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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

# Death in the line of duty...

*A Summary of a NIOSH fire fighter fatality investigation* *July 10, 2003*

## Fire Fighter Suffers a Heart Attack and Dies After Performing "Ventilation-Entry-Search" Activities in a Five-Story Apartment Building Fire - New York

### SUMMARY

On January 13, 2001, a 42-year-old male Fire Fighter responded to a fire in a five-story apartment building. On-scene, wearing full turnout gear and his self-contained breathing apparatus (SCBA)(not on air), he climbed his aerial ladder, performed roof ventilation, and then entered the fire building to search for fire victims and perform overhaul. After approximately 15 minutes on the fire floor, he returned to ground level where he conversed with crew members, walked to the rehabilitation unit, and rested on his apparatus. At this time he began to feel lightheaded. Crew members administered oxygen while ambulance personnel on the scene were summoned. Just as the paramedic arrived he collapsed. Despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) administered by crew members, ambulance paramedics, and personnel at the local hospital's emergency department (ED), the victim died. The death certificate, completed by the Medical Examiner's Office listed "hypertensive and arteriosclerotic heart disease" as the immediate cause of death and "smoke inhalation" as an other significant condition. Pertinent autopsy results included an enlarged heart (cardiomegaly with concentric left ventricular hypertrophy), coronary arteriosclerosis with superimposed coronary thrombosis (blood clot), generalized visceral congestion with pulmonary edema, and smoke inhalation.

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters. This strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals; and 3) encouraging increased individual physical capacity. Issues relevant to this Fire Department include:

- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***
- ***Ensure that fire fighters use self-contained breathing apparatus (SCBA) during operations (ventilation, overhaul, etc.) in smoke-filled environments***
- ***Ensure that fire fighters receive rehabilitation on a scheduled basis***

### INTRODUCTION AND METHODS

On January 13, 2000, a 42-year-old male Fire Fighter began to feel lightheaded after performing roof ventilation, searching for fire victims in a five-story apartment building, and performing overhaul. Despite CPR by fire fighters (trained and certified as first responders) and ALS by ambulance paramedics on the scene and the hospital's ED, the victim died.

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NIOSH was notified of this fatality on January 16, 2001, by the United States Fire Administration. On September 6, 2001, NIOSH contacted the affected Fire Department (FD) to initiate the investigation. On December 2, 2002, a Safety and Occupational Health Specialist, an occupational physician, and an occupational nurse practitioner from the NIOSH Fire Fighter Fatality Investigation Team traveled to New York to conduct an onsite investigation of the incident.

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

- FD Executive Officer, Safety Command
- Local Union Safety Director
- FD Deputy Medical Director
- FD Director, Occupational Safety and Health
- FD Deputy Director, Dispatch Operations
- FD Chief of Safety
- FD Deputy Counsel
- FD Chief, EMS Operations
- Crew members on-duty with the victim
- Victim's wife

During the site-visit NIOSH personnel reviewed:

- FD investigative report of the fatality
- FD policies and operating guidelines
- FD training records of the victim
- FD medical records of the victim
- FD annual report for 2001
- Emergency medical service (ambulance) report
- Death certificate
- Autopsy report

## INVESTIGATIVE RESULTS

*Incident*. On January 13, 2001, the deceased arrived for duty at Ladder 44 at 1800 hours. He was assigned the Roof position (which performs fire structure ventilation). At 2001 hours, dispatch received a telephone call reporting a structural fire on the fourth floor of a five-story apartment building. Engine 92, Ladder 44 (including the deceased), Ladder 19, and Battalion 17 were dispatched at 2002 hours. A total of 20 fire fighters, including the deceased and a Battalion Chief responded. For the response timeline, see Table 1.

Upon receipt of a second call reporting the fire at 2003 hours, Engine 71, Engine 42, and Engine 50 (a total of 15 fire fighters) were dispatched at 2005 hours. Ladder 44 and Engine 92 arrived on the scene at 2005 hours as Dispatch advised that there was a handicapped person in one of the apartments. When Ladder 19 arrived on the scene there was fire showing out a fourth floor window and they advised Dispatch of a 10-75 (working fire).

The involved structure was a five-story, 40-feet by 90-feet, non-fireproof, multiple dwelling apartment building. The daily average temperature was 35°F (Fahrenheit), with an average wet bulb temperature of 31°F, and average wind speed of 3.7 miles per hour. Between 2006 hours and 2008 hours, additional units were dispatched and arrived on the scene (see Table 1).

