



NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A summary of a NIOSH fire fighter fatality investigation

September 1, 1998

Fire Fighter Dies of a Heart Attack while Responding to a Residential Oil Heater Fire—Delaware

SUMMARY

On January 6, 1998, a 58-year-old male career fire fighter with a 28-year service record with the employing fire department collapsed while responding to a residential oil heater fire. The ladder truck to which the fire fighter was assigned was the first piece of equipment to arrive at the fire scene and approached the dwelling from the street in front. After parking the vehicle, the fire fighter and three other fire fighters exited the truck wearing full protective gear and headed toward the front door of the dwelling. The homeowner stated that the fire was from an oil heater in the basement. Ground-level access to the basement was in the rear of the building. The fire fighter and his partner hurried to the back of the building, while the other two fire fighters began placing ladders to access the roof of the structure. When the fire fighter and his partner reached the basement access, he stopped, said, "Hold on, I'm tired," and placed his hands on his knees. When his partner asked if he was okay, the fire fighter did not respond. The fire fighter then fell face-first to the pavement. His partner turned him onto his back, and noted that he was cyanotic. The partner immediately called for assistance from other fire fighters on the scene, cut the strap to the fallen fire fighter's SCBA so it could be removed, and initiated cardiopulmonary resuscitation (CPR). Other fire fighters arrived and assisted with CPR administration and removal of gear. Resuscitation efforts of rescue unit fire fighters, advanced life support medics, and hospital emergency department personnel failed. The medical examiner listed cardiac tamponade due to a ruptured myocardial infarct as the cause of death. Arteriosclerotic cardiovascular disease was listed as a contributing factor.

A three-pronged strategy for reducing the risk of heart attacks among fire

fighters has been proposed by other agencies. This strategy consists of (1) minimizing physical stress on fire fighters; (2) screening to identify and subsequently rehabilitate high-risk individuals; and (3) encouraging increased individual physical capacity.

The following recommendations address potential health and safety problems uncovered during the NIOSH investigation. Some of the recommendations are specific to this fatality; others are more general in nature.

- ***Consider modifying the current medical evaluation of fire fighters to include stress electrocardiography for those above the age of 35 with at least one risk factor for coronary artery disease.***
- ***Consider including a physician-signed medical clearance to wear respiratory protection, including self-contained breathing apparatus with full turnout gear, as a part of the existing medical evaluation program.***
- ***Reduce risk factors for cardio-vascular disease and improve cardiovascular capacity by implementing a wellness/ fitness program for fire fighters.***
- ***Clarify the department's policy regarding Incident Command and improve fire fighter training on this policy.***
- ***Review the department's policy regarding equipment provided for First Responders.***

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at:

<http://www.cdc.gov/niosh/firehome.html>

or call toll free **1-800-35-NIOSH**.

INTRODUCTION/METHODS

NIOSH was notified of this fatality on January 9, 1998. NIOSH telephoned the fire department during the week of January 19, 1998 to initiate the investigation. Jane McCammon, Senior Industrial Hygienist from the NIOSH Fire Fighter Fatality Investigation Team, traveled to Delaware on January 29, 1998 to conduct an investigation of the incident.

NIOSH personnel began the investigation by meeting with and interviewing the following:

- The Fire Chief and Fire Department officers;
- Fire Department personnel involved in this incident;
- Local president of the International Association of Fire Fighters (IAFF);
- Fire Marshall conducting the fire scene investigation;
- The Director of Public Safety;
- Ambulance personnel responding to the medical emergency;
- The spouse of the fallen fire fighter.

NIOSH also reviewed the following:

- Fire Department and Fire Marshall investigative records including incident reports, photographs of the fire, coworker statements, dispatch records;
- Ambulance dispatch records;
- Autopsy results and the death certificate of the deceased;
- Fire Department policies and operating procedures.

INVESTIGATIVE RESULTS

Fire Scene Response. On January 6, 1998, a 58-year-old male career fire fighter with 28 years of service with the employing fire department collapsed while responding to a residential oil heater fire. The ladder truck to which the fire fighter was assigned as Acting Lieutenant was dispatched to the fire from another incident location. The

first incident involved a fuel oil overflow, and the ladder truck was dispatched to that location to provide an exhaust fan. When the fire fighters began to unload the exhaust fan, an alarm sounded for the ladder truck to respond to a fire at a nearby location.

The ladder truck arrived at the fire scene at 1507 hours, 3 minutes after dispatch, and was the first piece of equipment to arrive at the dwelling. After the ladder truck was parked in the front of the residence, the fire fighter and his three partners exited the truck wearing full protective gear, including self-contained breathing apparatus (SCBA). They headed toward the front door of the dwelling, noting smoke showing from the roof. As they approached the building, the homeowner stated that the fire was from an oil heater in the basement and directed the fire fighters to the ground-level access to the basement in the rear of the building.

