



## Fire Chief Suffers Sudden Cardiac Death After Stretching a Hoseline at a Structure Fire – Mississippi

### SUMMARY

On April 12, 2008, a 65-year-old male volunteer Fire Chief was dispatched to a structure fire. On scene, he discussed fire suppression tactics with the Assistant Chief and assisted with stretching an uncharged 1¾-inch hose-line. The Chief then stated to the Assistant Chief that he “could not catch his breath.” After sitting down for about 5 minutes, the Chief requested an ambulance. Deciding not to wait for the ambulance to arrive, the Chief asked the police officer directing traffic around the incident to take him to the hospital. The Chief walked into the hospital’s emergency department saying he was having breathing difficulty. Approximately 20 minutes later, the Chief went into cardiac arrest. Despite advanced life support in the emergency room for 35 minutes, the Chief died. The death certificate, completed by the coroner, listed “acute myocardial infarction due to stress” as the cause of death. The autopsy, completed by the pathologist, listed “severe hypertensive heart disease” as the cause of death with “moderate multiple vessel coronary artery disease” as an underlying condition. NIOSH investigators conclude that responding to the fire and the physical stress of stretching the fire hose, given the Chief’s underlying heart condition, triggered a cardiac arrhythmia, resulting in his sudden cardiac death.

The NIOSH investigator offers the following recommendations to address general safety and health issues. Had these recommended measures been in place prior to the Chief’s collapse, his sudden cardiac death may have been prevented.

- *Provide preplacement and annual medical evaluations to fire fighters consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.*
- *Ensure 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 comprehensive wellness and fitness program for fire fighters.*
- *Perform an annual physical performance (physical ability) evaluation.*
- *Provide fire fighters with medical clearance to wear self-contained breathing apparatus as part of the Fire Department’s annual medical evaluation program.*



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## INTRODUCTION & METHODS

On April 12, 2008, a 65-year-old male volunteer Fire Chief suffered sudden cardiac death after stretching a hoseline at a structure fire. Despite CPR and advanced life support administered in the hospital's emergency department, the Chief died. The United States Fire Administration notified NIOSH of this fatality on April 14, 2008. NIOSH contacted the affected Fire Department to gather additional information on May 6, 2008, and on July 10, 2009, to initiate the investigation. On July 22, 2009, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Mississippi to conduct an on-site investigation of the incident.

During the investigation, NIOSH personnel interviewed the following people:

- Assistant Fire Chief
- Family members of the Chief

NIOSH personnel reviewed the following documents:

- Fire Department policies and operating guidelines
- Fire Department training records
- Fire Department annual report for 2008
- Fire Department incident report
- Hospital emergency department records
- Death certificate
- Autopsy report
- Primary care provider medical records

## RESULTS OF INVESTIGATION

**Incident.** On April 12, 2008, the Fire Department was dispatched to a fire in a vocational school (0601 hours). Engine 33 (driven by the Assistant Chief), Engine 31 (driven by a fire fighter), and the Chief (driving in his privately owned vehicle) responded, arriving at 0613 hours. Fire fighters found a large structure of noncombustible construction with heavy smoke and flames venting from the eaves at the rear of the structure (C side) (see Photographs 1 and 2).

The Chief discussed interior fire fighting tactics with the Assistant Chief as additional fire fighters arrived in their privately owned vehicles. The Assistant Chief donned his turnout gear as the Chief assisted in stretching an uncharged 1¾-inch hoseline to the front door of the structure. The Assistant Chief checked in with the Chief again and the Chief stated that he “could not catch his breath.” The Assistant Chief advised the Chief to sit down and rest as fire suppression operations continued; the Assistant Chief assumed incident command. The Chief notified Dispatch that he needed an ambulance (approximately 0616 hours). After waiting for a few moments, the Chief asked a fire fighter to notify the police officer (on scene directing traffic) that he needed the officer to take him to the hospital (0620 hours).

