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Death in the line of duty...

NIOSH
Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation *August, 2014*

Fire Chief Suffers Fatal Heart Attack While Fighting a Residential Structure Fire – Arkansas

Executive Summary

On the morning of January 28, 2014, a 53-year-old male career fire chief ("Chief") began his 9-hour shift. During the morning he spent over an hour fighting a grass fire using an attack line to knock down the flames and then wildland fire suppression tools to extinguish hot spots. During the ride back to the fire station, the Chief reported experiencing heartburn.

At 1214 hours, the Chief used his command vehicle to respond to another grass fire. When the Chief arrived, the fire had spread to the land owner's residence. While waiting for the fire department's engine to arrive, the Chief began exterior fire attack. Once the engine arrived, the Chief and a lieutenant donned their self-contained breathing apparatus (SCBA) and began interior fire attack. During the attack, the Chief appeared sluggish and somewhat disoriented and did not communicate well. After about 15 minutes, the Chief's and the lieutenant's SCBA low air alarms sounded, and both exited the structure. Once outside, the Chief reported feeling sick and called the emergency medical services (EMS) director who recommended he come to their headquarters for an electrocardiogram (EKG).

The Chief drove the command vehicle to headquarters with a mutual aid fire fighter as a passenger. He underwent an EKG, which revealed changes consistent with an acute heart attack. He was loaded into an ambulance for transport to the emergency department (ED) (1423 hours). Approximately 5 minutes into the transport, the Chief suffered cardiac arrest. Cardiopulmonary resuscitation (CPR) and advanced life support were begun, which included multiple defibrillation attempts, intubation, intravenous line placement, and cardiac resuscitation medications. The Chief was still in cardiac arrest when the ambulance arrived at the ED (1441 hours).

After approximately 10 minutes of treatment in the ED, the Chief regained a heart rhythm and pulse. He was taken (1522 hours) to the cardiac catheterization lab where he was found to have 100% blockage of his proximal left anterior descending (LAD) coronary artery. Percutaneous transluminal coronary angioplasty successfully opened the blockage; a stent was placed to keep the LAD artery open. Approximately 1 hour after being transferred to the intensive care unit, the Chief suffered another cardiac arrest (1735 hours). Subsequent resuscitation efforts were unsuccessful, and the Chief was pronounced dead at 1800 hours.

The death certificate and autopsy report, both completed by the associate state medical examiner, listed "hypertensive atherosclerotic cardiovascular disease" as the cause of death. Given the Chief's underlying heart disease, NIOSH investigators concluded that the physical stress of performing interior fire suppression in turnout gear with SCBA probably triggered his heart attack.

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Executive Summary (cont.)

Had the first two of the following recommendations been followed, the Chief's death may have been prevented.

Conduct exercise stress tests as part of the fire department medical evaluation program for fire fighters at increased risk for coronary heart disease (CHD).

Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

The recommendations below address general safety and health issues.

Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Provide fire fighters with medical clearance to wear a self-contained breathing apparatus as part of the fire department's medical evaluation program.

Conduct annual respirator fit testing.

Ensure fire attack team continuity.

Introduction & Methods

On January 28, 2014, a 53-year-old male career fire chief suffered a heart attack while fighting a structure fire and died a few hours later. NIOSH was notified of the fatality by the U.S. Fire Administration on January 29, 2014. NIOSH contacted the affected fire department on February 3, 2014, to gather additional information and on February 6, 2014, to initiate the investigation. On February 18, 2014, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program traveled to Arkansas to investigate the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Acting fire chief
- Crew members
- Chief's spouse

NIOSH personnel reviewed the following documents:

- FD standard operating procedures
- FD annual report for 2013
- Primary care physician records
- Emergency medical service (ambulance) report
- Hospital ED report
- Procedure note from the catheterization lab
- Progress note from the hospital intensive care unit
- Death certificate
- Autopsy report

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Investigative Results

Incident. The Chief arrived for duty at his fire station at 0800 hours for a 9-hour shift. Weather conditions included a temperature of 11 degrees Fahrenheit (°F), relative humidity of 42%, with a wind chill factor of −14°F [NOAA 2014].