Two of the four fire fighters on the ladder truck began to place ladders to access the structure's roof. The Acting Lieutenant and his partner hurried to the back of the building to access the fire. As they reached the basement access, the Acting Lieutenant stopped, said, "Hold on, I'm tired," and placed his hands on his knees. When his partner asked if he was okay, the fire fighter did not respond. The fire fighter then fell face-first to the pavement. His partner turned him onto his back, and noted that he was cyanotic. The partner immediately ran to the side of the building and yelled to the fire fighters who had accessed the roof, indicating that his partner was down. (These fire fighters had determined that the smoke was coming from the dwelling chimney and were descending the ladders.) They were unable to understand what the partner was saying, but assumed there might be a working fire in the basement. They ran to assist the other fire fighters.

The partner returned immediately to the fallen Lieutenant, cut the SCBA harness strap so the harness could be removed, and initiated cardiopulmonary resuscitation (CPR). At this point, the officer serving as Incident Commander and rescue fire fighters had arrived on the scene. The rescue team assisted the partner in removing the Lieutenant's gear and clothing, and with administering CPR. Dispatch was notified that an Advanced Life Support (ALS) ambulance was needed.

While some fire fighters worked on the fallen Lieutenant, others extinguished the fire within seconds using an "ABC" type of extinguisher that was retrieved from the ladder truck.

Medical Emergency Response. Rescue fire fighters worked with the Acting Lieutenant's partner to administer CPR. A check of the fallen Lieutenant's vital

signs revealed that he had no pulse and was not breathing. The fire fighters established an airway and began mouth-to-mask ventilations and chest compressions. A bag mask attached to oxygen was then used for 10 to 15 ventilations, at which time the fallen Lieutenant took a deep breath. Vital signs were again checked, revealing a weak pulse. Ventilations were continued without chest compressions. The Acting Lieutenant began to vomit and attempts were made to clear his airway. An ALS ambulance staffed with 4 medics arrived on the scene at 1515 hours (less than 2 minutes after dispatch, 8 minutes after the ladder truck had arrived at the fire scene, and an estimated 4 minutes after the fire fighter's collapse.)

During the transfer of treatment, or shortly thereafter, the Fire Chief arrived on the scene. Although the Chief did not formally take over the role of Incident Commander, he began issuing commands to move fire fighters to the front of the house and away from the area of treatment of the fallen fire fighter. There was confusion among the fire fighters as to who was Incident Commander and concern that they might be needed for transfer of the patient, equipment, etc. The Incident Commander suggested that it might be better to allow some or all of the fire fighters to remain in the area. The Chief again ordered the fire fighters to leave the area, and they complied.

Ambulance paramedics took over treatment of the patient and used a suction unit to clear the airway. The patient was combative with paramedics while they intubated him, and he continued to vomit. An intravenous (IV) line was established, and a cardiac monitor was placed on the patient. The patient had a pulse at this time. The patient was loaded into the ambulance which left the scene for the hospital at 1535 hours. He had a pulse throughout transport, and upon arrival at the hospital emergency department seconds later. Approximately 10 minutes after arriving at the hospital, he went into cardiac arrest. Resuscitation efforts were unsuccessful, and he was pronounced dead at 1608 hours.

Medical Findings. The death certificate was completed by the medical examiner who also conducted the autopsy. Cardiac tamponade due to a ruptured myocardial infarct was listed as the cause of death on the death certificate. Arteriosclerotic cardiovascular disease was listed as a contributing factor.

The final diagnoses resulting from the autopsy performed on January 7, 1998 are listed below:

- Cardiac tamponade due to ruptured myocardial infarct:
Cardiac tamponade (400 grams); Vertical

disruption of the left lateral ventricle superimposed upon an extensive transmural myocardial infarct.

- Arteriosclerotic cardiovascular disease (contributory):

Focal narrowing of the coronary arteries (90-95% occlusion of the proximal branches of the left anterior descending and circumflex arteries).

Medical information indicates that this fire fighter was on leave for a number of months in 1995/1996 for a non-cardiovascular medical condition. He had been cleared to return to work 18 months prior to this incident by both his private physician and the employer's designated provider. Although he did have resting electrocardiograms (ECGs), it does not appear that a stress ECG was part of his return-to-work evaluation. His last medical evaluation was 5 months prior to this incident, and his wife and co-workers reported that he was not complaining of any type of chest pain the few days before his heart attack and subsequent cardiac arrest.

DESCRIPTION OF THE FIRE DEPARTMENT AND DEPARTMENT OPERATIONAL POLICIES

The fire department employs 170 uniformed fire fighters, 41 of which are officers. The department serves a geographic area of 15.7 square miles with a population of 71,500. The average time between dispatch and arrival on the scene for the department is 1 minute 59 seconds; the longest time is 3 minutes.

