



## **Forestry Worker Dies While Bulldozing a Fire Line at a Wildland Fire-Alabama**

### **SUMMARY**

On July 6, 1998, a 50-year-old male Forestry Worker responded to a 50-acre wildland fire. After working on the scene for approximately 4 hours in 90 degree Fahrenheit heat, bulldozing fire lines around the perimeter of the fire and removing wire that was caught in the dozer tracks, the victim had a witnessed collapse. After cardiopulmonary resuscitation (CPR) and advanced life support (ALS) on the scene and at the hospital, the victim died. The death certificate, completed by the Emergency Room physician, listed "cardiac arrest" as the immediate cause of death and "respiratory failure" as the underlying cause. An autopsy performed by the State Medical Examiner listed the mechanism of death as an "acute myocardial infarction" (heart attack).

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 individuals at higher risk, and (3) encouraging increased individual physical capacity.

The following issues are relevant to this Agency:

- ***Fire fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a mandatory wellness/fitness program for fire fighters.***

- ***Provide portable radios with local emergency frequencies for use when operating away from a base station or mobile radio.***
- ***Provide training to staff and develop procedures regarding when and how to respond to medical emergencies.***

### **INTRODUCTION AND METHODS**

On July 6, 1998, a 50-year-old male Forestry Worker lost consciousness after bulldozing fire lines in high heat and humidity at a 50-acre wildland fire and removing wire caught in the tracks of his bulldozer. Despite CPR and ALS administered by rescue squad members, ambulance service paramedics, and emergency room personnel, the victim died. NIOSH was notified of this fatality by the United States Fire Administration. On December 2, 1999, NIOSH contacted the affected Agency to initiate the investigation. On January 10, 2000, a

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at:

<http://www.cdc.gov/niosh/firehome.html>

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## Fatality Assessment and Control Evaluation Investigative Report #F2000-02

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Safety and Occupational Health Specialist and a Nurse Epidemiologist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Alabama to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the following:

- Regional Staff Specialist for Fire
- Coworkers involved in this incident
- Rescue Squad personnel involved in this incident
- Chief of the Rescue Squad
- Victim's spouse
- The Department of Forensic Science's Head of the Toxicology Section

During the site visit NIOSH personnel reviewed

- Existing Agency investigative records, including the fire fighter fatality investigation report, incident reports, coworker statements, and dispatch records
- Victim's personnel record
- Emergency medical services—ambulance report
- Hospital's records of the resuscitation effort
- Autopsy results and death certificate
- Past medical records of the deceased
- Agency policies and operating procedures
- Agency training records
- Agency's annual report for 1998
- National Climatic Data Center data for the incident date

### **INVESTIGATIVE RESULTS**

***Incident Response.*** On July 6, 1998, a wildland fire was spotted by air, and at 0834 hours, County 911 Dispatch was notified by radio. 911 Dispatch notified the involved Agency of the fire. The fire, which would eventually consume 50 acres, was in undeveloped, very hilly, rough terrain with 60- to 80-foot cliffs and a 200-foot drop-off on one side. At the time of dispatch, the temperature was 88 °F, and relative humidity was 65%.

The victim retrieved the Agency bulldozer, a 350 crawler with a blade in front and a plow in the rear, which was loaded onto a truck and taken to the fire scene. A Forestry Specialist retrieved his water cooler and also responded to the scene. Both arrived at approximately 0900 hours.

Once on the scene, the victim unloaded the bulldozer and began to scrape fire lines around the perimeter of the fire. The crew were wearing their standard Agency work uniform plus flame-retardant jackets. The Forestry Specialist acted as ground guide during the operation. Due to the extreme heat and humidity, the crew took at least two breaks inside the Specialist's air-conditioned truck to cool off and drink water, and a couple of rest breaks outside the truck.

At approximately 1230 hours, the dozer got caught in some abandoned wire on the ground and would not operate. The victim stopped the dozer and had to cut, hammer, and pull the wire out of the dozer's tracks. During this phase of the operation, the temperature was 94 °F and relative humidity was 91%. Once the dozer tracks were cleared, the victim began scraping fire lines again. Near the end of the operation, representatives of the property owner arrived on the scene.