At 0835 hours, the fire department was dispatched to a grass fire, and a lieutenant and the Chief responded in the brush truck. Upon arrival at the scene, the Chief manned the attack line while the lieutenant drove the brush truck. Once the flames were knocked down, they both used wildland fire suppression tools to extinguish hot spots. The fire was declared under control at 0945 hours. During the drive back to the fire station, the Chief reported experiencing heartburn.

At 1214 hours, the fire department was dispatched to another grass fire, and the lieutenant drove the brush truck as the Chief responded in the command vehicle. Weather conditions at this time included a temperature of −5°F, relative humidity of 33%, with a wind chill factor of −34°F [NOAA 2014]. The lieutenant arrived first and noted that the fire had spread to the owner's residence (1222 hours). The lieutenant notified dispatch of the structure fire, and requested dispatch to send the fire department's Engine 3 and to request mutual aid. The Chief arrived a few moments after the lieutenant. Wearing full turnout gear, the Chief began exterior fire attack.

A few minutes later Engine 3 and the mutual aid fire fighters arrived. The Chief and the lieutenant donned SCBAs and stretched 150 feet of 1¾-inch hoseline as they continued exterior fire attack. Once the hoseline was stretched, they entered the structure with the Chief at the rear pulling hoseline into the structure (about 1245 hours). About 10 minutes later, without notifying the lieutenant, the Chief exited the structure to get a ventilation fan, which he turned on and placed at the front door. As he re-entered the structure, the lieutenant noted the Chief appeared sluggish and seemed somewhat disoriented. Later, the Chief's SCBA low air alarm sounded, and he told the lieutenant that he was leaving the structure. The lieutenant continued interior fire attack but exited the structure when his low air alarm sounded a few minutes later.

Outside the structure, the Chief reported that his indigestion was getting worse and that he called the EMS director to discuss his symptoms (1358 hours). The director suggested an evaluation, and the Chief drove the command vehicle with a mutual aid fire fighter as a passenger to EMS headquarters.

At 1418 hours the Chief walked into the EMS headquarters and sat on a couch. The paramedic found the Chief sweating heavily, short of breath, and belching often. A cardiac monitor revealed a lateral ST segment elevation consistent with a heart attack (myocardial infarction). His vital signs included a blood pressure of 162/102 millimeters of mercury, a pulse rate of 110 beats per minute, and a respiratory rate of 30 breaths per minute. The Chief reported left arm tingling, nausea, and chest pain. The paramedic advised immediate transport for an acute heart attack.

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Investigative Results (cont.)

At 1423 hours the Chief was placed into the ambulance, which departed for the ED. En route the Chief was given an aspirin and sublingual nitroglycerin as an intravenous line was placed and oxygen administered by nasal cannula. At approximately 1430 hours, the Chief became unresponsive, with no pulse or respirations. The cardiac monitor revealed ventricular fibrillation, and one shock was administered, which changed the Chief's heart rhythm to pulseless electrical activity. He was intubated with tube placement verified by capnography [Neumar et al. 2010]. During the remaining 11 minutes of transport, the Chief regained a weak pulse on three separate occasions, but each time he reverted to cardiac arrest, and CPR continued.

The ambulance arrived at the ED at 1441 hours. Inside the ED, cardiac resuscitation efforts continued for an additional 10 minutes when the Chief regained a heartbeat but remained unconscious (1451 hours). He was taken to the cardiac catheterization lab at 1522 hours for emergent coronary angiography revealing the following:

- a thrombus (blood clot) totally occluding the proximal portion of his LAD coronary artery
- no significant narrowing of his other two main coronary arteries (right and circumflex)
- reduced left ventricular function (ejection fraction of 35%–30%; normal varies by lab, but generally >55%) with moderate to severe anterior hypokinesis

The LAD blockage was successfully opened by percutaneous transluminal coronary angioplasty followed by a second generation drug-eluting stent to keep the LAD artery open. He was transferred to the intensive care unit at approximately 1630 hours. At approximately 1735 hours, the Chief had another cardiac arrest. Despite CPR and advanced life support in the intensive care unit for approximately 30 minutes, the Chief was pronounced dead at 1800 hours.

