



NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

July 14, 2004

Fire Fighter-Driver/Engineer Suffers Heart Attack and Dies at the End of his 24-hour Shift - Hawaii

SUMMARY

On April 2, 2001, a 52-year-old male career Fire Fighter-Driver/Engineer (FF-D/E) was approaching the end of his 24-hour shift. At approximately 0645 hours, the FF-D/E reported nausea and epigastric/chest pain to awakening crewmembers. Alertly, these crewmembers immediately called dispatch for an ambulance, and then retrieved the automated external defibrillator (AED) and oxygen equipment from the Station's Engine. Oxygen was administered by mask as the initial evaluation revealed a conscious, ambulatory FF-D/E with a weak pulse. A few minutes later, as the ambulance arrived on-site, his condition worsened as the deceased began to have severe shortness of breath and diaphoresis (a cold sweat on the skin). As the paramedics began loading the FF-D/E into the back of the ambulance for transport, he lost consciousness and had a cardiac arrest. Cardiopulmonary resuscitation (CPR) was started and, enroute to the hospital, the paramedics were able to successfully shock (cardiovert) the FF-D/E back into a viable heart rhythm with the FF-D/E regaining consciousness. Unfortunately, as the FF-D/E arrived in the hospital's emergency department (ED), he again suffered cardiac arrest. Despite advanced life support (ALS) begun in the ambulance and continuing in the ED for 41 minutes, the FF-D/E died. The death certificate and autopsy report, completed by a forensic pathologist with the Medical Examiner's Office, listed acute myocardial infarction and coronary artery thrombosis due to atherosclerotic cardiovascular disease as the immediate cause of death.

The following recommendations address some general health and safety issues. This list includes some preventive measures that have been recommended by other agencies to reduce the risk

of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These selected recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups. Sadly, it is unlikely any of these recommendations could have prevented the tragic and untimely death of this FF-D/E.

- **Provide annual medical evaluations consistent with NFPA 1582**
- **Consider performing exercise stress tests (EST) on select fire fighters**
- **Negotiate with the local union to phase-in a mandatory fitness and wellness program consistent with NFPA 1583 and/or the Fire Service Joint Labor Management Wellness/Fitness Initiative**
- **Negotiate with the local union to phase-in an annual physical ability test**

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. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. 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 www.cdc.gov/niosh/firehome.html or call toll free 1-800-35-NIOSH

Fire Fighter-Driver/Engineer Suffers Heart Attack and Dies at the End of his 24-hour Shift - Hawaii

- ***Perform autopsies on fire service personnel consistent with U.S. Fire Administration and U.S. Department of Justice Public Safety Officer Benefits protocols***
- ***Expand access to critical incident stress counseling to members of the entire Fire Department***
- Medical records of the deceased from the FD and his personal physician
- Ambulance records
- ED encounter form
- Death certificate
- Autopsy report

INTRODUCTION & METHODS

On April 2, 2001, a 52-year-old male Fire Fighter-Driver/Engineer suffered sudden cardiac arrest just before completing his 24-hour shift. Despite ALS treatment at the scene, enroute, and at the hospital's ED, the FF-D/E died. NIOSH was notified of this fatality on April 10, 2001, by the United States Fire Administration (USFA). NIOSH contacted the affected Fire Department (FD) on April 25, 2001, to obtain further information. On March 22, 2004, an Occupational Health Nurse and an Occupational Physician from the NIOSH Fire Fighter Fatality Investigation Team traveled to Hawaii to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel met and/or interviewed the:

- Fire Chief
- EMS Chief
- Training Assistant Chief
- Local Union President
- FF-D/E's crew members
- FF-D/E's spouse and family
- Medical clinic personnel who conduct the FD medical evaluations

During the site-visit NIOSH personnel reviewed:

- FD policies and operating guidelines
- FD training records
- FD annual report for 2001
- Station log book
- FD physical examination protocols

INVESTIGATIVE RESULTS

On April 1, 2001, at 0800 hours the FF-D/E reported for duty with ten of his crewmembers at fire station 14. Station 14 provided fire protection for the local airfield. Throughout the morning, the crew checked the apparatus (one engine and two crash trucks) and firefighting gear, and then performed normal station duties. The afternoon involved directed study interrupted by one-hour of scheduled physical fitness training. The FF-D/E typically went for a walk or a jog during this time period. Since the FF-D/E was an avid runner (frequently ran marathons), he probably walked/jogged several miles but the exact distance, or even that he actually went on a walk/jog this day, could not be definitively stated. Dinner was prepared at 1900 hours and the lights went out at approximately 2200 hours. The FF-D/E was typically one of the last crewmembers to retire for the night, and he was still watching television at approximately 2330 hours. Up to this point, not once did he complain of not feeling well.