Engine 92 and Engine 71 stretched the first 1¾-inch hoseline up the interior stairway to the fourth floor. The deceased, wearing full bunker gear and SCBA (not on air) got his tools and mask and climbed Ladder 19's aerial to the roof. He and Ladder 19's Roofman forced open the bulkhead at the top of the stairway. They then surveyed all sides of the building for fire and victims. Over the portable radio there were reports of fire entering the cockloft (attic). The deceased worked with Ladder 19's crew to open sections of the roof. While Ladder 19's Roofman cut with the saw, the deceased and others pulled the sections and pushed the ceilings down.

At 2009 hours a Signal 2-2 (second alarm) was received and, between 2009 and 2013 hours, additional units were dispatched and arrived on the scene (see Table 1).

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All the members of Ladder 44 interior team entered the fire apartment for "Vent-Entry and Search." Engine 92 and Engine 71 brought the handline into the fire apartment. The fire was in the rear of the apartment as configured from the entrance door. The apartment contained large amounts of debris and personal belongings, which added to the fire load and made the searches more difficult. The handline attacked and knocked down the fire. Engine 42 and Engine 50 stretched the second 1¾-inch handline to the fourth floor to back up the first handline, and then proceeded to the fifth floor to extinguish fire on that floor.

At 2013 hours, Battalion 17 issued a "doubtful will hold," (which means it is doubtful the current units on-scene can control the fire). Therefore, between 2014 hours and 2018 hours, additional units were dispatched and arrived on the scene (see Table 1). At 2015 hours, Battalion 17 issued a "10-45 Code One"; a civilian fire fatality.

With the roof operations completed and the fire knocked down, the deceased descended from the roof via the interior stairs to the fire floor where he joined the other members of Ladder 44 searching for civilian victims and assisted in overhauling. During interior operations, he was breathing air from his SCBA. Between 2020 hours and 2035 hours, additional units were dispatched to relieve units on the scene and then arrived on the scene. At 2027 hours, Dispatch was advised that there was heavy fire on the fourth floor and the trucks were opening up, three lines were stretched with two in operation, and searches were being conducted. Ambulance 14C3 transported one civilian with critical burns and in cardiac arrest to the hospital. At 2029 hours, DC 6 advised Dispatch of a second civilian fire fatality. At approximately 2030 hours, with operations nearing completion, the deceased told his officer that he was going to the street. He descended the interior stairs and went to the vicinity of Engine 92, where he conversed with the chauffeur of Engine 42. He told the chauffeur that the roof was a difficult operation and that he was very tired as he dropped to his knees. The chauffeur offered assistance and oxygen, but the deceased declined both. The deceased walked to RAC 3 (rehabilitation unit) (parked one block away) for a drink, then walked back to Ladder 44 (parked in front of the fire building) and sat down on the apparatus.

Between 2038 hours and 2050 hours, additional units were dispatched and arrived on the scene (see Table 1). In all, 131 personnel, 24 pieces of fire apparatus and 8 ambulances were deployed to this incident. Four civilians were transported to the hospital where two died and two were eventually discharged. (EMS units were dispatched and arrived at the scene between 2007 hours and 2134 hours). At 2047 hours, FC 1 advised Dispatch, "probably will hold" (current units on scene will probably be able to control the fire). At 2055 hours, FC 1 advised Dispatch, "under control."

While sitting and laying down on Ladder 44, the deceased was offered oxygen by the Engine 42 chauffeur, which he again declined. Shortly thereafter, as he sat on the crew cab step he asked the Motor Pump Operator of Engine 92 for some oxygen because he was feeling light-headed. The crew member noticed that the deceased was sweating heavily and suggested they walk over to where the EMS personnel were stationed. That crew member advised the DC at the Command Post of the situation, who then assigned Engine 46 and EMS members to the situation.

As the EMS personnel responded to Ladder 44, the deceased's condition deteriorated rapidly and he collapsed. Crew members provided assisted ventilations via bag-valve-mask with oxygen. He was loaded onto a stretcher and rushed to the ambulance located approximately one block away.

