2015
04

Death in the line of duty...

NIOSH Fire Fighter Fatality Investigation and Prevention Program

A summary of a NIOSH fire fighter fatality investigation

July 31, 2015

Captain Suffers Heart Attack During Fire Suppression and Dies Two Days Later- Texas

Executive Summary

On February 19, 2015, a 56-year-old male career Captain was dispatched to a house fire. At the scene, the Captain and a fire fighter, both wearing full turnout gear and self-contained breathing apparatus (SCBA), stretched a 1¾-inch hoseline to a window and sprayed water through the window's burglar bars. After another crew opened the burglar bars on the front door, the Captain and other fire fighters entered the house to continue fire suppression. After approximately 10 minutes, the Captain exited the house, remarking that he could not breathe and was having chest pains. After sitting on Ladder 46's bumper, he removed his SCBA and turnout gear. When moved to a stretcher, he became unresponsive, and lost his pulse and respirations. On scene ambulance paramedics provided advanced life support (cardiac monitoring, intravenous [IV] line placement, IV medications, and rescue airway) which continued en route to the local hospital's emergency department (ED). The ambulance arrived at the ED at 1945 hours where an acute heart attack with complications of cardiogenic shock was confirmed. Despite 24 hours of life support, the Captain suffered irreversible anoxic brain damage. In consultation with the family, life support was removed and the Captain died on February 21, 2015.

The death certificate and autopsy report listed "complications of myocardial infarct [myocardial infarction] due to hypertensive and atherosclerotic cardiovascular disease" as the cause of death. The autopsy report also listed obesity and diabetes mellitus as contributory factors. Given the Captain's underlying and undiagnosed heart disease, NIOSH investigators concluded that the physical stress of his activities at the structure fire triggered his heart attack, which resulted in his cardiac death.

Key Recommendations

- *Provide annual medical evaluations to all fire fighters consistent with NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments, to identify fire fighters at increased risk for coronary heart disease (CHD)*
- *Perform symptom-limiting exercise stress tests (ESTs) on firefighters at increased risk for CHD and sudden cardiac events*
- *Ensure that fire fighters are cleared for duty by a physician knowledgeable about the physical demands of fire fighting, the personal protective equipment used by fire fighters, and the components of NFPA 1582*
- *Perform an annual physical ability evaluation*
- *Phase in a mandatory comprehensive wellness and fitness program for fire fighters.*

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The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. In 1998, Congress appropriated funds to NIOSH to conduct a fire fighter initiative that resulted in the NIOSH "Fire Fighter Fatality Investigation and Prevention Program" which examines line-of-duty-deaths or on duty deaths of fire fighters to assist fire departments, fire fighters, the fire service and others to prevent similar fire fighter deaths in the future. The agency does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of fire departments and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the victim, the fire department or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit.

For further information, visit the program website at www.cdc.gov/niosh/fire or call toll free 1-800-CDC-INFO (1-800-232-4636).

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Introduction

On February 19, 2015, a 57-year-old male career Captain suffered a heart attack while fighting a house fire and died 2 days later. NIOSH was notified of this fatality on February 23, 2015, by the U.S. Fire Administration. NIOSH contacted the affected fire department (FD) on February 26, 2015, to gather additional information and on March 3, 2015, to initiate the investigation. On March 16, 2015, a safety and occupational health specialist from the NIOSH Fire Fighter Fatality Prevention and Investigation Program conducted an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Fire Chief
- Assistant Chief
- District Chief (DC) of Emergency Response – Special Events
- Arson investigators
- FD Emergency Medical Services Assistant Director
- Black Professional Fire Fighters Association President
- FD Member Advocate

NIOSH personnel reviewed the following documents:

- FD standard operating guidelines
- FD annual report for 2014
- Emergency medical service (ambulance) report
- Hospital ED records
- Hospital intensive care unit records
- Death certificate
- Autopsy report
- FD medical evaluation records
- Primary care physician records
- FD SCBA records

Investigation

On February 19, 2015, the Captain arrived at his fire station at about 0545 hours for his 24-hour shift. Throughout the day, Engine 46 responded to eight calls (one residential structure fire, six medical calls, and one vehicle accident). Between emergency responses, the Captain performed station duties and equipment checks.

