RESEARCH

U.S. Firefighter Deaths Related to Training, 2009–2018

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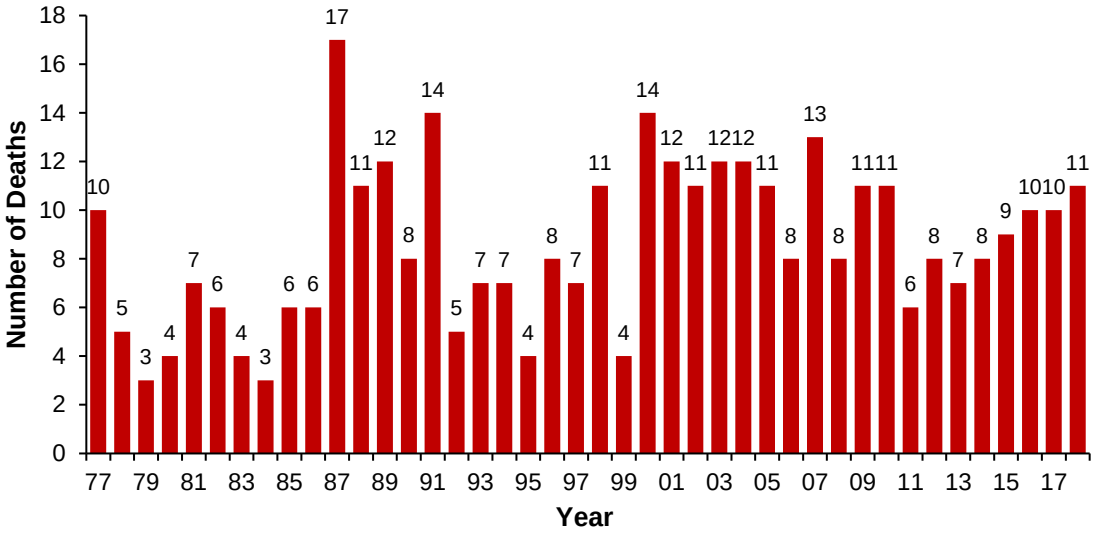
Key findings

- Between 2009 and 2018, 12.9 percent of all on-duty fatalities occurred during training.
- The largest shares of deaths occurred during physical fitness training and apparatus and equipment drills, with both shares accounting for 34 percent of the training deaths.
- Three-quarters of the deaths were attributed to stress, overexertion and medical causes.
- Sudden cardiac death accounted for two-thirds of the deaths.
- Most of the deaths occurred at the fire station or at off-site locations controlled by the fire department.

Introduction

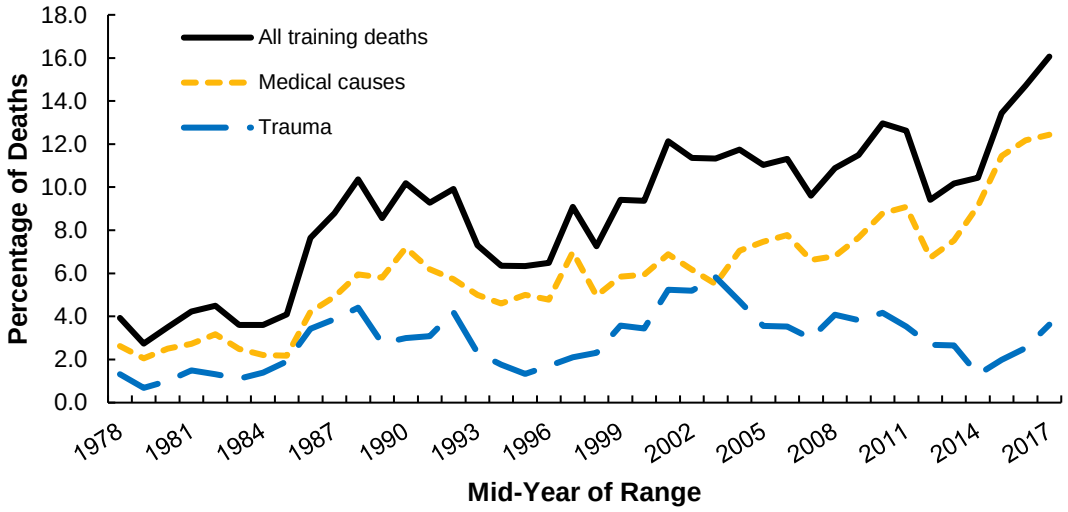
Training is a vital part of fire department operations, but it too often results in needless deaths and injuries. Between 1977 and 2018, 361 firefighters died during training activities. This represents 8.4 percent of all on-duty firefighter fatalities (4,306) in the U.S. over that 42-year period, excluding the deaths that occurred at the World Trade Center in 2001. (1977 is the first year for which NFPA has complete records of on-duty firefighter fatalities.) The number of training-related deaths in a year has ranged from a low of three to as many as 17 (in 1987). (See Figure 1.)