The police officer and the Chief departed the scene en route to the hospital's emergency department at 0620 hours. During the trip, the Chief asked the officer to drive faster because he “could not breathe.” Arriving at the hospi-



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tal at 0630 hours, the Chief exited the police cruiser and walked into the emergency department. He advised the staff that he was “having breathing difficulty and needed morphine.” Initial evaluation by emergency department personnel found the Chief ashen, sweating heavily, and anxious. His pulse was 96 beats per minute and he was breathing at a rate of 32–36 breaths per minute. The Chief was given oxygen by a nasal canula and then by nonrebreather mask. An intravenous (IV) line was placed, followed by the IV administration of morphine and lasix (standard treatment for acute pulmonary edema). A cardiac monitor was attached to the Chief’s chest and initially showed left bundle branch block (a type of electrical disturbance of the heart’s conduction system) which deteriorated after 10 minutes to ventricular fibrillation. At this point, the Chief became unresponsive, with no pulse, and stopped breathing. Cardiopulmonary resuscitation was begun, and the Chief was intubated. The cardiac monitor revealed asystole (no heart rhythm); cardiac resuscitation medications were administered. Cardiac isoenzyme blood testing revealed normal values for creatine kinase (2.2 nanograms per milliliter [ng/mL]), and troponin I (<0.05 ng/mL), and an elevated myoglobin level (156 ng/mL) (normal is < 107 ng/mL) [de Winter et al. 1995]. Resuscitation efforts continued for 35 minutes without change in the Chief’s condition until 0725 hours, when the Chief was pronounced dead by the attending physician.

**Medical Findings.** The death certificate, completed by the coroner, listed “acute myocardial infarction due to stress” as the cause of death.

The autopsy, completed by the pathologist, listed “severe hypertensive heart disease” as the cause of death with “moderate multiple vessel coronary artery disease” as an underlying condition. Specific findings from the autopsy are listed in Appendix A.

The Chief was 70 inches tall and weighed 221 pounds, giving him a body mass index (BMI) of 31.7. A BMI > 30.0 kilograms per meter squared is considered obese [CDC 2008]. The Chief’s risk factors for coronary artery disease (CAD) included male gender, age over 45, obesity, and family history of CAD. In December 2007, the Chief reported symptoms of heart failure (shortness of breath on exertion). An EKG showed atrial fibrillation and left bundle branch block, while a chest x-ray showed changes consistent with pulmonary edema and heart failure. Blood tests showed a minimally elevated level of troponin I. The cardiologist felt the troponin elevation was related to the atrial fibrillation and/or his acute pulmonary edema. Follow up tests included (1) cardiac catheterization in January 2008 that revealed “normal” coronary arteries; (2) an echocardiogram in April 2008 that revealed mild concentric left ventricular hypertrophy (LVH) with a reduced left ventricular ejection fraction (LVEF) of 45% (normal is 55%–70%); and (3) a Holter monitor that revealed left bundle branch block and no episodes of atrial fibrillation, which had resolved following treatment of his heart failure and a prescription of a beta blocker. The Chief reported additional episodes of shortness of breath on exertion, which were being closely monitored by his physician and cardiologist. He exercised regularly by walk-



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ing and performed strenuous yard work such as chopping wood.

## DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the volunteer Fire Department consisted of one fire station with 25 uniformed personnel that served a population of 2,500 residents in a geographic area of 5 square miles.

In 2008, the Fire Department responded to 51 calls: 20 structure fires, 9 motor vehicle crashes, 6 vehicle fires, 6 brush/grass fires, 4 other fires, 2 hazardous condition calls, and 4 false alarms.