At 1848 hours, Engine 46, Engine 35, Engine 24, Engine 26, Ladder 46, Ladder 33, Squad 46, Medic 40, DC 46, and DC 26 were dispatched to a residential structure fire with possible entrapment. Units responded at 1850 hours and began to arrive at 1852 hours (Engine 46 at 1906 hours) to find heavy

smoke showing from the front of a single story duplex. DC 46 assumed incident command as Ladder 46 crewmembers conducted an initial size-up with a 360º walkaround.

Ladder 46 and Engine 25 crewmembers forced entry into the building, having to cut through burglar bars on the windows and entry door, and performed a primary search (no victims were located). Engine 46 crewmembers began an offensive attack. As the crew entered the door, the door fell partially down; the Captain grabbed the door and dragged it out into the yard. Ladder 33 crewmembers ventilated the roof as Engine 35 crewmembers laid a supply line into Engine 46; Engine 24 and Engine 46 were assigned fire attack. As the DC received reports from bystanders of persons possibly trapped inside the building, Engine 26 was assigned as the rapid intervention team. Personnel accountability was established. DC 26 arrived and became Alpha Division command.

At approximately 1935 hours, DC 26 reported that the fire was extinguished. The Captain exited the structure alone and, after removing his SCBA facepiece, remarked that he could not breathe and was having chest pains with dizziness and light-headedness. As the Captain staggered to Ladder 46's bumper, crewmembers assisted with the removal of his turnout gear and SCBA. DC 46 was notified and ordered Engine 46's crew outside and added Rescue 42 to the incident.

The Captain was assisted to the stretcher where oxygen was administered via bag-valve-mask. Cardiac monitoring revealed a heartrate of 56 beats per minute (normal 60-100) which soon dropped into the 30's with no pulse; CPR was begun. Intraosseous and left forearm IV lines were started and a Cyanokit® was administered for possible cyanide poisoning. Intubation was attempted but not successful due to emesis. A King tube® was then placed with proper tube placement confirmed by end tidal CO_2, equal chest rise and fall, and breath sounds [Neumar et al. 2010]. Cardiac resuscitation medications were administered as a blood sugar reading of 230 milligrams per deciliter (mg/dL) was revealed. He was placed into Medic 40 which departed the scene at 1943 hours en route to the hospital's ED. A cardiac monitor revealed ventricular fibrillation and a shock was administered, reverting to pulseless electrical activity.

Medic 40 arrived at the ED (1945 hours) where advanced life support continued with endotracheal intubation. A heart attack was confirmed by elevated cardiac enzymes [creatine kinase level of 597 units per liter (normal is 12-191), a creatine kinase-myocardial band level of 57.9 nanograms per milliliter (normal is 0.5-3.6), and a Troponin I level of 3.74 nanograms per milliliter (normal is <0.40)]. The Captain had no heart rhythm (pulseless electrical activity) and was in cardiogenic shock. Extracorporeal membrane oxygenation (ECMO) (a heart and lung machine) was initiated and the Captain was transferred to the intensive care unit. He was cooled for 24 hours and rewarmed, at which point his neurological status was reassessed. A computed tomography scan showed a significant anoxic brain injury and cerebral edema. A neurological assessment determined that he lacked higher level brain functioning due to irreversible brain injury. In consultation with the family, mechanical support for ventilation and circulation was discontinued and the Captain was pronounced dead on February 21, 2015, at 1815 hours.

Medical Findings

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The death certificate and autopsy report listed "complications of myocardial infarct [myocardial infarction] due to hypertensive and atherosclerotic cardiovascular disease" as the cause of death. The autopsy report listed obesity and diabetes mellitus as contributory factors.