At approximately 0545 hours on April 2, the Station's Captain began making the morning coffee. At approximately 0615 hours the Captain noted the FF-D/E coming out of the Chief's room with his bedding underneath his arm. This was unusual because the FF-D/E's bunk was upstairs, and, although the Chief's bed was not being used that evening, it was typically reserved for the Chief. The FF-D/E washed-up upstairs, then returned downstairs around 0630 hours when he told the Captain that he did not feel well and was rubbing his epigastric/lower chest area. The Captain immediately

Fire Fighter-Driver/Engineer Suffers Heart Attack and Dies at the End of his 24-hour Shift - Hawaii

notified dispatch for an ambulance (0632 hours) and awoke the remaining crewmembers for assistance. The FF-D/E relayed that he had not felt well for a few hours, was nauseated, and could not sit still.

Initial evaluation found him to be pale with a weak pulse. He was laid down on a bed as the oxygen and the AED was retrieved from the nearby Engine. He then became diaphoretic (cold sweat on the skin) and short of breath just as the ambulance team arrived at 0639 hours. After being connected to a cardiac monitor, the FF-D/E was placed on a gurney and wheeled to the ambulance. The cardiac monitor showed an abnormal heart rhythm (accelerated junctional rhythm at 60 beats per minute) with ST segment elevation in leads V1 to V3. The ST segment elevation suggests a heart attack, otherwise known as a myocardial infarction (MI), with leads V₁ to V₃ suggesting it was occurring in the anterior portion of the heart.

As the gurney was loaded into the back of the ambulance, the FF-D/E lost consciousness and suffered a cardiac arrest. He was given intravenous (IV) cardiac medications and shocked (defibrillated) once at 0651 hours which successfully returned his heart rhythm, his peripheral pulse, as well as his ability to respond to commands. The ambulance departed from the scene enroute to the hospital at approximately 0655 hours. Enroute to the hospital the FF-D/E had at least one more instance of cardiac arrest, again being successfully treated by CPR, IV medications, and cardioversion (shocks). As the ambulance arrived at the ED (0704 hours), the FF-D/E was responding to commands and had a stable heart rhythm. However, in the ED once again he had a cardiac arrest. This time, unfortunately, the ED staff was unable to resuscitate the FF-D/E and after performing ALS for over 40 minutes, he was pronounced dead at 0745 hours and resuscitation efforts were stopped.

Medical Findings.

The death certificate, completed by a forensic pathologist with the Medical Examiner's Officer, listed "coronary artery thrombosis" due to "atherosclerotic cardiovascular disease" as the immediate cause of death. Significant findings from the autopsy which was performed by the same forensic pathologist were:

- Blood clot (thrombus) in one of the coronary arteries (mid-left anterior descending artery)
- Moderate to severe coronary atherosclerosis
- A large heart weighing 470 grams (normal < 400 grams)
- Thickened left wall of the heart (left ventricular hypertrophy)
- A negative drug screen

The FF-D/E had his last FD annual medical evaluation 13 months prior to his death. This evaluation consisted of a normal examination and normal laboratory tests including a resting electrocardiogram (EKG) and lung tests (spirometry), and he was cleared for full duty. The FF-D/E last saw his private physician five months before his death for a non-cardiac medical condition. For several years he was noted to have borderline high cholesterol levels. His last total cholesterol level in 1999 was 204 milligrams (mg) per deciliter (dl) (borderline is 200-239 ug/dl), with an HDL cholesterol of 40 mg/dl (normal is 35-65 mg/dl), and an LDL cholesterol of 147 ug/dl (normal is 70-130 ug/dl), and a Chol/HDL ratio of 5.1 (normal). According to his wife, the FF-D/E had a normal "treadmill test" conducted by his life insurance company two years prior to his death. At the time of this report, NIOSH was unable to review this medical information.