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About half way to the ambulance, a crew member noticed that the deceased was not breathing. An EMS member delivered a "cardiac thump." The deceased was then loaded into the ambulance and assessment revealed the deceased to be unresponsive with agonal respirations. Shortly after receiving assisted ventilations via BVM with oxygen, the deceased spontaneously regained consciousness and respirations. On examination, his lungs were clear but soot was noted around his mouth and nose. Although he was slightly disoriented, he was able to state his correct age. Assisted ventilations via BVM and oxygen continued. Cardiac monitor/ defibrillator pads were applied to his chest, and at 2111 hours, revealed sinus tachycardia. At 2116 hours, he became pulseless and stopped breathing. The monitor revealed ventricular fibrillation (VFib)(a heart rhythm incompatible with life). One shock was delivered, but his heart rhythm reverted to electromechanical dissociation (EMD) (a heart rhythm incompatible with life). An intravenous line was placed and resuscitation medications were administered. An intubation attempt was unsuccessful as CPR continued. At 2118 hours, the monitor again revealed VFib and a second shock was delivered. Again, his heart rhythm reverted to EMD. At 2120 hours, the ambulance transported the deceased to the hospital. Enroute, the monitor again revealed VFib and a third shock was delivered. Again, his heart rhythm reverted to EMD. No other change in patient status was noted enroute. The ambulance arrived at the hospital 2128 hours. Inside the ED, ALS procedures continued for eleven minutes. At 2139 hours, the Fire Fighter was pronounced dead and resuscitation measures were discontinued. Blood taken from the deceased in the ED at 2156 hours revealed a carboxyhemoglobin (COHb) level of 3% (normal 0.0 to 1.5%). A COHb level performed by the medical Examiner's Office using blood from the autopsy performed on 1/14/02 revealed a level of "less than 3%."

*Medical Findings*. The death certificate, completed by the Medical Examiner, listed "hypertensive and arteriosclerotic heart disease " as the immediate cause of death and "smoke inhalation" as an other significant condition. Pertinent findings from the autopsy, performed by the Medical Examiner's Office on January 14, 2001, are listed below:

- Hypertensive and arteriosclerotic cardiovascular disease
  - 60% calcific atherosclerotic stenosis in left main stem coronary artery
  - 30% stenosis in proximal right coronary artery
- Valves have focal atherosclerosis
- Cardiomegaly (heart weighed 560 grams) with concentric left ventricular hypertrophy
- Coronary arteriosclerosis, multifocal, moderate, with superimposed coronary thrombosis in the left main stem and right coronary artery
- Generalized visceral congestion with pulmonary edema
- Smoke inhalation
  - Scant soot in nares
  - Soot in upper airway
  - His blood carboxyhemoglobin level was less than 3%, suggesting the victim was not exposed to excessive carbon monoxide levels

The victim had three CAD risk factors including: male gender, cigarette smoking, and mildly elevated blood cholesterol. Prior to his fatal heart attack, he had no known CAD and did not complain of any pain suggestive of angina (heart pain due to reduced blood supply), and he maintained a fair amount of physical activity.

At his last Fire Department physical evaluation in 2000, the Fire Fighter was 6' 1" tall and weighed 240 pounds. His vital signs were within normal limits and a resting EKG revealed normal sinus rhythm.

At that time, his cholesterol level was measured at 259 mg/dl (milligrams per deciliter)(normal < 200 mg/dl), triglyceride level was 213 mg/dl (normal < 200 mg/dl), LDL cholesterol level was 173 mg/dl (normal < 130 mg/dl), and his LDL/HDL ratio was 3.93 mg/dl (normal 0-3.55 mg/dl). He also completed a submaximal step test and reached a heart rate response of 150 beats per minute. The FD physician advised the Fire Fighter to stop smoking and to follow up with his primary care physician regarding the high cholesterol levels.

## DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the Fire Fighter's death, the Fire Department consisted of approximately 11,495 Uniformed Fire Fighters and Fire Officers, 2,677 EMTs and Paramedics, 222 Fire Marshals, 195 Fire Inspectors, and 1,741 administrative support personnel serving a population of eight million residents, in a geographic area of 322 square miles. There are over 300 fire stations and buildings. The emergency medical services have operated as a function of the FD since 1996. Fire fighters work the following shifts: Day 1 & 2: 9am to 6pm; Day 3: off; Day 4&5: 6pm to 9am; Day 6-8: off.

In 2001, the FD responded to 437,021 fires, non-fire emergencies, and medical calls to include: 27,788 structural fires, 29,655 non-structural fires, 172,638 non-fire emergencies, 155,396 medical emergencies, and 51,544 malicious false alarms. Included in the responses were 3,157 serious incidents: 2,854 all hands, 246 second alarm, 35 third alarm, 13 fourth alarm, and 9 fifth alarm or greater incidents. Typical engine company staffing is four fire fighters plus one officer (some engine companies have five fire fighters plus one officer); typical ladder company staffing is five fire fighters plus one officer. (This staffing level meets NFPA 1710). AEDs are carried on all engines.