The Captain had the following medical conditions:

Hypertension (Stage II) - first diagnosed in 2008 and began prescription anti-hypertensive medication in 2008. Despite treatment, his blood pressure remained elevated; his last clinic reading on September 6, 2013 was classified as Stage II, 170/100 millimeters of mercury (normal is 120/80) (Stage II is >160 mmHg systolic or > 100 mmHg diastolic).

Type 2 diabetes mellitus – first diagnosed in 2008 and treated with diet and oral medications. His most recent blood glucose reading on September 6, 2013 was 156 milligrams per deciliter (mg/dL) (normal is 65-99 mg/dL) and his hemoglobin A1c blood level was 7.6% (normal is <7.0%) (suggesting fair to poor control of the diabetes).

Hyperlipidemia – first diagnosed in 2008 and prescribed a lipid-lowering medication in 2010. Despite treatment, his most recent (September 6, 2013) readings included an elevated blood cholesterol level of 234 mg/dL (normal is < 200 mg/dL), a normal triglyceride blood level of 127 mg/dL, an elevated blood low density lipoprotein (LDL) level of 161 mg/dL (normal is <130 mg/dL), and a normal blood high density lipoprotein (HDL) level of 48 mg/dL.

Obesity – The Captain was 74 inches tall and weighed 321 pounds at his primary care physician visit in September 2013, giving him a body mass index of 41.2 kilograms per meters squared [CDC 2014].

Abnormal Electrocardiograms (EKGs) – An EKG in 2008 revealed electrical problems (premature atrial complexes, complete right bundle branch block, and left anterior fascicular block), left ventricular hypertrophy (LVH), and a possible old (remote) infarct (heart attack) in the anteroseptal region of the heart.

Fire Department

At the time of the NIOSH investigation, the FD consisted of 93 fire stations with 3,854 career uniformed personnel. The FD served 2.2 million residents in a geographic area of 627 square miles. In 2014, the FD responded to 325,479 incidents (an average of 891 per day): 43,352 fire incidents and 282,127 emergency medical incidents. The average response time for the first unit on scene was less than 6 minutes.

Employment, Training, and Experience

The FD requires all applicants to pass a written test, attend applicant orientation, have fingerprints taken, pass a candidate physical ability test (see Appendix B), pass a questionnaire/interview, pass a polygraph examination, and pass a background investigation prior to receiving a conditional job offer. The new member must then pass a preplacement medical evaluation (components described below)

and a drug test. The FD requires new "fire fighter/emergency medical technician" applicants to be 18-36 years of age, have a valid state driver's license with two or fewer moving violations in the last 36 months, complete 60 accredited transferable college hours with a grade of "C" or higher OR 2 years of full time (active duty) military service with an honorable discharge The new member then enters the 8-month fire fighter academy to be trained to the Basic Fire Fighter level. Additional training to the Fire Fighter 1 and 2 level is provided through continuing education and on-the-job training.

The FD requires new "certified fire fighter/emergency medical technician" applicants to be 18-36 years of age, have a Texas Commission on Fire Protection Certification – Basic Fire Fighter or higher certification, have a valid state driver's license with two or fewer moving violations in the last 36 months, complete 15 accredited transferable college hours with a grade of "C" or higher. The new member then enters a 2½-month fire fighter academy to be trained to the Fire Fighter 1 and 2 level. After completing the academy, new employees work the following shifts: 24 hours on duty, 24 hours off duty, 24 hours on duty, 5 days off. Each month, members also work a "debit day" in addition to their regular shift.

The Captain was certified as a Fire Fighter-Advanced, Fire Officer 1 and 2, Field Examiner, and Apparatus Operator. He had 37 years of fire fighting experience and was promoted to Captain in February 2008**.**

Medical Evaluations

Preplacement Medical Evaluations

The FD requires preplacement medical evaluations for all applicants. Components of this evaluation include the following:

- Complete medical history
- Physical examination (including vital signs)
- Complete blood count with lipid panel
- Pulmonary function test
- Audiogram
- Vision screen
- Urinalysis
- Urine drug screen

The evaluation is performed by a physician contracted with the City. Once this evaluation is complete, the contracted physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the City's personnel director and the FD. It is unclear if the Captain had a preplacement medical evaluation when he joined the FD in 1977.