At autopsy, the FF-D/E weighed 180 pounds and measured 5'10" tall giving a normal body mass index of 25.8 kilograms/meter² (kg/m²). As mentioned previously, he exercised regularly by walking, jogging, and running on a regular basis. He never complained



Fatality Assessment and Control Evaluation Investigative Report #F2004-09

Fire Fighter-Driver/Engineer Suffers Heart Attack and Dies at the End of his 24-hour Shift - Hawaii

of any heart symptoms days or weeks preceding this untimely death.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, this FD consisted of 210 uniformed personnel serving a population of 96,000 in an area of 198 square miles. There are 14 fire stations. The FD also provides limited ALS with ten fire fighters being certified EMT-paramedics and six fire fighters being EMT-intermediates. The other members of the department are either EMT-basic (50%) or certified first responders (50%). Fire fighters work the following schedule: 24 hours on-duty, 24 hours off-duty for three shifts, then three days off. Shifts change at 0800 hours. In 2002, the Department responded to 7,244 emergency calls. In 2002, Station 14 responded to 199 emergency calls of which 73 (37%) were emergency medical service (EMS) calls.

Training. To become a member of the FD, applicants are ranked by their written application and their FD interview. The top ranked candidates must then pass a physical examination performed by the occupational health clinic (discussed below), an illicit drug test, and a physical agility test. The physical agility test is composed of four timed events: Obstacle course, Hose racking, Stair climb, and Hose repositioning.

Once hired as a probationary employee, the candidate must complete the 16-week training at the fire fighter Academy. Upon Academy completion, the probationary employee will be certified as a Fire Fighter I, Fire Fighter II, EMT-basic, ARFF (aircraft rescue fire fighter), and hazardous materials operations level, and then assigned to one of the fire stations. After serving two years as a probationary employee in good standing, the probationary

employee is allowed full membership. Recurrent training occurs daily on each shift. Other than for EMT-basic which requires recertification every two-years, there is no recertification required. The FF-D/E was certified as a Fire Fighter II, Driver/Engineer, EMT-basic, and in Hazardous Materials Operations. He had 28 years of fire fighting experience.

Pre-placement Evaluations. The FD requires a pre-placement medical evaluation for all fire fighter candidates, regardless of age. Components of the evaluation include:

- A complete medical history
- Physical examination
- Vital signs including height and weight
- Vision testing (acuity, color, peripheral)
- Audiogram
- Blood analysis: serum chemistry, lipid panel, and liver profile complete blood count
- Urinalysis (dipstick)
- Drug screen
- Pulmonary Function Test (spirometry)
- Chest x-ray
- 12-lead resting electrocardiogram (EKG)
- Tuberculosis skin test (PPD)
- Hepatitis screening if vaccination not complete (Hepatitis B)

These evaluations are performed by the physician in the occupational health clinic, who then makes a decision regarding medical clearance for fire fighting duties. This decision is forwarded to the Fire Chief.

Periodic Evaluations. Annual medical evaluations are required by this department with a more comprehensive medical examination conducted depending on the age of the member. The content of the annual medical evaluation includes a medical and occupational history, a TB screen, a vision screen (acuity and color), vital signs including height and

Fire Fighter-Driver/Engineer Suffers Heart Attack and Dies at the End of his 24-hour Shift - Hawaii

weight, and maintenance with immunizations. The more comprehensive medical examination occurs every three years for fire fighters under the age of 30, every two years for fire fighters between the ages of 30 and 39, and every year for fire fighters 40 years of age and above. The content of this examination is the same as the pre-placement except there is no chest x-ray (unless clinically indicated), and the resting EKG and lipid profile is done annually beginning at age 35. Annual physical ability testing is not required. Medical clearance for respirator use is required annually.

If an employee is injured at work, or is ill and off work for more than three shifts, the employee must be evaluated by the occupational health clinic physician. The physician then forwards a recommendation regarding "return to work" to the Fire Chief.

Exercise (strength and aerobic) equipment is located in all fire stations. Mandatory fitness programs are in place with one hour (1530 hour to 1630 hours) set aside for training each shift. Although this is a mandatory program, it is unclear if all fire fighters are using this time for fitness training. The health/wellness program consists of an anti-smoking educational program.