The operations division of the department is divided into two fire districts and an ambulance unit equipped with two contracted ambulances. Each of the fire districts is equipped with three engines and one ladder truck. Fire District 2 also houses a rescue squad. Each piece of equipment within the fire districts carries a four-man crew. Rescue medical services are provided by fire fighters. Advanced life support ambulance services are provided by a contractor. If both the rescue and ambulance units are unavailable (already in service), first response services are provided by fire fighting units and personnel. At the time of this investigation, rescue and ambulance units were equipped with oxygen and defibrillators. Fire fighting units (i.e., engines and ladders) were not equipped with either oxygen or defibrillators.

As part of their Incident Management System, the department implemented a badge accountability program approximately 5 months prior to this investigation.

DESCRIPTION OF MEDICAL AND PHYSICAL TRAINING AND SUPPORT SERVICES PROVIDED FOR FIRE FIGHTERS

This department provides all fire fighters with annual medical examinations consisting of a pulmonary function test, complete blood count, a drug screen, urinalysis, vision screening, a hearing test, resting electrocardiogram (EKG), and a physical examination provided either by the city's physician or the fire fighter's personal physician. Decisions about more extensive medical tests are made by the examining physician.

The department provides qualitative fit testing for respiratory protection. They do not specifically require medical clearance for wearing respirators, but the medical testing they require of all fire fighters covers the intent of respirator clearance.

The department requires medical clearance from the fire fighter's personal physician and the municipality's designated provider if the fire fighter has been on medical leave for 30 or more consecutive days.

The department provides critical incident stress debriefing services for fire fighters, although, for unclear reasons, some fire fighters were initially excluded from participation in the program after the death of this fire fighter.

A union contract that is in place includes an agreement regarding establishment of a wellness/fitness program to reduce risk factors for cardiovascular disease and improve cardiovascular capacity. Interviews indicated, however, that this program has not been implemented.

DISCUSSION

Data collected by the National Fire Protection Association (NFPA) indicate that 49% of on-duty fire fighter deaths occurring nationally in 1996 resulted from heart attacks.¹ NFPA data also indicate that heart attacks have always been the most common cause of on-duty fire fighter deaths since the agency began collecting data in 1978.

Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.² Conducting fire fighting activities in full turnout gear carries a high energy cost. For example, one study of fire fighters climbing stairs in full

equipment found that the fire fighters reached 80% of their maximum oxygen consumption and 95% of their maximal heart rate, and required at least 39 milliliters of oxygen per kilogram of body weight per minute.³ Other studies have shown similar results.⁴ These sudden and sometimes prolonged increases in heart rate may trigger coronary artery plaque disruption, leading to artery blockage, causing a heart attack and sudden death.⁵⁻⁷ Exposure to the heat of the fire, the stress of carrying out fire fighting activities, and chronic exposure to the many components of smoke all present an intense burden and corresponding high oxygen demand on the body and heart of a fire fighter.

Rupture of the heart wall is an infrequent (probably <5%), but dramatic complication of a heart attack. Older age, first heart attack, a history of high blood pressure (hypertension), and no history of chest pain (angina), are all associated with a higher incidence of cardiac rupture due to heart attacks.⁸ All of these factors were present in this individual. During the heart attack, the patient is also more likely to have the entire heart wall (transmural) involved, and to present with repetitive emesis, and significant restlessness/agitation.⁹ In this regard, in addition to other features of his clinical presentation, this victim was typical of a heart attack complicated by cardiac rupture and subsequent tamponade. Tamponade is the term used to describe the accumulation of fluid, in this case blood, into the sac surrounding the heart. As this fluid accumulates in the sac, it compresses the heart, inhibiting the forward flow of blood from the heart to the blood vessel leaving the heart (aortic root). This unfortunate sequence of events is almost universally fatal,⁸ although some recent publications suggest that with immediate diagnosis, pericardiocentesis, and surgery the prognosis is not quite as grim.¹⁰

This fire fighter had undergone extensive medical evaluation related to a previous non-cardiovascular illness. From the information provided to the NIOSH investigator, it was doubtful that any of the victim's prior medical evaluations included a stress ECG, which is a more sensitive diagnostic tool for coronary artery disease than the resting ECG. Probably due to the lack of symptoms suggestive of coronary artery disease, neither his personal physician nor his municipality-sponsored physician conducted tests to investigate the possibility of coronary artery disease.