Annual/Promotional Medical Evaluations

Promotional medical evaluations are required by the FD. Annual medical evaluations are voluntary and are provided at no cost to the fire fighter through the FD's health insurance plan. The results of these evaluations are not shared with the FD. The Captain was promoted in 2008 and had a promotional

medical evaluation in February 2011. However, only a questionnaire was located in his medical records.

Medical clearance to wear SCBA is not required. Members injured on duty must be evaluated by the worker's compensation physician and the results are provided to City risk management, who makes the final determination regarding return to work.

Wellness/Fitness Programs

Fitness equipment (strength and aerobic) is available in the fire stations. Members are encouraged to exercise 3 hours a week while on-duty. The Captain participated in the FD's fitness program by walking vigorously and lifting weights on each shift. The FD does not have a comprehensive wellness/fitness program as recommended by the IAFF/IAFC Wellness Fitness Initiative [IAFF, IAFC 2008].

DISCUSSION

Sudden Cardiac Events

In the United States, atherosclerotic coronary heart disease (CHD) is the most common risk factor for cardiac arrest and sudden cardiac death [Meyerburg and Castellanos 2008]. Risk factors for its development are grouped into non-modifiable and modifiable. Non-modifiable risk factors include age older than 45, male gender, and family history of coronary artery disease. Modifiable risk factors include diabetes mellitus, smoking, high blood pressure, high blood cholesterol, and obesity/physical inactivity [NHLBI 2014a; AHA 2015]. The Captain had two non-modifiable risk factors and four modifiable CHD risk factors; severe CHD was found during his autopsy.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades [Libby 2013]. However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion. 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. This sudden blockage is primarily due to blood clots (thromboses) forming on top of atherosclerotic plaques [Libby 2013]. Establishing a recent (acute) heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes, or coronary artery thrombus. In this case, the Captain's cardiac enzymes were elevated.

Physiological Stress of Firefighting

Heart attacks and sudden cardiac death are also triggered by heavy physical exertion [Mittleman 1993; Willich 1993; Albert et al. 2000]. Among fire fighters, sudden cardiac events have been associated with/triggered by alarm response, fire suppression, and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The Captain's activities at the structure fire while wearing full turnout gear and SCBA (on-air) expended about 9 metabolic equivalents, which is considered heavy physical activity [Gledhill and Jamnik 1992; Ainsworth et al. 2011]. The heart attack that preceded the Captain's cardiac death was probably triggered by the

physical exertion associated with his activities at the structure fire.

Occupational Medical Standards for Structural Fire Fighters

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 Departments* [NFPA 2013a]. This voluntary industry standard provides the components of a preplacement and annual medical evaluation and medical fitness for duty criteria. The Captain had several conditions addressed by NFPA 1582: 1) poorly controlled Stage II hypertension, 2) poorly controlled type 2 diabetes mellitus, 3) beta-blocker medication, and 4) cardiac arrhythmias.

Hypertension. The Captain fluctuated between Stage I and Stage II hypertension. NFPA 1582 suggests that members with stage I hypertension be referred to their primary care physician to ensure that their blood pressure is controlled and to determine whether screening for end organ damage is indicated [NFPA 2013a]. The Captain's hypertension was diagnosed in 2008, was poorly controlled with medication, and he did not have a complete work-up for end organ damage. However, an EKG did find LVH, one complication of hypertension. LVH is associated with an increased risk of sudden incapacitation and sudden cardiac death [Koren et al. 1991]. The finding of LVH was not communicated to the FD physician, no further evaluation was done, and no restrictions were assigned. The Captain's most recent blood pressure readings were elevated.