DISCUSSION

In the United States, coronary artery disease (CAD) is the most common risk factor for cardiac arrest and sudden cardiac death.¹ Risk factors for its development include advancing age, male gender, family history of coronary artery disease, smoking, high blood pressure (systolic >140 millimeters of mercury [mmHg] or diastolic > 90 mmHg), high blood cholesterol (total cholesterol > 240 milligrams per deciliter [mg/dL]), obesity/physical inactivity, and diabetes.^{2,3} The deceased had only two of these risk factors (male gender and advancing age).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.⁴ However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.⁵ Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.⁶ This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. The deceased had a thrombus on autopsy and moderate to severe atherosclerotic disease in his coronary arteries. The FF-D/E had a MI as diagnosed not only by the thrombus, but the EKG changes noted by the ambulance service at the fire station. Sudden cardiac death is associated with MI's due to the instability of the heart's conduction system.

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.⁷⁻¹⁰ During the FF-D/E's shift, there were no emergency incidents, but the deceased participated in the FD's physical fitness program. He either walked or ran for several miles during the one-hour time period. Depending on the pace of his walk/run, this could represent mild (walking) to heavy (running) level of physical exertion.^{11,12} The physical stress of exercising and his underlying atherosclerotic CAD could have contributed to this FF-D/E's cardiac arrest and sudden cardiac death, but why the heart attack occurred in the early hours of the morning, rather than during fitness testing is unclear.

To reduce the risk of heart attacks, sudden cardiac arrest and other medical conditions among fire fighters, the NFPA has developed the NFPA 1582 guideline entitled *Comprehensive Occupational Medicine Program for Fire Departments*.¹³ The 2003 edition recommends a comprehensive medical examination to be performed **annually** on all members. This standard also includes a

Fire Fighter-Driver/Engineer Suffers Heart Attack and Dies at the End of his 24-hour Shift - Hawaii

recommendation that fire fighters with two or more risk factors for CAD (family history of premature [less than age 60] cardiac event, hypertension, diabetes mellitus, hypercholesterolemia [total cholesterol greater than 240 mg/dL or HDL cholesterol less than 35 mg/dL], and cigarette smoking) be screened for obstructive CAD by an EST.¹³ These recommendations are similar to those of the American College of Cardiology/American Heart Association (ACC/AHA).¹⁴ According to this criteria, the FF-D/E did not have a single CAD risk factor as listed above, therefore would not have been recommended for an EST.

RECOMMENDATIONS

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the NFPA or fire service labor/management groups. Sadly, it is unlikely any of these recommendations could have prevented the tragic and untimely death of this FF-D/E.

Recommendation #1: Provide annual medical evaluations consistent with the 2003 edition of NFPA 1582.

We applaud the efforts of the occupational health clinic for implementing a comprehensive medical evaluation and examination program. This program, however, appears to be based on the 1997 and 2000 editions of NFPA 1582. In the fall of 2003, NFPA issued a significantly revised edition. A copy of the revised edition has been left with both the FD and the occupational medical clinic.

Recommendation #2: Consider performing exercise stress tests (EST) on select fire fighters.

As mentioned in the discussion section, the 2003 edition of NFPA 1582 recommends EST for asymptomatic fire fighters with two or more risk factors for CAD. We recommend the occupational health clinic take these guidelines into consideration when developing their policy on screening asymptomatic fire fighters for CAD.

Recommendation #3: Collaborate with the local union to phase-in a mandatory fitness and wellness program consistent with NFPA 1583 and/or the Fire Service Joint Labor Management Wellness/Fitness Initiative.

The FD currently mandates physical fitness training for one hour of each shift, but there appears to be inconsistent individual compliance. Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States and is independently associated with obesity and diabetes.¹⁵ A comprehensive fitness program, such as NFPA 1583 *Standard on Health-Related Fitness Programs for Fire Fighters*, also provides health promotion activities for preventing health problems and enhancing overall well-being.¹⁶ Another example of a comprehensive fitness/wellness program is the Fire Service Joint Labor Management Wellness/Fitness Initiative published by the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) in 1997.¹⁷ Copies of both these documents were provided to the FD and the local union. We recommend the FD and the union review these documents to identify elements that could be added to strengthen the existing program.