*Training*. The FD requires all fire fighter candidates to complete an application, complete background checks, and pass a City candidate physical ability test prior to being offered conditional employment. Candidates must then pass a preplacement physical examination prior to being fully hired. The newly hired fire fighters then attend a 12-week training program at the Division of Training, after which they are certified fire fighters. Candidates must be CFR-D (certified first responder-defibrillator) qualified in order to be hired. Chauffeurs (Driver/Operators) are required to undergo an additional two-week training course. The State requires 100 hours training for annual in-service training The victim was a certified as a Fire Fighter, Hazardous Materials Operations level, and First Responder, and had 14 years of fire fighting experience.

*Preplacement Evaluations*. Fire Fighter Candidates are required to complete a Candidate Physical Ability Test (CPAT) prior to graduating from probationary school. The CPAT used by this FD is very similar to the CPAT developed jointly by the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC).[1] All qualified Candidates are placed on a hiring list. As positions in the FD become available, applicants are brought into the FD's Health Services Department for a preplacement medical evaluation. Components of the preplacement evaluation for all applicants include:

- A complete medical history and questionnaire
- Height, weight, and vital signs
- Physical examination
- Vision test
- Hearing test
- Blood tests: Complete blood count (CBC), chemistry panel (SMA 20) which includes a cholesterol and triglyceride measurement
- Urinalysis
- Urine drug test
- Spirometry (lung function tests)

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- Resting electrocardiogram
- Chest X-ray
- Skin test for tuberculosis (PPD)
- Immunizations administered if proof of vaccination cannot be provided (hepatitis B, measles, mumps, & rubella (MMR), tetanus if a booster had not been given within the past ten years)
- Fire Fighters assigned to waterways also are offered a hepatitis A vaccine

These evaluations are performed by the FD Medical staff, who make a decision regarding medical clearance for fire fighting duties. This medical evaluation also consists of a physical fitness and strength test. The aerobic/fitness component of this test involves three minutes on a Stairmaster operating at 60 steps per minute with the new hire wearing a sixty-pound vest. An EKG is not taken, but the heart rate is recorded with a target being less than 90% of their maximum (220 minus age).

*Annual Evaluations.* Since 1998, annual medical evaluations have been required by this Department for **all** fire fighters. Components of this evaluation are identical to the preplacement evaluation with three exceptions: the chest X-ray is required every three years, 2) the drug screen is not required, 3) and the aerobic fitness test does not include a 60-pound pack and the target heart rate is 85% of the member's maximum.

The victim's last medical evaluation was conducted by the FD's Health Services Department in October 2000 as part of his annual medical examination and he was cleared for full duty.

*Medical Clearance, and Fitness/Wellness Programs.* A fire fighter injured at work must be evaluated and cleared for "return to work" by a physician in the FD's Health Services clinic. A fire fighter who misses work for one or more days because of an illness (work-related or not), must also be evaluated and cleared for "return to work" by the FD Medical staff.

All fire houses have exercise (strength and aerobic) equipment, typically purchased by the fire fighters themselves. There is a voluntary weight control program and a voluntary wellness/fitness program consistent with the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.[1] There is also a voluntary, but proactive smoking cessation program.

## DISCUSSION

In the United States, atherosclerotic CAD is the most common risk factor for cardiac arrest and sudden cardiac death.[2] Risk factors for its development include increasing age (> 45 years old), male gender, family history of CAD, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.[3,4] The victim had three of these risk factors (male gender, smoking, and high cholesterol).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[5] However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.[6] Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.[7] This sudden blockage is primarily due to blood clots (thrombus) forming on the top of atherosclerotic plaques. The deceased had two thrombi noted at autopsy. Sudden cardiac death is the first clinical manifestation of CAD in 20 to 25% of cases.[8]

Blood clots, or thrombus formation, in coronary arteries is initiated by disruption of atherosclerotic plaques. Certain characteristics of the plaques (size, composition of the cap and core, presence of a local

inflammatory process) predispose the plaque to disruption.[6] Disruption then occurs from biomechanical and hemodynamic forces, such as increased blood pressure, increased heart rate, increased catecholamines, and shear forces, which occur during heavy exercise.[9,10] Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.[4] Firefighting activities are strenuous and often require fire fighters to work at near maximal heart rates for long periods. The increase in heart rate has been shown to begin with responding to the initial alarm and persist through the course of fire suppression activities.[9-11] Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.[12-15] The Fire Fighter, wearing full bunker gear and SCBA (weighing approximately 45 pounds) and carrying ventilation tools (weighing approximately 15 pounds), climbed the aerial ladder to the roof of the five-story fire building, pulled sections of the roof away, pushed down ceilings below, then descended the interior stairs to the fire floor to assist with overhaul. This is considered heavy physical exertion and as mentioned earlier, probably triggered his sudden cardiac death. These events raise three distinct issues discussed below: (1) COHb at low levels, (2) Rehabilitation, and (3) Screening.