NFPA considers that Stage II hypertension (systolic ≥160 mmHg or diastolic ≥ 100 mmHg) or end organ damage (retinopathy, nephropathy, neuropathy, or vascular/cardiac complications) compromises the member's ability to safely perform essential job tasks such as the following: 1) wearing personal protective ensemble and SCBA, performing fire fighting tasks (hoseline operations, extensive crawling, lifting and carrying heavy objects, ventilating roofs or walls using power or hand tools, forcible entry, etc.), rescue operations, and other emergency response actions under stressful conditions, including working in extremely hot or cold environments for prolonged time periods; 2) wearing fire protective ensemble that is encapsulating and insulated, which will result in significant fluid loss that frequently progresses to clinical dehydration and can elevate core temperature to levels exceeding 102.2ºF; 3) wearing personal protective ensemble and SCBA, advancing water-filled hoselines up to 2½-inches in diameter from fire apparatus to occupancy [approximately 150-feet], which can involve negotiating multiple flights of stairs, ladders, and other obstacles; 4) unpredictable emergency requirements for prolonged periods of extreme physical exertion without benefit of warm-up, scheduled rest periods, meals, access to medication(s), or hydration; and 5) functioning as an integral component of a team, where sudden incapacitation of a member can result in mission failure or in risk of injury or death to civilians or other team members. Therefore, according to NFPA 1582, the Captain's Stage II hypertension and LVH should have resulted in work restrictions [NFPA 2013a].

Diabetes Mellitus. NFPA 1582 provides guidance for fire department physicians treating diabetic fire fighters [NFPA 2013a]. The standard states that fire fighters with diabetes mellitus that is controlled by diet, exercise, or oral hypoglycemic agents should be restricted from duty unless the member meets all of the following criteria:

(1) If on oral hypoglycemic agents, has had no episodes of severe hypoglycemia (defined as requiring assistance of another in the preceding year)

(2) Has achieved a stable blood glucose as evidenced by HA_1C level less than 8 during the prior 3-month period

(3) Has a dilated retinal exam by a qualified ophthalmologist or optometrist that shows no higher grade of diabetic retinopathy than microaneurysms

(4) Has normal renal function on the basis of a calculated creatinine clearance greater than 60 milliliters per minute and absence of proteinuria

(5) Has no autonomic or peripheral neuropathy

(6) Has normal cardiac function without evidence of myocardial ischemia on cardiac stress testing (to at least 12 METs) by EKG and cardiac imaging [NFPA 2013a]

The Captain had diabetes mellitus and had not had a dilated retinal exam or an exercise stress test. Therefore, according to NFPA 1582, he should have been restricted from fire fighting duties until these screening tests were conducted.

Beta-Blocker Medication. NFPA 1582 considers use of antihypertensive beta-blockers to compromise the member's ability to safely perform essential job tasks such as the following: 1) wearing fire protective ensemble that is encapsulating and insulated, which will result in significant fluid loss that frequently progresses to clinical dehydration and can elevate core temperature to levels exceeding 102.2^{o}F; and 2) wearing personal protective ensemble and SCBA, climbing ladders, operating from heights, walking or crawling in the dark along narrow and uneven surfaces, and operating in proximity to electrical power lines and/or other hazards due to risk for dehydration, electrolyte disorders, lethargy, and disequilibrium, and the physician shall report applicable job limitations to the FD.

Right Bundle Branch Block. NFPA 1582 states that right bundle branch block might compromise a member's ability to safely perform as an integral component of a team, where sudden incapacitation of a member can result in mission failure or in risk of injury or death to civilians or other team members [NFPA 2013a]. Restrictions should be considered if cardiac structural abnormalities are present (e.g., CHD, valve problems, or heart failure). Given the Captain's diagnosis of LVH by EKG, a further cardiac work-up was indicated.

<u>Exercise Stress Tests</u>
Recommendations on whether to screen asymptomatic individuals for CHD with EST are varied. The following paragraphs summarize the positions of widely recognized organizations on this topic.