**Membership and Training.** The Fire Department requires all new fire fighter applicants to be 18 years of age (age 21 to operate fire apparatus), have a valid state driver's license, and pass a background check. Applicants meeting these criteria are voted on by the Fire Department members. New members are assigned to an experienced member and receive orientation, apparatus familiarization, and in-house fire fighter training. Members are urged to attend training at the local fire college. The state has no mandatory minimum training levels for volunteer fire fighters. The Chief was certified as a Volunteer Fire Fighter II, Driver/Operator, HazMat for first responders, Dive Rescue Specialist I, and had 25 years of fire fighting experience.

**Preplacement and Periodic Medical Evaluations.** The Fire Department does not currently require a preplacement or annual medical evaluation for its members. Annual medical clearance to wear SCBA is not required.

**Health and Wellness Programs.** The Fire Department does not have a wellness/fitness program, but exercise (strength and aerobic) equipment is available in the fire station. Most members perform aerobic and/or strength training. Health maintenance programs are not available from the city. No annual physical ability test is required.

## DISCUSSION

The Chief had a number of cardiac conditions including LVH/cardiomegaly, a history of heart failure, rhythm disturbances (atrial fibrillation and left bundle branch block), and ultimately sudden cardiac death.

**LVH/Cardiomegaly.** On autopsy, the Chief was found to have LVH and an enlarged heart. Both LVH and cardiomegaly increase the risk for sudden cardiac death [Levy et al. 1990]. Hypertrophy of the heart's left ventricle is a relatively common finding among individuals with long-standing high blood pressure (hypertension), a heart valve problem, or chronic cardiac ischemia (coronary artery disease) [Siegel 1997]. Although the Chief was not known to be hypertensive, hypertension is the most likely cause of his LVH because: (1) his echocardiogram showed no valve problems, (2) his cardiac catheterization showed no evidence of



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coronary artery disease, (3) the pattern of his LVH (concentric) is consistent with hypertension, and (4) prior to 2007, the Chief had not had his blood pressure checked for decades.

**Heart Failure.** The Chief was diagnosed with severe pulmonary edema due to heart failure in December 2007. With treatment his condition improved, but his heart functioning remained abnormal (LVEF of 45% by echocardiogram). The Chief’s heart failure is likely due to hypertensive heart disease and LVH. Heart failure is an independent risk factor for sudden cardiac death [Meyerburg and Castellanos 2001].

***Rhythm Disturbances – Atrial Fibrillation.***

Atrial fibrillation is a disturbance of the heart’s conduction system. During atrial fibrillation, the heart’s two small upper chambers (the atria) beat very rapidly in a nonproductive, quivering manner. Atrial fibrillation has been associated with caffeine use, alcohol use, hyperthyroidism, and obesity, but by far the most important and strongest risk factors are the presence of other heart conditions [Waktare 2002; Wang et al. 2004; Frost et al. 2005; Fuster et al. 2006]. Predisposing heart conditions include CAD, heart valve problems, heart failure, left atrial enlargement, and hypertension. The Chief’s atrial fibrillation was probably due to his underlying heart failure.

Atrial fibrillation can occur in three different patterns: paroxysmal, persistent, or permanent. Paroxysmal atrial fibrillation occurs in episodes lasting seconds to days, and resolves spontaneously. Persistent atrial fibrillation does not stop spontaneously. Permanent atrial

fibrillation describes the condition when the heart’s normal sinus rhythm cannot be restored despite treatment. The Chief was diagnosed with paroxysmal atrial fibrillation.

Could the Chief’s atrial fibrillation been a result of fire fighting activities? One case of atrial fibrillation associated with acute exposure to fire smoke has been reported [Bass and Hildreth 1979]. However, in this case, the Chief’s carboxyhemoglobin level (a measure of exposure to carbon monoxide, which is a component of fire smoke) was within the laboratory’s normal range. Therefore, it is unlikely that fire smoke, by itself, triggered the Chief’s atrial fibrillation or his sudden cardiac death.