COHb at Low Levels

Firefighters' exposure to carbon monoxide represents a relatively constant occupational hazard.[16,17] Carbon monoxide (CO) levels up to 1,900 parts per million (ppm) have been found during the knockdown phase and up to 82 ppm during overhaul.[17] Even wearing respiratory protection may not eliminate a fire fighter's exposure to CO. In fact, CO levels from 1-105 ppm have been found inside fire fighters' SCBA masks.[17] Exertional levels and, therefore, ventilatory rates may be so great during firefighting that even in moderate or low levels of atmospheric carbon monoxide the COHb can rise to dangerous levels within minutes.[16] The deceased performed ventilation activities on the roof without breathing air from his SCBA. This exposure contributed to his COHb level of 3% first measured in the ED. Upon entry onto the fire floor, he donned his mask and began breathing air from his SCBA during search and overhaul activities.

Rehabilitation

Rehabilitation, or rehab, relative to the fire service describes the process of providing rest, rehydration, nourishment, and medical evaluation to responders who are involved in extended and/or extreme incident scene operations.[18] Injuries caused by heart attacks, strokes, strains, sprains, and thermal stress accounted for about 50 percent of all firefighter injuries.[18] It can rationally be assumed that a significant portion of these injuries occurred when firefighters were overfatigued.[18] In this case, the Fire Fighter performed heavy physical exertion on the roof for approximately ten minutes in a smoke-filled atmosphere. He then performed additional heavy physical exertion, while breathing air from his SCBA, in the fire apartment for approximately 12 minutes. After which, he exited the building and went to rehab for rehydration. His crew, however, remained inside the building.

Screening

To reduce the risk of heart attacks and sudden cardiac arrest among fire fighters, the National Fire Protection Association (NFPA) has developed guidelines entitled "Medical Requirements for Fire Fighters," otherwise known as NFPA 1582.[19] They recommend, in addition to screening for risk factors for CAD as provided by this department, an exercise stress electrocardiogram (EKG), otherwise known as an exercise stress test (EST). The EST is used to screen individuals for CAD. Unfortunately, it has problems with both false negatives (inadequate sensitivity) and false positives (inadequate specificity), particularly for asymptomatic individuals (individuals without symptoms suggestive of

angina).[20,21] This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.[22,23]

When these asymptomatic individuals **have** risk factors for CAD, however, recommendations vary by organization. The American College of Cardiology/American Heart Association (ACC/AHA) identifies two groups for EST: 1) men over the age of 40 with a history of cardiac disease (as a screening test prior to beginning a strenuous exercise program), and 2) men over age 40 with multiple risk factors.[22] They define five risk factors for CAD: hypercholesterolemia (total cholesterol > 240 mg/dL), hypertension (systolic >140 mm Hg or diastolic > 90 mm Hg), smoking, diabetes, and family history of premature CAD (cardiac event in 1st degree relative < 60 years old).[22] The U.S. Preventive Services Task Force (USPSTF) does not recommend EST for asymptomatic individuals, even those with risk factors for CAD; rather, they recommend the diagnosis and treatment of modifiable risk factors (hypertension, high cholesterol, smoking, and diabetes).[23]

These recommendations change for individuals who might endanger public safety if an acute episode were experienced, or those who require high cardiovascular performance such as police and fire fighters. The National Fire Protection Association (NFPA) recommends EST for fire fighters without CAD risk factors at age 40, and for those with one or more risk factors at age 35.[19] NFPA considers risk factors to be family history of premature (less than age 55) cardiac event, hypertension, diabetes mellitus, cigarette smoking, and hypercholesterolemia (total cholesterol greater than 240 or HDL cholesterol less than 35).[19] The EST should then be performed on a periodic basis, at least once every two years.[19] The NFPA acknowledges that their recommendations are based on "no firm guidelines", but rely on a "reasonable approach" using expert consensus. The ACC/AHA indicates that there is insufficient data to justify periodic exercise testing in people involved in public safety, however, as mentioned previously, they recommend that men over age 40 with a history of cardiac disease be screened before beginning a strenuous exercise program.[22] Fire suppression activities involve strenuous physical activity; therefore, the ACC/AHA seem to be making a distinction between those already engaged in strenuous physical activity (conditioning), and those **beginning** a strenuous exercise program. The USPSTF indicates that there is insufficient evidence to recommend screening middle age and older men or women in the general population, however, "screening individuals in certain occupations (pilots, truck drivers, etc) can be recommended on other grounds, including the possible benefits to public safety."[23] The USPSTF did not specifically address whether asymptomatic fire fighters with CAD risk factors should undergo EST.