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NFPA
NFPA 1582, a voluntary industry standard, recommends an EST be performed "as clinically indicated by history or symptoms" and refers the reader to Appendix A [NFPA 2013a]. 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) ESTs as a screening tool to evaluate a fire fighter's aerobic capacity. Maximal (i.e., symptom-limiting) ESTs with imaging should be used for fire fighters with the following conditions:
- abnormal screening submaximal tests
- cardiac symptoms
- known CHD
- one or more risk factors for CHD (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 CHD (heart attack or sudden cardiac death in a first-degree relative less than 60 years old). Given the Captain's age and risk factors, NFPA 1582 would have recommended a symptom-limiting EST.

American College of Cardiology/American Heart Association (ACC/AHA)
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)

Given the Captain's public safety position, the ACC/AHA criteria suggest an EST would have been appropriate.

U.S. Department of Transportation
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 CHD
- Framingham risk score predicting a 20% CHD event risk over the next 10 years

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The Captain was over age 45, had diabetes mellitus, and had multiple risk factors for CHD. Despite his last Framingham risk score of 15%, the U.S. Department of Transportation would have recommended an EST for a commercial truck driver with a similar profile [NHLBI 2014b].

U.S. Preventive Services Task Force (USPSTF)
The U.S. Preventive Services Task Force (USPSTF) does not recommend stress tests for asymptomatic individuals at low risk for CHD events. For individuals at increased risk for CHD 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."

In summary, the Captain had multiple medical conditions that should have resulted in restricted duty, or at the very least prompted further medical evaluation.

Recommendations

Recommendation #1: Provide annual medical evaluations to all fire fighters in accordance with NFPA 1582,* Standard on Comprehensive Occupational Medical Program for Fire Departments, *to identify fire fighters at increased risk for CHD.

Discussion: 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 2013a]. Although the FD is not legally required to follow the NFPA standard or the IAFF/IAFC guideline, clearly steps need to be taken to ensure the medical ability of fire fighters to perform duties without presenting a significant risk to the safety and health of themselves or others.

Recommendation #2: Perform symptom-limiting ESTs on firefighters at increased risk for CHD and sudden cardiac events.

Discussion: Firefighters with multiple or severe CHD risk factors, or a Framingham risk score > 10%, are at increased risk of a sudden cardiac event [AHA 2014; NHLBI 2014b]. Currently, the FD does not screen members for CHD risk factors nor require aerobic capacity tests or exercise stress tests for fire fighters at increased risk for a sudden cardiac event.

Recommendation #3: Ensure that fire fighters are cleared for 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.

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According to NFPA 1582, the FD 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 [NFPA 2013a]. The physician should review job descriptions and essential job tasks required for all fire department positions 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 FD currently encourages members to use their personal physician through the FD health insurance. Personal physicians may be unaware of the hazardous and physical demands of structural fire fighting and the guidance provided by NFPA 1582 and do not provide medical findings to the FD contract physician.

Recommendation #4: Perform an annual physical ability evaluation.

Discussion: NFPA 1500, *Standard on Fire Department Occupational Safety and Health Program,* requires the FD to develop physical performance requirements for candidates and members who engage in emergency operations [NFPA 2013b]. Members who engage in emergency operations must be annually qualified (physical ability test) as meeting these physical performance standards for structural fire fighters [NFPA 2013b]. Once developed by the FD, this evaluation could be performed as part of the FD annual training program.

Recommendation #5: Phase in a mandatory comprehensive wellness and fitness program for fire fighters.

Discussion: 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 been shown to be cost effective by increasing productivity, reducing absenteeism, and reducing the number of work-related injuries and lost work days [Stein et al. 2000; Aldana 2001]. 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]. 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 FD has an outstanding voluntary wellness/fitness program. However, NIOSH recommends a formal, structured wellness/fitness program to ensure ALL members receive the benefits of a health promotion program. In addition, during exercise time, employees should be taken out of service to ensure uninterrupted member participation.

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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 Health, and Vice-Chair of the Public Safety Medicine Section of the American College of Occupational and Environmental Medicine (ACOEM).

