types. The nine deaths in stores and offices included the three deaths in Philadelphia. The eight deaths in manufacturing properties include the four industrial fire brigade members mentioned above. The breakdown shown in this graph illustrates that the danger of becoming lost inside a structure exists even in a dwelling -- the complex layout of an industrial property is not required for such an event to occur.

Fire fighter protective equipment and its use have improved markedly in recent years, but the dangers of operating inside a hostile environment obviously still exist. NFPA 1500, *Fire Department Occupational Safety and Health Program*, requires that members operating in hazardous areas work in teams of two or more. Adhering to this standard would prohibit fire fighters exiting structures alone when their low air alarm sounds or when they are having

Figure 18
Fire Fighters Lost Inside Structures
by Type of Occupancy 1982 - 1991



equipment problems. Leaving a fire fighter alone jeopardizes both the exiting fire fighter and his or her partner.

NFPA 1561, *Fire Department Incident Management System*, which was published in 1990, requires the officer in charge to maintain an accounting of all members at all times using a standard personnel identification system. This system must include a means to specifically identify and keep track of members entering and leaving hazardous areas. This will minimize opportunities for freelancing and require that the location and length of exposure for each fire fighter be known. The standard also requires that a procedure be in place to handle the evacuation of areas where an imminent hazard exists and to account for the safety of members from that area. Some of the fatalities outlined above involved situations where fire fighters were reentering buildings evacuated because of deteriorating condition& In at least one case, the fact that a fire fighter was missing was not known until far too late for rescue and resuscitation.

The 26 incidents involving municipal fire fighters were reviewed for the number of fire fighters operating inside the structure. In 12 of the 17 incidents for which this information was available, there were at least three fire fighters operating together inside when the fatal sequence of events began. The five exceptions include 1) a fire fighter left alone while his partner exited to change his SCBA; 2) a fire fighter left alone while his partner went out to fix his mask; 3) the fire fighter cited above who was apparently operating a handline alone inside; 4) the partner of the fire fighter who went to the story above to check for fire; and 5) the two fire fighters who left their hose line about two minutes after entering the building. These incidents illustrate once again that how the job is being done is at least as important as how many members are available to work on the job.

No fire fighter should be operating a line alone inside a structure. Fire fighters working in pairs should not break physical, verbal or visual contact while

inside the structure. Constant monitoring of conditions throughout the fire ground and a careful accounting of all fire fighters working in a hostile environment are paramount. It will never be possible to eliminate all such fatal incidents, but following proper operating and incident management procedures should further reduce this part of the fire fighter fatality problem.

VI. Conclusions and Recommendations

For the third consecutive year, there was a drop in the number of fire fighter deaths in the United States. Heart attacks and motor vehicle accidents continue to account for a large share of fire fighter deaths and represent two areas where additional improvements should be possible. Deaths among municipal volunteer fire fighters have held fairly steady over the past three years and have shown no net improvement over the past 10 years. Deaths among municipal career fire fighters increased from 1990 to 1991, but the total is still the second lowest over the 15 years for which complete data is available.

The first of the three special analyses contained in this report took a closer look at the experience of career and volunteer municipal fire fighters. Being able to isolate the specific areas where fire fighter fatalities persist will allow programs to be targeted to those areas and should further decrease the incidence of fire fighter deaths. Among volunteer fire fighters, heart attacks and vehicle collisions stand out as the principal problems. Among career fire fighters, heart attacks and deaths on the fire ground are areas where sizeable problems still remain.

The second analysis looked at multiple-death incidents and illustrated the point that there is little difference between the incidents that claim several lives and those that result in one or no fatalities. The events that occurred in the incidents described are not unusual. Careful attention to training, proper equipment and incident management will be more effective than depending on luck to prevent such tragic outcomes.

The third analysis looked at fire fighters who died as a result of becoming lost inside structures. These incidents demonstrated the need for fire department procedures that mandate fire ground operations in teams of two or more, careful

monitoring of the overall emergency situation and an accounting of all members at all times throughout the incident. Standards requiring these procedures exist and should be adopted and enforced.

For several years we had a situation where the annual fire fighter death toll had reached a plateau. Results observed over the past few years indicate that we may have moved off that plateau and begun to again make progress in eliminating avoidable fire fighter deaths. Continued vigilance in the areas where progress has been made and renewed efforts in the areas where problems still exist must continue.

References

1. Michael J. Karter, Jr., *U.S. Fire Department Profile through 1990*, Quincy, MA: National Fire Protection Association, Fire Analysis and Research Division, November 1991.
2. Michael J. Karter, Jr., "U.S. Fire Loss in 1991," *NFPA Journal*, Vol. 86, No. 5, (September 1992).
3. The four regions defined by the U.S. Census Bureau are as follows:

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, Washington, and Wyoming.