There are three major treatment considerations for atrial fibrillation. The first involves returning the heart to a normal (sinus) rhythm by treating the underlying condition causing the disturbance (e.g., the Chief’s heart failure). If these efforts fail to restore sinus rhythm, other treatments may include prescribing anti-arrhythmic medications (e.g., Flecainide, Amiodarone), administering a shock (direct current cardioversion), ablation surgery (selective elimination of one or more sites in the atria to reduce the recurrence of atrial fibrillation), or the placement of a cardiac pacemaker [Oral et al. 2006; Ames and Stevenson 2006]. The Chief’s atrial fibrillation was successfully treated by treating his underlying heart failure.

The second treatment consideration involves reducing the number of impulses transmitted through the AV node by prescribing “rate-limiting” medications (e.g., digoxin, beta block-



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ers). The Chief was prescribed both of these rate-limiting medications.

The third treatment consideration involves preventing blood clots thereby reducing the risk of stroke. The risk of blood clots can be reduced by prescribing anticoagulant drugs (e.g., Coumadin) or antiplatelet drugs (e.g., aspirin). The Chief was prescribed both of these medications.

With treatment, the Chief's paroxysmal atrial fibrillation resolved, but he continued to have shortness of breath on exertion. From 2007 to 2008, the Chief was prescribed anti-arrhythmic and anticoagulant medications. The Chief's last heart rhythm tracings showed sinus rhythm, first degree AV block, left atrial abnormality, and left bundle branch block. According to the medical records available to NIOSH, the Chief's physicians never addressed whether he was medically fit for duty as a fire fighter.

***Rhythm Disturbances – Left Bundle Branch Block (LBBB).*** LBBB is an abnormality of the heart's conduction system. LBBB occurs when transmission of the cardiac electrical impulse is delayed or fails to be conducted along the normal electrical pathway [Flowers 1987]. LBBB correlates strongly with age and increases risk of cardiac mortality [Ghostine et al. 2006].

***Sudden Cardiac Death.*** Most cases of sudden cardiac death are related to coronary heart disease and/or a heart attack (myocardial infarction). Establishing the occurrence of a heart attack requires any of the following: characteristic EKG changes, elevated cardiac enzymes,

or coronary artery thrombus. In the Chief's case, possible EKG changes suggestive of a heart attack would be hidden by his cardiac conduction abnormality (LBBB). His cardiac enzymes at death were normal, but the Chief died before the enzymes would be expected to increase. These enzymes take at least 4 hours after a heart attack to become positive. Finally, no coronary artery thrombus was found at autopsy, but coronary artery spasm can cause a heart attack without forming a thrombus [AHA 2009]. Although a heart attack cannot be ruled out, it is unlikely given the Chief's clean coronary arteries on cardiac catheterization and autopsy. More likely, the Chief died of a primary cardiac arrhythmia due to his heart's rhythm (atrial fibrillation) and conduction (first degree A-V block and LBBB) disturbances.

Approximately one hour prior to his death the Chief directed fire suppression operations and stretched a hoseline. Even though he was not wearing an SCBA, he was not exposed to a large volume of fire smoke, and his blood carboxyhemoglobin level at autopsy was less than 10% (normal for the testing laboratory), suggesting minimal exposure to carbon monoxide. Carbon monoxide has been reported to increase ventricular arrhythmias and lower the threshold for ventricular fibrillation, however, even at levels of carboxyhemoglobin less than 10% [Sheps et al. 1990]. Therefore, it is unclear if carbon monoxide from the Chief's fire smoke exposure helped trigger his sudden cardiac death.



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Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks and sudden cardiac death [Siscovick et al. 1984; Tofler et al. 1992; Mittleman et al. 1993; Willich et al. 1993; Albert et al. 2000]. Deaths from coronary heart disease in fire fighters have been associated with fire suppression and heavy exertion during training (including physical fitness training) [Kales et al. 2003; Kales et al. 2007; NIOSH 2007]. The Chief had responded to the structure fire and stretched 200 feet of uncharged 1¾-inch hoseline to the front door of the structure. This activity expended at least 6 metabolic equivalents (METs), which is considered moderate physical activity [Lemon and Hermiston 1977; Gledhill and Jamnik 1992]. Given the Chief's underlying hypertensive heart failure and conduction system abnormalities, the physical stress of stretching the fire hose could have triggered a cardiac arrhythmia (or less likely a heart attack), resulting in his sudden cardiac death.