Figure 1. Deaths of U.S. Firefighters during Training 1977 - 2018



As the number of on-duty firefighter deaths overall has declined over the years, the lack of a corresponding decline in training-related deaths has produced a pronounced increase in the training *share* of deaths. Figure 2 shows the trends for training-related deaths overall and compares trauma deaths and medical-related deaths over the period. (A running three-year average is shown in order to smooth out the year-to-year fluctuations.) As shown on the graph, the proportion of deaths annually has been generally increasing since the mid-1990s, driven largely by the increasing share of deaths due to medical causes.

Figure 2. Proportion of Training-Related Deaths Annually (3-Year Rolling Average)



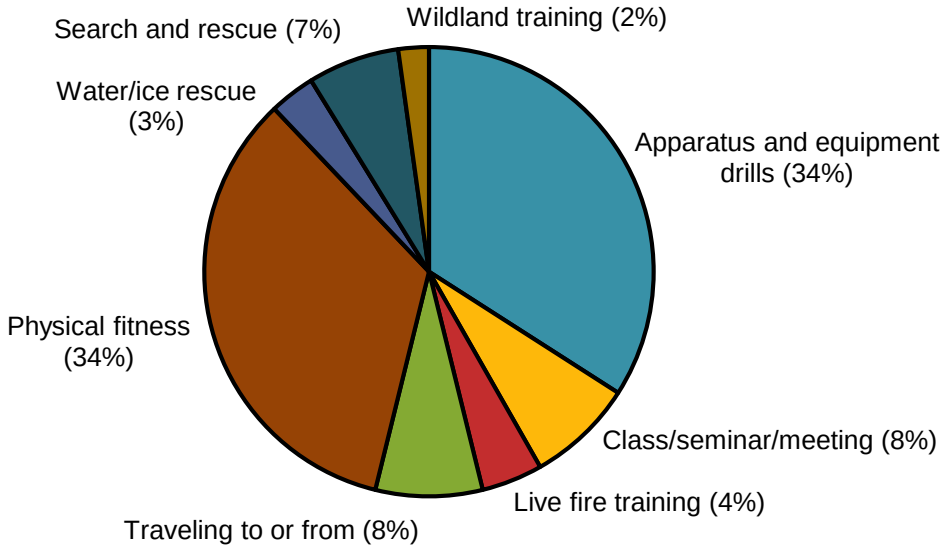
This special analysis will focus on the most recent 10-year period for which data is available – 2009 through 2018. Over that period, 91 firefighters died while engaged in training-related activities (12.9 percent of all on-duty firefighter deaths in those years). Of these 91 victims, 42 were volunteer firefighters, 37 were career firefighters, six were employees of federal land management agencies, three were members of inmate firefighting crews, one was an employee of a state land management agency, one was a contractor to a federal land management agency and one was a civilian employee of the military.

Ten of the victims were recruits or trainees when they died.