Recommendation #4: Negotiate with the local union to phase-in an annual physical ability test.

Fire Fighter-Driver/Engineer Suffers Heart Attack and Dies at the End of his 24-hour Shift - Hawaii

NFPA 1500 requires fire department members who engage in emergency operations to be annually evaluated and certified by the fire department as meeting the physical performance requirements identified in paragraph 8-2.1.¹⁸

Recommendation #5: Perform autopsies on fire service personnel, consistent with the U.S. Fire Administration and U.S. Department of Justice Public Safety Officer Benefits protocols.

As of December 15, 2003, the PSOB program will compensate a fire fighter's family if they die in the line of duty due to a heart attack or stroke under certain conditions. To be eligible for the monetary compensation, an autopsy must be conducted. The USFA had developed a comprehensive autopsy protocol for line of duty deaths. We recommend the FD obtain a copy of this document and educate their members about this new provision in the PSOB program.

Recommendation #6: Expand access to critical incident stress counseling to members of the entire Fire Department.

REFERENCES

1. Meyerburg RJ, Castellanos A [2001]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 15th Edition. New York: McGraw-Hill. pp. 228-233.
2. AHA [1998]. AHA Scientific Position, Risk Factors for Coronary Artery Disease. Dallas, TX: American Heart Association.
3. Jackson E, Skerrett PJ, and Ridker PM [2001]. Epidemiology of arterial thrombosis. In: Coleman RW, Hirsh J, Marder VIJ, et al. eds. Homeostasis and thrombosis: basic principles and clinical practice. 4th edition. Philadelphia: Lippincott Williams and Wilkins.
4. Libby P [2001]. The pathogenesis of atherosclerosis. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 15th Edition. New York: McGraw-Hill. p.1378.
5. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol 20 (11 Suppl2): II-38-44.
6. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Eng J Med 326:242-250.
7. Willich SN, Lewis M, Lowel H, et al. [1993]. Physical exertion as a trigger of acute myocardial infarction. N Eng J Med 329:1684-1690.
8. Mittleman MA, Maclure M, Tofler GH, et al. [1993] Triggering of acute myocardial infarction by heavy physical exertion. N Eng J Med 329:1677-1683.
9. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. N Eng J Med 311:874-877.
10. Tofler GH, Muller JE, Stone PH, et al. [1992] Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. J Am Coll Cardiol 20:1049-1055.
11. Ainsworth BE, Haskell WL, Leon AS, et al [1993]. Compendium of physical activities:



Fatality Assessment and Control Evaluation Investigative Report #F2004-09

Fire Fighter-Driver/Engineer Suffers Heart Attack and Dies at the End of his 24-hour Shift - Hawaii

- classification of energy costs of human physical activities. *Med Sci Sports Exerc* 25:1:71-80.
12. American Industrial Hygiene Association Journal [1971]. Ergonomics guide to assessment of metabolic and cardiac costs of physical work. *Am Ind Hyg Assoc J* 560-564.
13. NFPA [2003]. Standard on comprehensive occupational medical program for fire departments. Quincy MA: National Fire Protection Association. NFPA 1582-2003.
14. American College of Cardiology/American Heart Association [2002]. ACC/AHA 2002 guideline update for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). Gibbons RJ, Balady GJ, Bricker JT, et al., eds. Bethesda, MD.
15. Plowman SA, Smith DL [1997]. Exercise physiology: for health, fitness and performance. Boston, MA: Allyn and Bacon.
16. NFPA [2000]. Standard on health-related fitness programs for fire fighters. Quincy MA: National Fire Protection Association. NFPA 1583-2000.
17. IAFF, IAFC [2000]. The fire service joint labor management wellness/fitness initiative. Washington: International Association of Fire Fighters, International Association of Fire Chiefs.
18. NFPA [1997]. Standard on fire department occupational safety and health program. Quincy MA: National Fire Protection Association. NFPA 1500-1997.

INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by J. Scott Jackson, MSN, Occupational Health Nurse Practitioner and Thomas Hales, MD, MPH. Mr. Jackson and Dr. Hales, are with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located in Cincinnati, Ohio.