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Captain Suffers Heart Attack During Fire Suppression and Dies Two Days Later- Texas

Appendix A
Autopsy Findings

- Coronary artery atherosclerosis
  - 70% focal narrowing in the proximal left anterior descending coronary artery
  - 75% focal narrowing in the proximal left circumflex coronary artery
  - 75% focal narrowing in the right coronary artery
  - Mottling appearance of the left ventricle and septum
  - Necrotic areas of the posterior septum and right ventricle
  - Acute infarct in the septum with a neutrophilic infiltrate and contraction band formation
- Hypertensive heart disease
  - Cardiomegaly (heart weighed 825 grams [g]; predicted normal weight is 432 g [ranges between 327 g and 570 g as a function of sex, age, and body weight]) [Silver and Silver 2001]
  - Biventricular hypertrophy
    - Concentric left ventricle thickening (1.9 centimeter [cm] and 2.0 cm respectively)
      - Normal at autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]
      - Normal by echocardiographic measurement is 0.6–1.0 cm [Connolly and Oh 2012]
    - Right ventricle thickening (0.9 cm)
      - Normal at autopsy is 0.2–0.7 cm with an average of 0.35–0.39 cm [Hutchins and Anaya 1973; Murphy et al. 1988]
      - Normal by echocardiography 0.7–2.3 cm [Armstrong and Feigenbaum 2001]
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood carboxyhemoglobin level < 5% (suggesting the Captain was not exposed to significant levels of carbon monoxide)
- Negative blood test for drugs and alcohol

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Captain Suffers Heart Attack During Fire Suppression and Dies Two Days Later- Texas

Appendix B
Candidate Physical Ability Test (CPAT)

The test consists of two separate components. The first component is a series of tasks designed to assess important physical abilities necessary for effective job performance as a fire fighter. The second component is a 1.5-mile run. The following section describes both components of the physical ability test and offers information to assist the candidate in preparing.

Component 1: Job Simulation Tasks

The first component of the test contains five job-simulation events that will be times in a continuous series. These events include:

- Ladder Raise
- Stair Climb With Equipment
- Hoseline Hoist
- Equipment Carry
- Victim Rescue (dummy drag)

The following guidelines apply to this component of the CPAT:

- Applicants must wear a self-contained breathing apparatus (SCBA), excluding the facepiece and low-pressure hose, for all elements of the job simulation component. The SCBA weighs approximately 20 pounds.
- Applicants are strongly encouraged to wear athletic shoes (sneakers) and appropriate clothing for physically demanding work. You will be performing physical acts that demonstrate strength, agility, and endurance, and it is important to be outfitted in attire that does not hinder your performance. During the CPAT, you may get dirty and/or wet from maneuvering through the exercises. Plan your dress accordingly.
- Protective gloves are optional and it is the candidate's choice whether or not to use gloves. You may bring your own gloves, kneepads, etc. to use; however, the testing authority reserves the right to inspect all equipment, and to disallow equipment, to ensure that its use does not affect the fair and impartial administration of the CPAT.
- All five elements of this component of the CPAT will be timed in a series. The test has a cutoff time and failure to complete the course in the allowed time will result in disqualification.
- You must not run during the test. Running is not permitted on a working fireground, and it will not be allowed during this test. Failure to heed a first warning not to run may result in disqualification. Running is defined as any time both feet are off the ground at the same time while you are advancing on the course. You may move as fast as you like, while remaining safe, on the stair climb stations as it is not technically possible to run during these components.
- You should hit every stair going up and coming down while climbing the stairs. You may move as quickly as you like and are encouraged to use the hand rails as needed.

- Test monitors will be assigned to time you while on the course. It is acceptable to ask the test monitor questions concerning course rules and layout prior to beginning the course and while on the course.
- You will be allowed as much time as needed to complete each individual component of the CPAT within the maximum allotted time. Should you perform one of the components incorrectly, the test monitor will guide you as to how to correct your actions or to perform the component again. Pay careful attention to the instruction of the test monitor and ask for clarification when needed.
- Unnecessarily dropping, throwing, or other intentional misuse of any of the testing props will be grounds to disqualify a candidate.