At approximately 1300 hours, the victim scraped the last of the fire line and pushed the debris into a strip pit. He backed up the dozer, then moved forward again. The property owner representatives asked the Forestry Specialist if something was wrong with the victim. The Forestry Specialist went to check the victim and saw that he had slumped over the controls of the dozer (which had caused the dozer to move forward). One property owner representative got on the dozer, turned it off, and checked the victim for a pulse. The victim was unresponsive, not breathing, and pulseless. The Forestry Specialist ran to his truck (parked uphill



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and about 100 yards away) and radioed 911 Dispatch to request the rescue squad and an ambulance.

The rescue squad and the ambulance were dispatched at 1318 hours. The Rescue Squad Chief, a city employee, responded in the city truck (2 miles away) and Ambulance 112 (two Paramedics) responded from their station 21 miles away. The Rescue Squad responded soon thereafter. The Rescue Chief arrived on the scene and assisted the Forestry Specialist and property owner representatives in removing the victim from the dozer. The victim was reassessed and found to be unresponsive, not breathing, and pulseless. CPR (chest compressions and mouth-to-mouth breathing) began. The Rescue Squad arrived on the scene and CPR (chest compressions and assisted ventilation via bag-valve-mask and 100% oxygen) was begun. Ambulance 112 arrived on the scene at 1337 hours.

The victim was intubated and intravenous (IV) access was established. A heart monitor was attached to the victim which revealed asystole (no heart beat). Medications were administered consistent with ALS protocols. Reassessment of the heart rhythm revealed no change. The victim was placed onto a stretcher and loaded into the ambulance. Ambulance 112 departed the scene at 1356 hours for the 21-minute trip to the hospital. During the trip, the victim's heart rhythm remained in asystole and CPR continued.

Ambulance 112 arrived at the hospital at 1417 hours. Upon arrival at the hospital, the victim's heart rhythm was reevaluated and found again to be in asystole. In the emergency department (ED), CPR and ALS continued until 1425 hours when the victim was pronounced dead and resuscitation efforts were stopped.

Medical Findings. The death certificate was completed by the Emergency Room physician, who listed "cardiac arrest" as the immediate cause of death and "respiratory failure" as the underlying cause. The victim had severe coronary artery disease, as noted on autopsy, and was under the care and monitoring of a cardiologist (heart specialist). In January 1994, he experienced a myocardial infarction within the minor vessels of his heart. At that time, he underwent cardiac catheterization along with angioplasty to open stenotic (clogged) vessels. This procedure was repeated 1 month later for recurrent chest pain, and once more 7 months later. According to his medical record, he did not report recurrent chest pain again, and in September 1996, he underwent a thallium-graded exercise stress test (EST) to check his heart function. The findings of this test were normal. Medical records from his cardiologist follow-up in August 1997 indicated that his heart and lungs sounded normal and clear.

The victim reported some increased shortness of breath when he climbed the 133 steps leading to the 100-foot observation tower or when climbing steep hills, but he stated this did not interfere with his job performance. The victim walked 2 to 3 miles at least three times each week in addition to climbing and descending the observation tower, sometimes several times daily, particularly during the summer months, which are considered "fire season." He had not complained of chest pain during these activities since his angioplasties in 1996.

Pertinent coronary artery disease findings from the autopsy include

- Atherosclerotic cardiovascular disease, tri-vessel, very severe (Ninety-percent occlusion of each of the following arteries: left anterior descending, right, and circumflex arteries)
- Myocardial infarctions, old, remote, multiple
- Myocardial infarction, recent, acute



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Toxicological analysis reported a 10-percent carboxyhemoglobin level. In an interview, the head of the Toxicology Section who performed this analysis communicated that the victim's actual carboxyhemoglobin range was within 5 to 10 percent, a range he considered indicative of carbon monoxide exposure during this fire suppression but **not** indicative of a toxic exposure.