Considerable concern was evident among interviewed fire fighters and administrators about some or all of the following issues which surfaced during this investigation:

- the absence of oxygen and defibrillators on fire fighting equipment that serve as first responders when the ambulance and rescue units

are unavailable

- the absence of automatic defibrillators on ambulance and rescue units
- confusion over the Incident Management System, particularly regarding Incident Command
- insufficient or inadequate training for all members and officers of the department
- inappropriate use of radio communications during this incident.

During the interview process, fire fighters, rescue personnel, and paramedics involved with this incident were asked if, in their opinion, any of the above issues in any way contributed to this fire fighter's death. Responses were consistent without exception: none of the above issues contributed to his death, or caused delays in medical treatment, or resulted in inadequate medical treatment.

Dispatch tapes reviewed with personnel who were familiar with the incident and experienced with radio communication procedures again indicated, both in the opinion of those assisting with and conducting the review, that radio communications were appropriately conducted. Again, no evidence indicated that there was any delay in handling of the emergency due to inappropriate radio communications.

RECOMMENDATIONS

The following recommendations address potential health and safety problems uncovered during the NIOSH investigation. Among the list of recommendations and preventive measures below are policies of other agencies that are intended to reduce the risk of on-the-job heart attacks among fire fighters. These policies have not been evaluated by NIOSH, but represent research presented in the literature, consensus votes of Technical Committees of the National Fire Protection Association, or labor/management groups within the fire service. In addition, the recommendations are presented in a logical programmatic order, and are not listed in a priority manner.

Recommendation #1: Consider modification of the current medical evaluation of fire fighters to include stress ECG for those above the age of 35 who have at least one risk factor for coronary artery disease.

Discussion: Guidance regarding the content and scheduling of periodic medical

examinations for fire fighters can be found in National Fire Protection Association (NFPA) 1582, Standard on Medical Requirements for Fire Fighters,⁸ and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs wellness/fitness initiative.⁹ NFPA 1582 Appendix B Guide for Fire Department Physicians points out that although there are no firm guidelines for stress ECG in asymptomatic individuals, there is probably justification for performing the testing on individuals above the age of 35 years with one or more risk factors for coronary artery disease. NFPA 1582 also recommends that the frequency of testing should increase with age.

Recommendation #2: Consider including a physician-signed medical clearance to wear respiratory protection (self-contained breathing apparatus and full turnout gear) as a part of the existing medical evaluation program. This clearance is required for private industry employees and public employees in States operating OSHA (Occupational Safety and Health Administration) approved State plans.

Discussion: OSHA's revised respiratory protection standard¹⁰ requires employers to provide medical evaluations and clearance for employees using respiratory protection. The standard requires that the employer obtain a written recommendation from the physician regarding the employee's ability to use a respirator. The recommendation must provide information about any limitations of respirator use related to any medical condition of the employee, the need for follow-up medical evaluations, and a statement that the physician has provided the employee with a copy of the written recommendation. Because Delaware is a Federal OSHA state, municipalities within that state are not required to comply with these standards. Nonetheless, we recommend voluntary compliance with this aspect of the respiratory protection standard to ensure that fire fighters can safely wear self-contained breathing apparatus, and to ensure that the physician conducting medical evaluations understands that one intent of the medical evaluation is respirator clearance.

Recommendation #3: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by implementing a wellness/fitness program for fire fighters.

Discussion: NFPA 1500¹¹ requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being. In 1997, the International Association of Fire Fighters and the

International Association of Fire Chiefs joined in a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual with a video detailing elements of such a program.⁹ These materials should be reviewed by the fire department to identify elements that would be feasible and effective in their situation.

Recommendation #4: Clarify the department's policy regarding Incident Command and improve training on this policy for fire fighters.

Discussion: Although Incident Command did not impact on this fatality, several fire fighters and officers indicated confusion about the department's policy regarding this issue. This confusion could seriously impact on the safety of all fire fighters in future incidents. The Standard Operating Procedures (SOP) of the department state that upon arrival of a Deputy Chief or the Chief, he/she will automatically assume Incident Command after the transfer of command procedures have been completed. The SOP then describes the procedures for transfer of command. The confusion over Incident Command during this incident (and related interviews) indicated that the SOP is not always followed. This SOP should either be followed, or reviewed and revised as necessary. All fire fighters should be trained in every aspect of the incident command system to ensure they understand the system and the role of all officers and fire fighters during emergency operations.

Recommendation #5: Review the department's policy regarding equipment provided for first responders.

Discussion: Many fire fighters expressed concern over the lack of oxygen and defibrillators on fire fighting vehicles that function in a First Response capacity on occasion. They pointed out that all department fire fighters must be certified as Emergency Care Technicians, are expected to carry out the duties of Emergency Care Technicians, and then are not given the tools they need to provide basic rescue. The department should review their policies related to this issue, and provide oxygen and automatic defibrillators for any vehicle that may serve in a First Response capacity.

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