Type of Activity

Training-related deaths occurred during a broad range of activities as shown in Figure 3. There were 31 deaths (34 percent) during physical fitness training. This category includes exercising at the station, as well as agility tests and fitness screenings, job task evaluations and pack tests (work capacity testing for wildland firefighting).

Figure 3. Training Deaths by Category 2009 - 2018



Another 31 deaths (34 percent) occurred during apparatus and equipment drills. This category includes training on specific apparatus and equipment, ladder climbing, pump and drafting operations, self-contained breathing apparatus (SCBA) and smoke drills, driver/pilot training and training in extrication.

Seven firefighters (8 percent) died while attending classes, seminars or training meetings, and seven others died while traveling to or from such activities outside of their normal jurisdiction.

There were five deaths during search and rescue training (7 percent).

Live fire training exercises claimed four lives (4 percent), although none of these deaths occurred during exercises within burn structures.

There were three deaths (3 percent) during water or ice rescue training.

In addition, two firefighters died during an unspecified type of wildland fire training and one died during survival training.

Physical Fitness Training

Physical fitness training accounted for 31 firefighter deaths – 29 were sudden cardiac deaths, one was due to heat stroke or hyperthermia, and one was due to stroke. These 31 victims include five cadets or trainees, one of whom died of heat stroke and the others of sudden cardiac death.

- Five of the victims were taking work capacity (pack) tests to qualify for wildland firefighting duties. All suffered sudden cardiac death. Three of the five were seasonal or career employees of land management agencies, one was a volunteer firefighter and one was an inmate trainee. Three of the five had pre-existing health conditions, including hypertension, prior heart attacks or heart surgery, diabetes and arteriosclerotic heart disease.
- Five of the firefighters were engaged in physical ability or agility tests as part of their annual or bi-annual fitness evaluations. All suffered sudden cardiac death.
- Four were recruits. One was engaged in a 15-component exercise in full turnout gear including SCBA over a 15-minute period. One was running evolutions up and down the drill tower when he collapsed. The third was a wildland firefighter trainee who was on a hike in moderately steep terrain carrying 18 lbs (8 kg) of protective equipment and tools. All suffered sudden cardiac death. The fourth trainee was jogging as part of the physical fitness portion of his department's training program. He died of heat stroke.
- The other 17 victims were working out (e.g., running, hiking, lifting weights, playing basketball, etc.), usually at the fire station, when they died. One of the 17 suffered a fatal stroke; the others, sudden cardiac death. Most of the sudden cardiac death victims were found to have significant pre-existing health problems.

Thirteen of the 29 victims of sudden cardiac death belonged to departments that required annual physical examinations. One department required periodic medical evaluations at frequencies dependent on the firefighter's age.

Eleven did not require annual physicals. Information on requirements for annual physicals was not reported for the other four victims of sudden cardiac death.

Apparatus and Equipment Drills

The 31 fatalities that occurred during apparatus and equipment drills included 17 caused by overexertion, stress or underlying medical issues that resulted in 14 sudden cardiac deaths, two strokes and one aneurysm. Two of these 17 victims were involved in recruit training.

Eight of the 31 firefighters in this category died in falls. In three separate incidents, firefighters fell from aircraft – one while rappelling from a helicopter, one from a helicopter's skid during hoist training and the third during a proficiency jump when his parachute opened only 200 feet (60 meters) above the ground. Two firefighters fell 85 feet (26 meters) while practicing getting on and off a roof from an aerial platform. One firefighter fell while climbing a rope after a rope skills class, striking his head on the pavement. One firefighter fell from an aerial ladder during an unstructured training exercise. Another firefighter fell from an aerial ladder while carrying a roof kit.

Fire ground survival training resulted in three deaths. Two firefighters died of heat stroke in separate incidents - both were in full turnout gear with SCBA. One was a recruit. The third firefighter suffered sudden cardiac death in a similar exercise.

One firefighter was involved in a tree-falling training exercise when a broken piece of a dead tree fell on him.

A firefighter test driving a tanker before a drill lost control on a curve, possibly while texting, and the vehicle overturned. The victim was wearing a seatbelt.