Based on the findings discussed above, NIOSH investigators concluded that the Chief died from a cardiac arrhythmia due to a combination of his underlying cardiac abnormalities (electrical disturbances of his heart, left ventricular hypertrophy, CAD, and cardiomegaly) and moderate physical exertion during fire operations.

***Occupational Medical Standards for Structural Fire Fighters.*** To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA de-

veloped NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments [NFPA 2007a]. This voluntary industry standard provides medical requirements for candidates and current fire fighters.

The Chief had a number of medical conditions (heart failure, atrial fibrillation, and anticoagulation therapy) that could have precluded his work as a fire fighter. NFPA 1582 considers that atrial fibrillation and full-dose anticoagulation 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 2007a]. But it is unclear if these standards apply to the Chief who performed as the incident commander during emergencies and was not conducting interior fire suppression.

## **RECOMMENDATIONS**

The NIOSH investigator offers the following recommendations to address general safety and health issues. Had these recommended measures been in place prior to the Chief's collapse, his sudden cardiac death may have been prevented.

***Recommendation #1: Provide preplacement and annual medical evaluations to fire fighters consistent with National Fire Protection Association (NFPA) 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments.***



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Guidance regarding the content and frequency of these 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 2000; NFPA 2007a]. These guidelines help to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others. However, fire departments are not legally required to follow this standard or this initiative. Applying this recommendation involves economic repercussions and may be particularly difficult for small, volunteer fire departments to implement. NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, paragraphs A.10.6.4 and A.11.1.1 and the National Volunteer Fire Council (NVFC) Health and Wellness Guide address these issues [USFA 2004; NFPA 2007b].

To overcome the financial obstacle of medical evaluations, fire departments 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 (EMTs) from the local emergency medical service (vital signs, height, weight, visual acuity, and electrocardiogram [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 could be performed by a private physician at the fire fighter's ex-

pense (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. Medical evaluations should occur prior to performing fire suppression duties and/or other physically demanding duties including training.

Although incidental to his death, the NIOSH investigator found that the Chief was blind in his right eye. NFPA 1582 states that this condition "might compromise the member's ability to safely perform various duties including critical, time-sensitive, complex problem solving during physical exertion in stressful, hazardous environments, etc." [NFPA 2007a]. A member with this condition should probably be precluded from fire suppression duties. However, since the Chief only served as incident commander at emergency scenes, it is unclear if this guidance is applicable.

***Recommendation #2: Ensure 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 [NFPA 2007a] and in the IAFF/IAFC Fire Service Joint Labor Management Wellness/Fitness Initiative [IAFF, IAFC



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2000]. 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 as required by NFPA 1500, Standard on Fire Department Occupational Safety and Health Program [NFPA 2007b]. The physician should review job descriptions and essential job tasks required for all Fire Department positions and ranks, in order 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. This recommendation should prevent a physician from making an uninformed decision to release a fire fighter to return to the physically demanding stresses of full duty. The Chief was receiving regular medical evaluations, but none of these evaluations addressed medical clearance to full duty as a fire fighter.

***Recommendation #3: Phase in a comprehensive wellness and fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

Guidance for fire department wellness/fitness programs 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 the National Volunteer Fire Council (NVFC) Health and Wellness Guide [IAFF, IAFC 2000; USFA 2004; NFPA 2008]. 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 over \$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 2007].