#### **DESCRIPTION OF THE AGENCY**

At the time of the NIOSH investigation, the Agency office involved was comprised of three uniformed personnel and served a population of 19,006 residents in a geographic area of 130 square miles. Forestry workers normally work the following tour of duty: Monday-Friday, 8 hours per day.

In 1998, the Agency responded to 47 wildland fires, which consumed a total of 145.2 acres, including the 50-acre fire involved in this incident.

The day of the incident, the victim began his shift at 0700 hours. The fire call occurred at 0834 hours. During the day the victim did not report or show signs of discomfort, pain, or distress, but appeared to his coworker that he did not have much energy and did not feel well. The incident described was the victim's first emergency response during his shift.

***Training.*** The Agency provides all new forestry workers with training that includes equipment operation and maintenance, handtools, personal protective equipment, communications, safety, fire behavior, fire suppression, standards for survival, and CPR. Annual recertification training includes standards for survival and CPR. The victim had 10 years of forestry fire fighting experience.

***Preemployment/Preplacement Evaluations.*** The Agency requires preemployment/preplacement medical evaluations for all new hires.

Following are components of this evaluation for all applicants:

- A medical history
- Physical examinations and tests including
  - Height, weight, and vital signs
  - Vision testing
  - Hearing testing
  - Serology (components unknown)
  - Chest X-ray
  - Urinalysis
  - Urine drug, albumin, and glucose testing
  - Examination of the heart after exercise for those greater than age 35

These examinations are paid for by the Agency and are performed by a potential applicant's personal physician using a standardized Agency form.

***Periodic Evaluations.*** The Agency requires all employees whose jobs include strenuous physical labor to undergo a physical examination and tests as described above when they reach the age of 50, 55, 60, and 63, and every 2 years thereafter. Employees may be required to undergo additional physical examinations whenever their supervisor has reason to believe they may have a medical condition which could impair safe and efficient performance of duties. A supervisor may require a medical evaluation following a lengthy period of absence. A narrative statement from the employee's personal physician certifying fitness to return to full duty can be required at the supervisor's discretion. As mentioned earlier, the victim was closely monitored by a heart specialist as well as a private physician. His last visit to his personal physician was 5 days preceding his death. This was a routine checkup and clearance for unrestricted duty was not discussed. Similarly, a review of his medical record from his cardiologist visit 5 months earlier do not provide any discussions of recommendations limiting work activities.



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An annual physical fitness test has recently been implemented which involves carrying a 25-pound pack for 2 miles within 30 minutes. The Agency has no exercise (strength and aerobic) equipment available for physical fitness training. There are voluntary State wellness programs for smoking cessation and weight control. Additionally, a local Health Department nurse visits each Agency facility monthly to monitor all workers' blood pressure, semi-annually to administer cholesterol and blood glucose tests, and annually to offer flu shots.

#### **DISCUSSION**

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.<sup>1</sup> Risk factors for its development include family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.<sup>2</sup> As well as having diagnosed coronary artery disease, the victim had these risk factors: age greater than 45 years old, male gender, a positive family history, hypertension, high cholesterol, and obesity. The victim had a history of smoking for over 35 years, but had stopped smoking in 1994 after his heart attack.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.<sup>3</sup> However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.<sup>4</sup> 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.<sup>5</sup> This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques. Although the victim did not have a blood clot in one of his coronary arteries on autopsy, he did have severe atherosclerotic disease.

Fire fighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.<sup>6</sup> Fire-fighting activities 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.<sup>7-9</sup> Additional demands are placed on the heart when high work intensities are sustained for long periods, particularly when work is carried out in hot surroundings.<sup>10</sup> Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.<sup>11-14</sup> Additionally, studies have shown that exertional levels and, therefore, ventilatory rates may be so great during fire fighting that even with moderate or low levels of atmospheric carbon monoxide, the carboxyhemoglobin can rise to dangerous levels within minutes and may increase the risk of cardiovascular disease.<sup>15,16</sup> The victim's carboxyhemoglobin level was in the 5-to-10 percent range at autopsy. The mental and physical stress of responding to the emergency, operating the bulldozer, clearing the wire from the dozer tracks in the high atmospheric temperature and humidity, and his underlying atherosclerotic CAD all probably contributed to this victim's death.