One firefighter hit his elbow while inside the compartment of a rescue vehicle during training and died of necrotizing fasciitis (also known as flesh-eating disease) less than three months later.

Classes, Seminars and Meetings

Seven firefighters died during classroom training, at seminars or while attending a conference. Sudden cardiac death claimed three lives. Two others died as the result of an embolism and a stroke. One firefighter died shortly after developing complications from a recent medical procedure while he was attending a classroom refresher class at the fire station. One firefighter died of influenza while he was attending training out-of-state.

Search and Rescue Training

There were six deaths during search and rescue training – all due to sudden cardiac death. One of the victims was a probationary firefighter and the other was a recruit.

Live Fire Training

Live fire training resulted in four of the 91 deaths. All were the result of sudden cardiac death, and none occurred while in a burn building. Two of the victims were instructors. After several hours of training, one of the instructors was refilling air cylinders before the next round of drills when he collapsed. The other instructor collapsed after changing his air cylinder during the second evolution of training in the burn building.

One firefighter was exposed to smoke at a controlled burn of vegetation when the wind changed direction and he collapsed while trying to pull a stuck vehicle out of the mud. The fourth victim collapsed after extinguishing an exterior propane tank fire.

Water and Ice Rescue Training

Water and ice rescue training resulted in the deaths of three firefighters. One firefighter, while acting as the victim during ocean rescue training, died of blunt force injuries to the head and neck when he was knocked off a sled being towed in heavy surf by a rescue watercraft. Another firefighter drowned during an advanced underwater diving course. Insufficient dive experience and training, an over weighted dive belt and lack of medical screening were cited as contributing factors. The third firefighter suffered sudden cardiac death after spending approximately an hour playing the role of victim at a frozen pond.

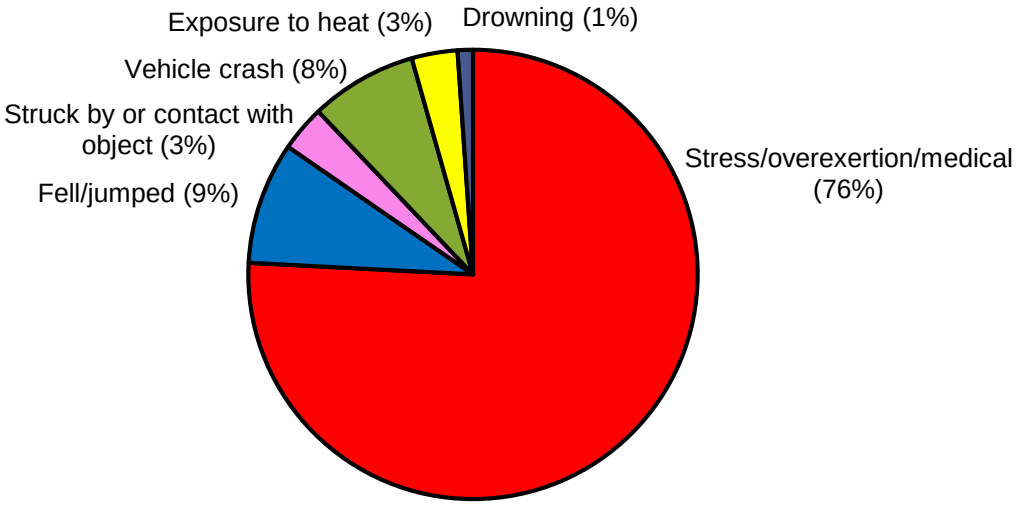
Traveling to and from Training

Seven firefighters died while traveling to or from training sessions. Six were killed in vehicle crashes and one suffered sudden cardiac death.

Cause of Fatal Injury

Figure 4 shows the distribution of training-related deaths by cause of fatal injury or illness. As is found overall for firefighter deaths in most years, the largest proportion of fatalities (in this case, 76 percent or 69 deaths) were due to stress, overexertion or medical issues, and usually resulted in sudden cardiac death or strokes.