This FD was fully aware of the NFPA recommendations and the consensus opinion on which they are based. They have made an informed decision, taking into account the advantages and disadvantages of conducting EST in asymptomatic fire fighters regardless of the number of CAD risk factors present.

## RECOMMENDATIONS AND DISCUSSION

Other agencies have proposed a three-pronged strategy for reducing the risk of on-duty heart attacks and cardiac arrests among fire fighters. These recommendations have not been evaluated by NIOSH, but represent research presented in the literature or of consensus votes of Technical Committees of the National Fire Protection Association or labor/management groups within the fire service. This strategy consists of: 1) minimizing physical stress on fire fighters; 2) screening to identify and subsequently rehabilitate high risk individuals;

and 3) encouraging increased individual physical capacity. Issues relevant to this Fire Department include:

***Recommendation #1: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***

*NFPA 1500, Standard on Fire Department Occupational Safety and Health Program*, and *NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters*, require a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[24,25] In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) published a comprehensive *Fire Service Joint Labor Management Wellness/Fitness Initiative* to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.[1] The Fire Department should review these materials to identify applicable elements. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.[26,27]

***Recommendation #2: Ensure that fire fighters use self-contained breathing apparatus (SCBA) during operations (ventilation, overhaul, etc.) in smoke-filled environments***

SCBA must be worn when a fire fighter enters an area that is considered immediately dangerous to life or health (IDLH) or potentially IDLH or where the atmosphere is unknown. Smoke, vapor, or fumes from a fire or hazardous material incident contains many toxic components.[17] Some of these components will have immediate effects on the unprotected fire fighter (e.g. carbon monoxide or hydrogen cyanide poisoning) while others are cumulative, caused by years of exposure (e.g. smoke particulates or benzene).[17] While the Fire Fighter's carboxyhemoglobin level was measured at 3% (normal range for a smoker), and the amount of smoke he was exposed to was not excessive, the soot in the deceased's airway demonstrates he was not following the FD's SCBA policy. The FD should re-examine their training program to ensure SCBA use is emphasized.

***Recommendation #3: Ensure that firefighters receive rehabilitation on a scheduled basis.***

The scheduled rotation out of service should take into account not just the total time on scene, but the degree of physical exertion and the environmental conditions. Rehabilitation was available at the fire scene. However, the deceased was performing a duty on the roof separate from his crew, which was inside the fire building. And, after exiting the fire building, he did not go immediately to rehab. The USFA recommends a "two air bottle rule" or 45 minutes of worktime as an acceptable level prior to mandatory rehabilitation.[18,28] In this case, the deceased performed approximately 22 minutes of heavy physical exertion, including ten minutes in a smoke-filled environment not breathing SCBA air. This schedule is acceptable if the work performed is not heavy exertion. Perhaps, during heavy exertional activities (such as roof ventilation, victim search, etc.), rehab could be scheduled at 20-25 minute intervals.

## REFERENCES

1. IAFF, IAFC. [2000]. The fire service joint labor management wellness/fitness initiative. Washington, D.C.: International Association of Fire Fighters, International Association of Fire Chiefs.

2. Meyerburg RJ, Castellanos A [2001]. Cardiovascular collapse, cardiac arrest, and sudden cardiac death. In: Braunwald E, Fauci AS, Kapser DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 15th Edition. New York: McGraw-Hill. pp. 228 233.

3. AHA [1998]. AHA Scientific Position, Risk Factors for Coronary Artery Disease. Dallas, TX: American Heart Association.

4. Gledhill N, Jamnik, VK [1992]. Characterization of the physical demands of firefighting. Can J Spt Sci 17:3 207 213.

5. Libby P [2001]. The pathogenesis of atherosclerosis. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 15th Edition. New York: McGraw-Hill. p.1378.

6. Shah PK [1997]. Plaque disruption and coronary thrombosis: new insight into pathogenesis and prevention. Clin Cardiol 20 (11 Suppl2): II-38-44.