Medical Findings. The death certificate and autopsy report, both completed by the associate state medical examiner, listed "hypertensive arteriosclerotic cardiovascular disease" as the cause of death. Autopsy findings were significant for a fresh thrombus inside the LAD stent partially occluding the lumen. Blood analysis showed no elevation of carboxyhemoglobin levels, suggesting the Chief did not have carbon monoxide poisoning. Additional pertinent autopsy findings are listed in Appendix A.

The Chief was 71 inches tall and weighed 242 pounds, giving him a body mass index of 33.7 kilograms per meters squared [CDC 2014]. According to medical records, the Chief's risk factors for CHD included hypertension (diagnosed in 2009 but not controlled well until 2012) and obesity. Prior to this incident the Chief never complained of chest pain, although he did have a 2-year history of gastroesophageal reflux disease treated with Prilosec®.

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Description of the Fire Department

At the time of the NIOSH investigation, the fire department consisted of one fire station with 6 career and 11 volunteer uniformed personnel. The fire department served 8,000 residents in a geographic area of 100 square miles. In 2013, the fire department responded to 177 incidents: 90 fire calls, 58 rescue/emergency medical calls, and 29 other calls including hazardous conditions, false alarms, and service calls.

Membership and Training. The fire department requires career fire fighter applicants to be 21 years of age, be a high school graduate or have a GED certificate, have a valid state driver's license, and pass the following: a background check, an interview, a candidate physical ability test (Appendix B), a preplacement medical evaluation (contents described below), and a drug screen. If selected, the applicant is provided a conditional job offer. The new hire must then complete the Arkansas Fire Academy within 1 year to become trained as a fire fighter II and driver/operator. The new hire works 24 hours on duty, 48 hours off-duty for 3 weeks, then works 0730–1630 hours Monday through Thursday the fourth week.

The Chief worked Monday through Friday, 0800–1700 hours. He was certified as a fire fighter II, driver/operator, emergency medical technician, fire officer, fire investigator, fire instructor, fire inspector, wildland fire fighter, and hazardous materials technician, and was certified in technical rescue. He had 28 years of fire fighting experience.

Preplacement and Periodic Medical Evaluations. The fire department requires preplacement medical evaluations for all applicants. Components of this evaluation include a complete medical history and a physical examination, including vital signs – height, weight, blood pressure, pulse, and respirations.

The medical evaluations are performed by the applicant's personal physician. Additional medical testing is at the discretion of the examining physician. Once the medical evaluation is complete, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the fire department.

Annual medical evaluations are not required. The Chief's last medical evaluation was performed by his primary care physician in August 2013 for a medical condition unrelated to this incident. Medical clearance to wear a respirator is not required. Members injured on duty or who become ill and miss work must be evaluated by their personal physician who forwards his or her determination for return-to-duty to the fire department. Members who have an illness or temporary disability and miss more than three consecutive tours must be evaluated by their primary care physician, who forwards his or her opinion regarding return-to-duty to the fire department; the fire department makes the final determination regarding return-to-duty.

Health and Wellness Programs. The fire department has a voluntary wellness/fitness program, and exercise equipment is available in the fire station. An annual job performance physical ability test is required for members (Appendix B). The Chief participated in physical fitness activities 5 days each week.

Discussion

Atherosclerotic Coronary Heart Disease. In the United States, atherosclerotic CHD is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development include age older than 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes [NHLBI 2012; AHA 2014]. The Chief had two modifiable CHD risk factors (high blood pressure and obesity), and his cardiac catheterization and autopsy revealed thrombotic lesions occluding his LAD coronary artery.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2008]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion [Shah 1997]. Heart attacks (myocardial infarctions) typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply [Fuster et al. 1992]. This sudden blockage is primarily due to blood clots (thrombosis) forming on top of atherosclerotic plaques. On the basis of the characteristic changes on his EKG (ST-segment elevation) and the acute thrombotic lesion in his LAD coronary artery, the Chief had an acute heart attack.