Figure 4. Cause of Fatal Injury
2009 - 2018



Eight firefighters were killed when they fell or jumped, including two from an aerial platform, two from aerial ladders, one while rappelling from a helicopter, one from a helicopter skid while hoist training, one during a parachute proficiency jump and one during rope training at the fire station.

Seven firefighters died in vehicle crashes. Speed was mentioned as a factor in three of the crashes. One of the others was not wearing his seatbelt. One firefighter was possibly texting while driving.

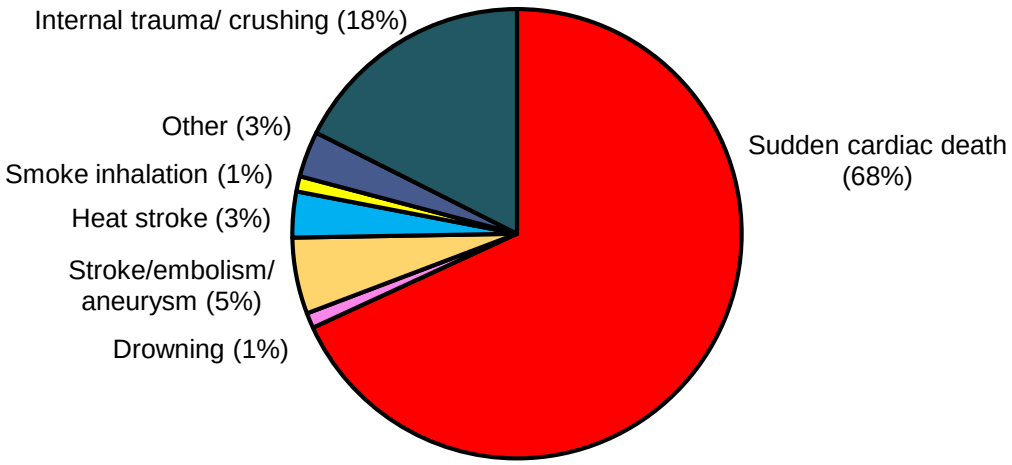
Three firefighters were overcome by heat. Two were training in full personal protective equipment (PPE) with SCBA and the other was running during recruit training and was not sufficiently hydrated.

Three firefighters were struck by or came into contact with objects. One was struck by a falling tree. One was struck by a wave while riding as 'victim' on a rescue sled. One struck his elbow during SCBA training and subsequently died of necrotizing fasciitis and septic shock.

Nature of Fatal Injury

The distribution of training-related deaths by nature of fatal injury is shown in Figure 5. Overall, two-thirds of the training fatalities (61 deaths) were due to sudden cardiac death. Almost all of these firefighters for whom medical documentation was available had experienced prior heart attacks, bypass surgery, severe arteriosclerotic heart disease, diabetes, hypertension or other pre-existing conditions.

Figure 5. Nature of Fatal Injury
2009 - 2018



Another 16 deaths were due to internal trauma and crushing injuries that were largely caused by motor vehicle crashes and falls. The remaining deaths resulted from stroke, embolism or aneurysm (six deaths), heat stroke (three deaths), complications due to illness (two deaths) and one each to drowning, smoke inhalation and septic shock.

Ages of Firefighters

The distribution of the training-related fatalities by age and cause of death is shown in Figure 6. The victims ranged in age from 19 to 84 years with a median age of 49 years. As can be seen in this graph, fatalities were more frequently the result of sudden cardiac death as age increased.