7. Fuster V, Badimon JJ, Badimon JH [1992]. The pathogenesis of coronary artery disease and the acute coronary syndromes. N Eng J Med 326: 242 250.

8. Selwyn AP, Braunwald E [2001]. Ischemic heart disease. In: Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL, eds. Harrison's principles of internal medicine. 15th ed. New York: McGraw-Hill. pp. 1399 1410.

9. Barnard RJ, Duncan HW [1975]. Heart rate and ECG responses of fire fighters. J Occup Med 17: 247 250.

10. Manning JE, Griggs TR [1983]. Heart rate in fire fighters using light and heavy breathing equipment: Simulated near maximal exertion in response to multiple work load conditions. J Occup Med 25:215 218.

11. Lemon PW, Hermiston RT [1977]. The human energy cost of fire fighting. J Occup Med 19: 558 562.

12. Willich SN, Lewis M, Lowel H, et al. [1993]. Physical exertion as a trigger of acute myocardial infarction. N Eng J Med 329:1684 1690.

13. Mittleman MA, Maclure M, Tofler GH, et al. [1993]. Triggering of acute myocardial infarction by heavy physical exertion. N Eng J Med 329:1677 1683.

14. Siscovick DS, Weiss NS, Fletcher RH, Lasky T [1984]. The incidence of primary cardiac arrest during vigorous exercise. N Eng J Med 311:874 877.

15. Tofler GH, Muller JE, Stone PH, et al. [1992] Modifiers of timing and possible triggers of acute myocardial infarction in the Thrombolysis in Myocardial Infarction Phase II (TIMI II) Study Group. J Am Coll Cardiol 20:1049 1055.

16. Griggs TR [1977]. The role of exertion as a determinant of carboxyhemoglobin accumulation in firefighters. J Occ Med 19;11:759 761.

17. Lees PSJ [1995]. Combustion products and other firefighter exposures. In: Orris P, Melius J, and Duffy RM, eds. Firefighters. Occupational Medicine. 10;4:696 697.

18. Dickinson ET and Wieder MA, eds. [2000]. Emergency incident rehabilitation. Upper Saddle River: Brady, pp 5 6, 8, 18.

19. NFPA [2000]. Standard on medical requirements for fire fighters and information for fire

department physicians. Quincy MA: National Fire Protection Association. NFPA 1582 2000.

20. Michaelides AP, Psomadaki ZD, Dilaveris PE, et al. [1999]. Improved detection of coronary artery disease by exercise electrocardiography with the use of right precordial leads. New Eng J Med 340:340 345.

21. Darrow MD [1999]. Ordering and understanding the exercise stress test. American Family Physician. January 15, 1999.

22. Gibbons RJ, Balady GJ, Beasley JW, Bricker JT, Duvernoy WFC, Froelicher VF, Mark DB, Marwick TH, McCallister BD, Thompson PD, Winters WL Jr, Yanowitz FG [1997]. ACC/AHA guidelines for exercise testing: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Exercise Testing). *J Am Coll Cardiol*. 30:260 315.

23. U.S. Preventive Services Task Force [1996]. Guide to clinical prevention services, 2nd Ed. Baltimore, MD: Williams & Wilkins, pp. 3 15.

24. NFPA [1997]. Standard on fire department occupational safety and health program. Quincy MA: National Fire Protection Association. NFPA 1500 1997.

25. NFPA [2000]. Standard on health-related fitness programs for fire fighters. Quincy MA: National Fire Protection Association. NFPA 1583 2000.

26. Maniscalco P, Lane R, Welke M, Mitchell J, Husting L [1999]. Decreased rate of back injuries through a wellness program for offshore petroleum employees. J Occup Environ Med 41:813 820.

27. Stein AD, Shakour SK, Zuidema RA [2000]. Financial incentives, participation in employer sponsored health promotion, and changes in employee health and productivity: HealthPlus health quotient program. J Occup Environ Med 42:1148 1155.

28. USFA [1992]. Emergency incident rehabilitation. Washington, DC: Federal Emergency Management Agency, U.S. Fire Administraion Publication No. FA-114.