Given the Fire Department's structure, the NVFC program might be the most appropriate model [USFA 2004]. NIOSH recommends a formal, structured wellness/fitness program to ensure all members receive the benefits of a health promotion program. The Fire Department has exercise equipment in the fire station but does not have a written wellness/fitness program. An issue facing volunteer fire departments is incorporating physical fitness training into their training programs. Physical fitness could be performed at other times in the station or at other locations such as a local fitness center or the fire fighter's home.

***Recommendation #4: Perform an annual physical performance (physical ability) evaluation.***



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NFPA 1500 recommends fire department members who engage in emergency operations be annually evaluated and certified by the fire department as having met the physical performance requirements identified in paragraph 10.2.3 of the standard [NFPA 2007b]. This is recommended to ensure fire fighters are physically capable of performing the essential job tasks of structural fire fighting. The physical ability test could be performed as part of the fire department's training program. Even though the Chief was the incident commander, he occasionally performed physically demanding duties.

***Recommendation #5: Provide fire fighters with medical clearance to wear self-contained breathing apparatus as part of the Fire Department's annual 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<sup>1</sup> 1910.134]. These clearance evaluations are required for private industry employees and public employees in States operating OSHA-approved State plans [OSHA 2008]. The clearances are completed as part of the fire department medical evaluation program. Mississippi does not operate an OSHA-approved State plan for the public sector; therefore, public sector employers (including volunteer/paid fire departments) are not required to comply with OSHA standards. However, NIOSH investigators recommend following this standard to ensure an increased level of medical fitness and safety.

<sup>1</sup>Code of Federal Regulations. See CFR in references.

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## INVESTIGATOR INFORMATION

This incident was investigated by the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component located 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) Cer-

tified 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).

## Appendix A

### Autopsy Findings

- Hypertensive heart disease
  - Cardiomegaly (enlarged heart). Heart weighed 470 grams (g); predicted normal weight is 391 g (ranges between 296 g and 516 g as a function of sex, age, and body weight). [Silver and Silver 2001]
- Coronary artery disease
  - Mild (20%) focal narrowing of the left anterior descending coronary artery
  - Mild (10%) focal narrowing of the right coronary artery
  - Mild (30%) focal narrowing of the left main coronary artery
  - No evidence of a thrombus (blood clot) in the coronary arteries



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- Left ventricular hypertrophy
  - Left ventricular wall thickened (2.1 cm; normal by autopsy is 0.76–0.88 cm [Colucci and Braunwald 1997]; normal by echocardiographic measurement is 0.6–1.1 cm) [Armstrong and Feigenbaum 2001]
- No evidence of congestive heart failure
- Normal cardiac valves
- No evidence of a pulmonary embolus (blood clot in the lung arteries)
- Blood tests for drugs and alcohol were negative except for a morphine blood level of 0.05 microgram per milliliter (administered in the hospital)
- Carboxyhemoglobin (blood test for carbon monoxide exposure) < 10% saturation

(a level considered incidental by the medical examiner)

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**Photo1.** Side view of incident site.



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**Photo2.** Front view of incident site.

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 fiscal year 1998, the Congress appropriated funds to NIOSH to conduct a fire fighter initiative. NIOSH initiated the Fire Fighter Fatality Investigation and Prevention Program to examine deaths of fire fighters in the line of duty so that fire departments, fire fighters, fire service organizations, safety experts and researchers could learn from these incidents. The primary goal of these investigations is for NIOSH to make recommendations to prevent similar occurrences. These NIOSH investigations are intended to reduce or prevent future fire fighter deaths and are completely separate from the rulemaking, enforcement and inspection activities of any other federal or state agency. Under its program, NIOSH investigators interview persons with knowledge of the incident and review available records to develop a description of the conditions and circumstances leading to the deaths in order to provide a context for the agency's recommendations. The NIOSH summary of these conditions and circumstances in its reports is not intended as a legal statement of facts. This summary, as well as the conclusions and recommendations made by NIOSH, should not be used for the purpose of litigation or the adjudication of any claim. For further information, visit the program website at

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