Figure 6. Training Deaths by Age and Cause of Death
2009 - 2018

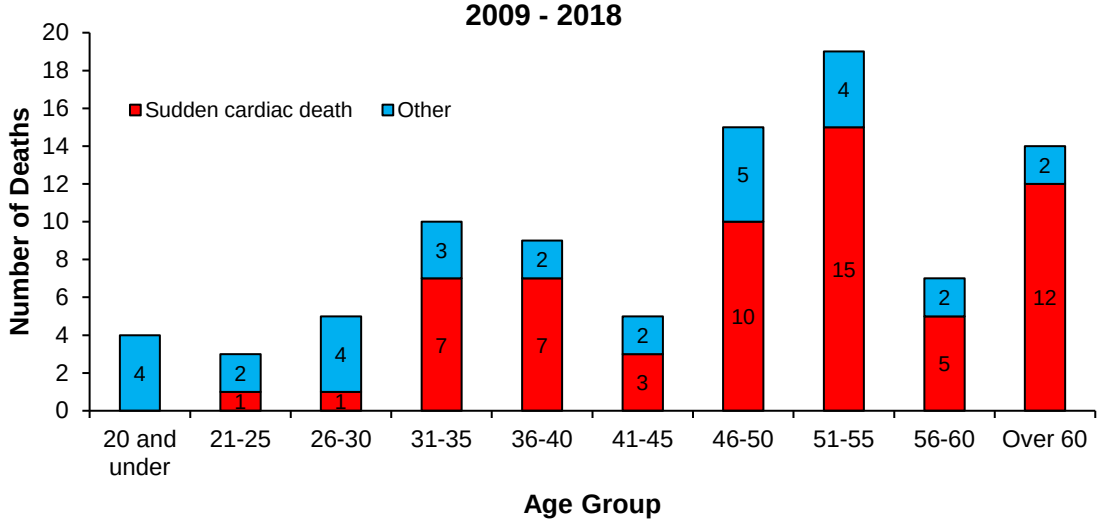
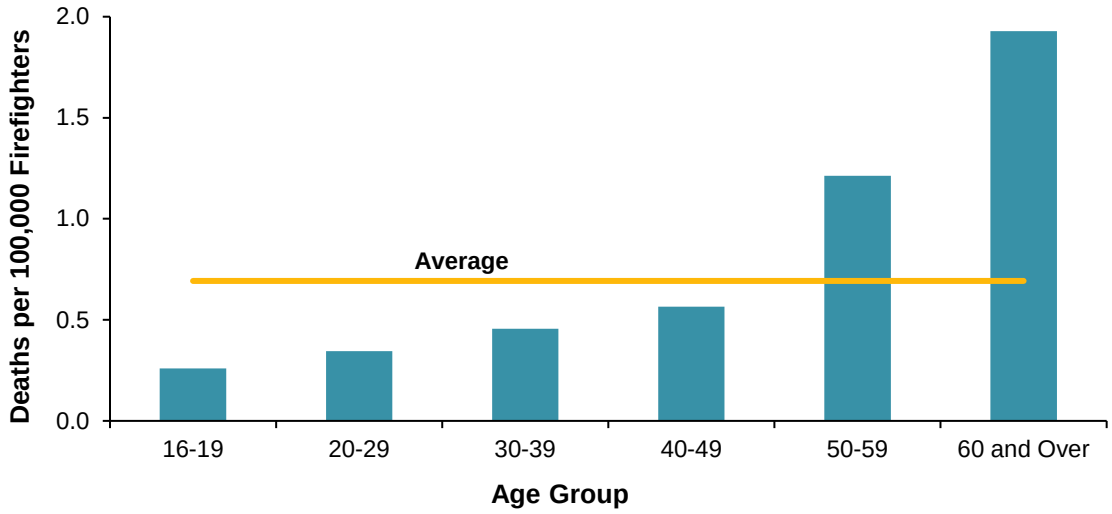


Figure 7 shows the death rate (for career and volunteer firefighters only) in training-related incidents by age group. The rates for firefighters under age 50 are below the average for all firefighters. When this study was done for the years 1996 through 2005, teenage firefighters had a death rate 50 percent higher than the all-age average; in this 10-year period, their death rate has dropped to just over one-third the all-age average.[1] The rates climb steeply after age 49, with a rate for firefighters age 60 and over that is almost triple the all-age average.