The following provides a description and preparation information regarding each of the five events contained in the first component of the CPAT.

1. Ladder Raise. The candidate will raise the fly section of a 24-foot extension ladder using the rope (halyard). The ladder is secured to the rails of the tower staircase. The candidate will use a hand-over-hand technique to extend the fly section of the ladder until the ladder is fully extended. The candidate will then lower the fly section down using a hand-under-hand technique. If the candidate loses control of the halyard (e.g., the rope slips through hands), he/she will be required to perform the event again. While raising and lowering the ladder, the candidate's feet must remain in a 3-foot by 3-foot box that is painted on the ground.

Preparation: To simulate the ladder raise exercise, you can tie a rope securely to a weighted bag and place the rope over a sturdy horizontal bar that is eight to ten feet above the ground. Then you can use the same movements as you would in the ladder raise to bring the weight to the top of the bar and slowly lower it back to the ground.

2. Stair Climb. The candidate will climb up to and back down from the 7th floor of the training tower (6 flights of stairs) while carrying a bundled section of 2½-inch hoseline that weighs 35 pounds. Before entering the tower, the candidate will pick up the bundled hose pack. The candidate must carry this hose pack without dragging it. The candidate should hit every stair going up and coming back down the staircase. When the candidate reaches the 7th floor, he/she will place his/her feet on the landing and then turn around and descend the stairs. The candidate may use the hand rails and may move as fast as he/she chooses on the stairs. Once the candidate exits the tower, he/she should set the hose pack on the ground.

Preparation: This station assesses muscular and cardiovascular endurance. You may practice for this station by ascending and descending stairs while carrying approximately 55 pounds of weight (SCBA plus hose pack).

3. Hose Hoist. The candidate will ascend to the third floor of an outdoor staircase, use a rope to hoist a rolled-up section of hoseline up to and back down from the third floor, and then descend the staircase. If the candidate loses control of the rope (e.g., the rope slips through hands), he/she will be required to perform the event again. While raising and lowering and hose roll, the candidate's feet must remain in a box that is

painted on the ground on the 3rd floor landing.

Preparation: To simulate the hose hoist, you can tie a rope securely to a weighted bag and place the rope over a sturdy horizontal bar that is eight to ten feet above the ground. Then you can use the same movements as you would to reel in a load attached to the rope. The weight of the hoseline is approximately 35 pounds.

4. Equipment Carry. The candidate will carry a box weighing 75 pounds for a distance of 100 feet. The candidate will pick up the box off a 2-foot platform, carry the box for 50 feet around a cone and back to the starting location, and place the box on top of a 3-foot platform. The weighted box simulates the weight of a hydraulic power plant. You may set the box down at any time to rest, but may not drag or push the box – it must be carried.

Preparation: This station assesses core body strength, grip strength, and overall cardiovascular endurance. You may prepare for this event by carrying a 75-pound object for a distance of 100 feet.

5. Victim Rescue (Dummy Drag). The candidate will drag a human form dummy weighing 165 pounds (weight of dummy and clothing) for 25 feet, around a barrel/cone and then back across the starting point for a total distance of 50 feet. The candidate will drag the dummy using the pull harness attached to the dummy or by placing his/her elbows under the armpits of the dummy. In order to complete this station, the candidate and the dummy must both completely cross the finish line.

Preparation: This station assesses lower body strength and endurance. You may prepare for this event by dragging a weighted object using a rope.

The five simulation events are timed in a series. Any candidate that completes the course in 6 minutes and 40 seconds (6:40) or less will pass this first component of the CPAT.

Component 2: 1.5 Mile Run

Assuming the candidate successfully completed the first component of the CPAT, he/she will be afforded a rest period of approximately 15 to 20 minutes. After this time, the candidate will run 1.5 miles. The 1.5 mile run musts be completed in 15 minutes (15:00) or less to pass the CPAT.

The 1.5 mile run is cardiovascularly demanding. In order to prepare for this component, you should run 1.5 miles multiple times and time yourself to ensure that you can achieve the necessary time.