## INVESTIGATOR INFORMATION

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***Fire Fighter Suffers a Heart Attack and Dies After Performing "Ventilation-Entry-Search" Activities in a Five-Story Apartment Building Fire - New York***

TABLE 1 - Incident Timeline

| | |
|---|---|
| 2001 hours: | Dispatch received a telephone call reporting a structural fire |
| 2002 hours: | Engine 92, Ladder 44 (including the deceased), Ladder 19, and Battalion 17 dispatched |
| 2003 hours: | Received a second source (second call reporting the fire) |
| 2005 hours: | Engine 71, Engine 42, and Engine 50 dispatched |
| | Ladder 44 arrived on the scene |
| | Dispatch advised that there was a handicapped person in one of the apartments |
| | Engine 92 arrived on the scene |
| | Units advised Dispatch of a 10-75 (working fire) |
| 2006 hours: | Battalion 17 arrived on the scene |
| | Ladder 55, Battalion 14, Rescue 3, and Engine 41 dispatched |
| | Engine 71 arrived on the scene |
| 2007 hours: | Signal 7-5 (working fire) was received |
| | Ambulance 14C3 dispatched |
| 2008 hours: | Division 6, RAC 3 (rehabilitation unit), Engine 46, and Ladder 49 (2008 hours) dispatched |
| | Engine 42 arrived on the scene |
| 2009 hours: | Signal 2-2 (second alarm) was received |
| | Engine 60, Engine 94, Engine 83, Ladder 31, Battalion 26, FC 1 (Field Communications unit), SO 1 (Special Operations unit), ST 2 (Satellite unit), Engine 72, and Battalion 3 dispatched |
| | A request for an ambulance was received |
| | Engine 41 and Ladder 55 arrived on the scene |
| 2011 hours: | Ladder 45 was dispatched |
| | Ladder 33 relocated to Ladder 44 |
| | Engine 90 relocated to Engine 71 |
| | Rescue 3 arrived on the scene |
| 2012 hours: | Ambulance 14C3 on the scene |
| 2013 hours: | Engine 46 arrived on the scene |
| | Battalion 17 issued a 10-88, Code 1 (doubtful that units on the scene can control the fire) |
| | Engine 67 relocated to Engine 60 |
| 2014 hours: | Battalion 14 arrived on the scene |
| | Ladder 28 relocated to Ladder 19 |
| | Ladder 13 relocated to Ladder 55 |
| | Engine 60 arrived on the scene |
| | Ambulance 26F3 dispatched |
| | Unit C143 (EMS supervisor) dispatched |
| 2015 hours: | Battalion 17 issued a 10-45 Code One (civilian fire fatality) |
| | Engine 80 relocated to Engine 92 |

Engine 79 relocated to Engine 46
Battalion 16 relocated to Battalion 17
Ambulance 26T3 dispatched
Ambulance MV1 dispatched

2016 hours: Battalion 3 arrived on the scene
2017 hours: Engine 83 arrived on the scene
Ambulance 26F3 on the scene
2018 hours: Ladder 45 arrived on the scene
Tactical Support Unit 1 dispatched
2019 hours: Battalion 20 relocated to Battalion 14
2020 hours: Unit C143 on the scene
2024 hours: Special Operations Unit 1 arrived on the scene
2026 hours: Battalion 20 relocated to Battalion 3
Engine 72 arrived on the scene
2027 hours: Dispatch was advised that there was heavy fire on the fourth floor and the trucks were opening up (ventilating), three lines were stretched with two in operation, and searches were being conducted
Ambulance 14C3 transports one burn victim to the hospital
2029 hours: DC 6 advised Dispatch of a second 10-45, Code 1 (civilian fire fatality)
2034 hours: Field Com 1 arrived on the scene
2035 hours: Car 4C (City-wide Tour Commander) arrived on the scene
2036 hours: RAC 3 arrived on the scene
2038 hours: Ladder 55 [original FAST (firefighter assist and search team) truck] was put to work and Ladder 49 would become the FAST truck
Ambulance 19G3, Ambulance 17E3, Ambulance 18Y3, and EMS DC 2 dispatched
2039 hours: Field Com 1 issued a 10-45, Code 2 (civilian fire injury)
Ambulance 19G3 arrived on the scene
EMS 621 dispatched
2042 hours: Dispatch was advised of a total of three 10-45's, two Code 1's and one Code 2
Ambulance 17E3 arrived on the scene
2045 hours: Ambulance 14C3 transports a second victim to the hospital
2046 hours: Ambulance 18Y3 arrived on the scene
2047 hours: Field Com 1 advised Dispatch units on the scene will probably be able to control the fire
EMS 621 arrived on the scene
2049 hours: EMS DC 2 arrived on the scene
2050 hours: EMS C553 dispatched
2055 hours: Field Com 1 advised Dispatch "under control"
2119 hours: Ambulance 18Y3 transporting Fire Fighter in cardiac arrest
2121 hours: Ambulance 18Y3 arrived at hospital