Figure 7. Death Rates for Training-Related Fatalities per 100,000 Career and Volunteer Firefighters 2009 - 2018



Where Career and Volunteer Firefighter Fatalities Occurred

Most of the deaths of the 79 career and volunteer firefighters occurred at the fire station or at off-site locations controlled by the fire department. Of the 79 deaths, 33 occurred at fire stations, with another six at local parks or trails, and two outside on a city street and a parking lot. Taking a closer look at these deaths:

- The 33 deaths at fire stations included 10 during fitness workouts, five at classroom sessions or meetings, four during apparatus training, four during SCBA or air management training, four during search and rescue training, three during equipment training, and three during physical ability tests; all but two of the deaths were medical-related (mainly sudden cardiac death)

[1] Fahy, Rita F., "U.S. Firefighter Deaths Related to Training, 1996-2005," NFPA, June 2006.

- The six firefighters who died at local parks or trails were running or hiking; all were sudden cardiac deaths
- The death that occurred on a city street was during pumper relay training and the death in a parking lot occurred while loading hose; both were medical-related.

There were five deaths at fire department training facilities. Four of the victims were cadets. One of the four was involved in an SCBA maze drill in full PPE, one was on a 4.5 mile (7.2 km) training run, one was participating in a 15-component physical ability training, and one was running up and down the drill tower on the first day at the academy. Two of the four died of heat stroke and two of sudden cardiac death. The fifth victim was on the third day of a three-day fire ground survival course and suffered sudden cardiac death.

Three firefighters were killed while training on aerial apparatus at buildings in their jurisdictions and one during search and rescue training in a vacant restaurant.

Twelve deaths occurred at state or county training schools or academies, one at a community college and one at a private training school. All but one suffered sudden cardiac death; the other victim died in his room of an unreported medical cause.

- Three of the victims were recruits – one was involved in search and rescue training in full turnout gear and SCBA, one in a hose trace evolution with obscured vision but no actual smoke and the third was practicing on a ground ladder in full turnout gear with SCBA.
- Three were in classroom settings.
- Three were involved in live fire training – one was preparing for the next drill, one had just completed an exterior burn, and one was an instructor who collapsed while changing his SCBA cylinder.
- One firefighter was participating in his annual physical ability test.
- Another was involved in search and rescue training.
- One was participating in rescue training that involved moving heavy blocks.
- One was participating in a mask confidence course in full gear with SCBA.
- One firefighter was involved in vehicle extrication training.

Eight deaths occurred while traveling to or from off-site or out-of-town training sites – six in crashes and two were due to sudden cardiac death. Another firefighter was killed in a crash on a highway while test driving a tanker prior to a drill. The three deaths in the water occurred at a quarry, at a local pond and in the ocean. One firefighter was training on a helicopter in flight. One was at a controlled wildfire burn. One firefighter was involved in some type of wildland fire training but there were no additional details available.

Relevant NFPA Standards

Firefighting is a dangerous profession but with proper attention to safety and health issues, on-duty fatalities can be reduced. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Programs*, provides the requirements for a program that will reduce deaths and injuries not only during emergency operations but during training operations as well.

Firefighter deaths during training are particularly needless. The purpose of training is to teach proper techniques so as to prevent deaths and injuries during emergency operations and should certainly not be the cause of casualties. Over the past 10 years, 91 firefighters died during training activities. Ten of the 91 were fatally injured during recruit training, and 18 had one year of service or less.

NFPA publishes a range of standards that provide requirements for safely conducting firefighter training. *NFPA 1402, Standard on Facilities for Fire Training and Associated Props*, addresses the design and construction of fire service training centers. *NFPA 1403, Standard on Live Fire Training Evolutions*, describes a process for conducting live fire training evolutions to ensure that they are conducted safely, in safe facilities and environments, and that the exposure to health and safety hazards for the firefighters receiving the training is minimized. The standard provides guidance on the prior qualifications necessary for firefighters to participate in such training, as well as preparation of the training site, its contents, and the manner of igniting the training fire, assignments of safety personnel, provisions for emergency egress, and preparation of records and reports on the training exercise. The standard specifically prohibits the ignition of any type of material whose burning properties are not known or that may be uncontrollable. Flammable or combustible liquids are never to be used in acquired structures, and only in limited amounts in certain circumstances in training center burn buildings. NFPA 1041, *Standard for Fire and Emergency Services Instructor Professional Qualifications*, identifies the minimum job

performance requirements (JPRs) for fire service instructors, including those supervising live fire evolutions.