The Chief underwent emergent percutaneous transluminal coronary angioplasty followed by the placement of a second generation drug-eluting stent in the LAD coronary artery. Although first generation drug-eluting stents reduced the incidence of restenosis (i.e., the buildup of atherosclerotic plaque inside the stent) [Baim 2008], they did not reduce the incidence of stent thrombus formation [Lüscher et al. 2007; Mauri et al. 2007; Baim 2008; Hao et al. 2010]. Second generation drug-eluting stents are reported to have lower thrombosis rates (<1%), but this case illustrates that stent thrombosis remains a serious complication [Palmerini et al. 2013].

Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Heart attacks in fire fighters have been associated with alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The Chief had performed exterior fire suppression and pulled the fire attack hose inside the structure while wearing full turnout gear and SCBA (on-air). This activity expended about 12 metabolic equivalents, which is considered heavy physical activity [Gledhill and Jamnik 1992; Ainsworth et al. 2011].

Occupational Medical Standards for Structural Fire Fighters and Exercise Stress Test. To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the National Fire Protection Association (NFPA) developed NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire

Discussion (cont.)

Departments [NFPA 2013]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The Chief's underlying CHD was not identified until this incident. On the basis of the Chief's age and history of high blood pressure, the NFPA and the American College of Cardiology/American Heart Association (ACC/AHA) would have recommended a symptom limiting exercise stress test (EST) to screen for CHD. However, recommendations for ESTs on asymptomatic individuals without known heart disease are varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

NFPA 1582, a voluntary industry standard, recommends an EST performed "as clinically indicated by history or symptoms" and refers the reader to Appendix A [NFPA 2013]. Items in Appendix A are not standard requirements, but are provided for "informational purposes only." Appendix A recommends using submaximal (85% of predicted heart rate) EST as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (i.e., symptom-limiting) EST with imaging should be used for fire fighters with the following conditions:

- abnormal screening submaximal tests
- cardiac symptoms
- known coronary artery disease (CAD)
- one or more risk factors for CAD (in men older than 45 and women older than 55)

Risk factors are defined as hypercholesterolemia (total cholesterol greater than 240 milligrams per deciliter), hypertension (diastolic blood pressure greater than 90 mm of mercury), smoking, diabetes mellitus, or family history of premature CAD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old).

The ACC/AHA has also published exercise testing guidelines [Gibbons et al. 2002]. The ACC/AHA guideline states that the evidence to conduct stress tests in asymptomatic individuals is "less well established" (Class IIb) for the following groups:

- persons with multiple risk factors (defined similarly to those listed by the NFPA)
- asymptomatic men older than 45 years and women older than 55 years:
    - who are sedentary and plan to start vigorous exercise
    - who are involved in occupations in which impairment might jeopardize public safety (e.g., fire fighters)
    - who are at high risk for coronary artery disease due to other diseases (e.g., peripheral vascular disease and chronic renal failure)

The U.S. Department of Transportation provides guidance for those seeking medical certification for a commercial driver's license. An expert medical panel recommended exercise tolerance tests (stress tests) for asymptomatic "high risk" drivers [Blumenthal et al. 2007]. The panel defines high risk drivers as those with any of the following:

- diabetes mellitus
- peripheral vascular disease
- age 45 and above with multiple risk factors for coronary heart disease
- Framingham risk score predicting a 20% coronary heart disease event risk over the next 10 years

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Discussion (cont.)

The U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals at low risk for coronary heart disease events. For individuals at increased risk for coronary heart disease events, the USPSTF found "insufficient evidence to recommend for or against routine screening with EKG, exercise tolerance test, or electron beam computerized tomography scanning…." Rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes) [USPSTF 2004]. The USPSTF does note that "For people in certain occupations, such as pilots, and heavy equipment operators (for whom sudden incapacitation or sudden death may endanger the safety of others), consideration other than the health benefit to the individual patient may influence the decision to screen for coronary heart disease."

Had an EST been performed as recommended by NFPA and AHA/ACC, perhaps the Chief's CHD could have been identified, leading to further evaluation and treatment.

Recommendations

Had the first two of the following recommendations been followed, the Chief's death may have been prevented.

Recommendation #1: Conduct exercise stress tests for fire fighters at increased risk for coronary heart disease.

NFPA 1582, the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, and the ACC/AHA recommend an exercise stress test for male fire fighters older than 45 with one or more coronary artery disease risk factors [IAFF, IAFC 2008; Gibbons et al. 2002; NFPA 2013]. The Chief was over the age of 45 and had one modifiable risk factor for CHD (high blood pressure). A symptom-limiting exercise stress test may have identified his underlying CAD, possibly leading to further evaluation and treatment.

Recommendation #2: Provide preplacement and annual medical evaluations to all fire fighters in accordance with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.

Guidance regarding the content and frequency of these medical evaluations can be found in NFPA 1582 and in the International Association of Fire Fighters (IAFF)/International Association of Fire Chiefs (IAFC) Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC 2008; NFPA 2013]. These evaluations are performed to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. Following this recommendation will require significant resources and may be particularly difficult for smaller fire

Recommendations (cont.)

departments to implement. The fire department is not legally required to follow the NFPA standard or the IAFF/IAFC guideline.

To overcome the financial obstacle of medical evaluations, the fire department could urge current members to get annual medical clearances from their private physicians. Another option is having the annual medical evaluations completed by paramedics and emergency medical technicians from the local ambulance service (vital signs, height, weight, visual acuity, and EKG). This information could then be provided to a community physician (perhaps volunteering his or her time), who could review the data and provide medical clearance (or further evaluation, if needed). The more extensive portions of the medical evaluations (e.g., EST) could be performed by a private physician at the fire fighter's expense (personal or through insurance), provided by a physician volunteer, or paid for by the fire department, city, or state. Sharing the financial responsibility for these evaluations between fire fighters, the fire department, the city, the state, and physician volunteers may reduce the negative financial impact on recruiting and retaining needed fire fighters.

The recommendations below address general safety and health issues.

Recommendation #3: Ensure that fire fighters are cleared for return to duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the various components of NFPA 1582.

Guidance regarding medical evaluations and examinations for structural fire fighters can be found in NFPA 1582 and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/ Fitness Initiative [IAFF, IAFC 2008; NFPA 2013]. According to these guidelines, the fire department should have an officially designated physician who is responsible for guiding, directing, and advising the members with regard to their health, fitness, and suitability for duty. The physician should review job descriptions and essential job tasks required for all fire department positions and ranks to understand the physiological and psychological demands of fire fighters and the environmental conditions under which they must perform, as well as the personal protective equipment they must wear during various types of emergency operations. The fire department currently uses the member's personal physician to initially clear fire fighters injured on duty or who miss work because of a lengthy illness. The extent of these physicians' knowledge of the fire fighting duties or their awareness of the voluntary standards issued by NPFA is unknown.

Recommendation #4: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Guidance for fire department wellness/fitness programs to reduce risk factors for cardiovascular disease and improve cardiovascular capacity is found in NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, the IAFF/ IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative, and in Firefighter Fitness: A Health and Wellness Guide [IAFF, IAFC 2008; NFPA 2008; Schneider 2010]. Worksite health promotion programs have

Recommendations (cont.)