Other relevant training standards include:

- NFPA 1404, *Standard for Fire Service Respiratory Protection Training*
- NFPA 1405, *Guide for Land-Based Fire Departments that Respond to Marine Vessel Fires*
- NFPA 1407, *Standard for Training Fire Service Rapid Intervention Crews*
- NFPA 1410, *Standard on Training for Emergency Scene Operations*, and
- NFPA 1451, *Standard for a Fire and Emergency Service Vehicle Operations Training Program*

As is true for all other types of duty, sudden cardiac death (usually heart attacks) accounts for the major share of training-related deaths, and many of the victims had prior heart attacks, bypass surgery or heart disease. NFPA 1582, *Standard on Comprehensive Occupational Medical Program for Fire Departments* provides the medical requirements for candidate firefighters and identifies a category of existing medical conditions "that would preclude a person from performing as a member in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others." Among many others, these conditions include coronary artery disease, history of myocardial infarction, coronary artery bypass surgery, coronary angioplasty, cardiomyopathy, and myocarditis. NFPA 1582 also establishes that the fire department physician must evaluate an incumbent firefighter who has a medical condition and recommend possible restrictions from performing essential job tasks based on the firefighter's medical condition. There is an entire section devoted to cardiovascular disorders and which of the essential job tasks could be compromised if a member has specific cardiac disorders.

NFPA 1002, *Standard on Fire Apparatus Driver/Operator Professional Qualifications*, specifies the minimum job performance requirements for service as a fire department emergency vehicle driver, pump operator, aerial operator, tiller operator, wildland apparatus operator, aircraft rescue and fire-fighting apparatus operator, and mobile water supply apparatus operator. The standard requires that routine tests, inspections, and servicing functions on the systems and components of fire department vehicles be performed and that drivers and operators have the requisite knowledge and skills to safely operate the apparatus.

NFPA 1451, *Standard for a Fire Service Vehicle Operations Training Program*, includes ongoing training requirements for vehicle operators, including operators of personally owned vehicles.

These and all other NFPA codes and standards can be viewed on NFPA's website as a public service to enhance the safety of the public and the fire service community.

Conclusion

Since training exercises should be conducted in controlled settings, they must be designed so as not to endanger the participants. This requires that recommended safety procedures be followed. That, in combination with competent instruction, should result in the level of safety necessary to protect the lives of those participating in training.

Findings for firefighter fatalities overall indicate consistently that the number one cause of on-duty firefighter fatalities is sudden cardiac death, and that is also the case during training activities. Sudden cardiac death among on-duty firefighters has been discussed in NFPA and NIOSH reports. (See, for example, https://www.cdc.gov/niosh/docs/2007-133/.) These reports indicate the steps that should be taken to reduce the risk of heart attacks among firefighters, which include:

- conducting annual medical evaluations;
- screening for coronary artery disease (CAD) risk factors;
- conducting exercise stress tests (EST) for those with multiple CAD risk factors;
- giving appropriate treatment for those risk factors; and
- restricting the job tasks that firefighters with positive stress tests are allowed to perform.

The risk factors for CAD include diabetes, smoking, high cholesterol, high blood pressure, family history of the disease and obesity or physical inactivity.

Motor vehicle crashes during training sessions or while traveling to or from training sessions represent an area where ordinary precautions and attention to driving rules and road conditions should have an impact. Seatbelts should be worn at all times in all vehicles.

NIOSH has investigated more than 100 of the deaths that occurred during training exercises over the past 20 years. All their reports include recommendations to improve safety. NIOSH investigation reports are available on their website: www.cdc.gov/niosh/fire/.