been shown to be cost effective by increasing productivity, reducing absenteeism, and reducing the number of work-related injuries and lost work days [Pelletier 2009; Baicker et al. 2010]. Fire service health promotion programs have been shown to reduce CAD risk factors and improve fitness levels, with mandatory programs showing the most benefit [Dempsey et al. 2002; Womack et al. 2005; Blevins et al. 2006; Poston et al. 2013]. A study conducted by the Oregon Health and Science University reported a savings of more than $1 million for each of four large fire departments implementing the IAFF/IAFC wellness/fitness program compared to four large fire departments not implementing a program. These savings were primarily due to a reduction of occupational injury/illness claims with additional savings expected from reduced future nonoccupational healthcare costs [Kuehl et al. 2013].The fire department currently has a voluntary wellness/fitness program, and exercise equipment is available in the fire station. However, NIOSH recommends a formal, mandatory wellness/fitness program to ensure all members receive the benefits of a health promotion program.

Recommendation #5: Provide fire fighters with medical clearance to wear SCBA as part of the fire department's medical evaluation program.

The Occupational Safety and Health Administration (OSHA) Revised Respiratory Protection Standard requires employers to provide medical evaluations and clearance for employees using respiratory protection [29 CFR 1910.134]. These clearance evaluations are required for private industry employees and public employees in states operating OSHA-approved state plans. Arkansas does not operate an OSHA-approved state plan; therefore the fire department is not required to ensure all members have been medically cleared to wear an SCBA [OSHA 2013]. However, we recommend voluntary compliance with this recommendation to improve fire fighter health and safety.

Recommendation #6: Conduct annual respirator fit testing.

The OSHA respiratory protection standard requires employers whose employees are required to use a respirator (e.g., an SCBA) to have a formal respiratory protection program, including annual fit testing [29 CFR 1910.134]. Therefore, members should have their own SCBA facepiece, or the fire department would have to ensure enough facepieces of each size were made available on each fire apparatus. As mentioned previously, Arkansas does not operate an OSHA-approved State plan; therefore, the fire department is not required to follow OSHA standards [OSHA 2013]. Nevertheless, NIOSH investigators recommend voluntary compliance with this standard to ensure proper fitting personal protective equipment to improve safety and health.

Recommendation #7: Ensure fire attack team continuity.

Interior fire attack teams should consist of at least two fire fighters, depending on the type of structure, size of the hoseline, and distance to reach the fire. A fire fighter should not operate alone inside a structure [IFSTA 2013]. In this case, the Chief left the structure to obtain a ventilation fan, leaving the lieutenant alone inside the burning structure.

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Investigator Information

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component in Cincinnati, Ohio. Mr. Tommy Baldwin (MS) led the investigation and co-authored the report. Mr. Baldwin is a Safety and Occupational Health Specialist, a National Association of Fire Investigators (NAFI) Certified Fire and Explosion Investigator, an International Fire Service Accreditation Congress (IFSAC) Certified Fire Officer I, and a former Fire Chief and Emergency Medical Technician. Dr. Thomas Hales (MD, MPH) provided medical consultation and co-authored the report. Dr. Hales is a member of the NFPA Technical Committee on Occupational Safety and Heath, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

Appendix A

Autopsy Findings

- Coronary artery atherosclerosis
  - Thrombus (blood clot) within the stent in the proximal LAD coronary artery
  - 70% narrowing in the distal branch of the LAD
  - 50% focal narrowing of the left circumflex coronary artery
  - 40% focal narrowing of the right coronary artery
- Hypertensive heart disease
  - Cardiomegaly (enlarged heart; heart weighed 640 grams [g]; predicted normal weight is 410 g [ranges between 311 g and 541 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Carboxyhemoglobin blood level of 5% (considered normal in this laboratory)
- Blood tests for drugs and alcohol were negative.

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Appendix B

Candidate and Annual Physical Ability Test (pass/fail)

1. Drag 3-inch uncharged hoseline 100 feet.

2. Roll the hose into a donut, unroll the hose, place a nozzle on the hoseline.

3. Advance the hoseline to the chopping block.

4. Using the axe, strike the chopping block five to six times.

5. Walk to the ladder. Climb the ladder and perform a leg lock. Descend the ladder.

6. Drag a 175-pound manikin 100 feet.