The victim's heart rhythm was first evaluated by the heart monitor at 1337 hours and found to be in asystole. His heart rhythm remained in asystole throughout the incident.

After his 1994 treatments for heart disease, the victim did not report any more episodes of chest pain. He passed a thallium-graded exercise stress test less than 2 years later and was monitored closely by his cardiologist and family physician.

There were discrepancies between the frequency and content of the Agency's preemployment and periodic medical evaluations and those recommended by the



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NFPA.<sup>17, 18</sup> To reduce the risk of sudden incapacitation among fire fighters, the National Fire Protection Association (NFPA) has developed guidelines entitled “Medical Requirements for Fire Fighters and Information for Fire Department Physicians,” otherwise known as NFPA 1582.<sup>18</sup> They recommend, in addition to screening for risk factors for CAD, 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).<sup>19, 20</sup> This has led other expert groups to **not** recommend EST for asymptomatic individuals without risk factors for CAD.<sup>21, 22</sup> The victim’s last EST was in September 1996 (less than 2 years before his death), and was reported as normal.

**RECOMMENDATIONS AND DISCUSSION**

The following recommendations address health and safety generally. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac death 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. In addition, they are presented in a logical programmatic order and are not necessarily listed in order of priority.

***Recommendation #1: Fire fighters should have annual medical evaluations to determine their medical ability to perform duties without presenting a significant risk***

***to the safety and health of themselves or others.***

Guidance regarding the content and scheduling of periodic medical evaluations for fire fighters can be found in (1) NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians,<sup>18</sup> (2) the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative,<sup>23</sup> and (3) the National Wildfire Coordinating Group publication on Fitness and Work Capacity, NFES 1596.<sup>24</sup> Currently, the Agency follows NFES 1596, NFES 1594 (Heat Stress)<sup>25</sup>, and NFES 2072 (Fatigue and the Firefighter).<sup>26</sup> Although the Agency is not legally required to follow NFPA 1582 or the IAFF/IAFC wellness/fitness initiative, we recommend that the content and frequency of the medical evaluations be consistent with the guidelines found in NFPA 1582 and the IAFF/IAFC wellness/fitness initiative.<sup>18, 23</sup> The content of these two guidelines is more extensive and provides more guidance to examining physicians than the recommendations of the National Wildfire Coordinating Group. Specifically, the preemployment/preplacement stress (EKG) tests are not medically necessary for applicants under the age of 35. Additionally, the use of chest X-rays in surveillance activities in the absence of significant exposures, symptoms, or medical findings has not been shown to reduce respiratory or other health impairments.<sup>18</sup> Therefore, only preemployment/preplacement chest X-rays are recommended by the NFPA. Medically unnecessary X-ray studies result in unnecessary exposure to radiation and represent an unnecessary expense for the Agency. On the other hand, annual/periodic medical evaluations should be conducted, and, according to the NFPA, should include EST beginning at age 35 for fire fighters with risk factors for CAD. The EST will undoubtedly increase the costs associated with the medical evaluations. To some extent these costs could be



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offset by reducing the frequency of other tests included in the Agency's annual examinations (e.g., periodic chest X-ray, serology, and perhaps drug testing). The EST could be conducted by the fire fighter's personal physician with results communicated to the Agency physician responsible for decisions regarding medical clearance for fire-fighting duties. This physician, whether a State employee or contractor, should be familiar with all components of NFPA 1582. In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire-fighting tasks. (Currently, medical decisions regarding additional physical examinations or testings are left up to the discretion of the fire fighter's supervisor.)

Applying NFPA 1582 involves legal issues, so it should be carried out in a **confidential, nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for Fire Department Administrators regarding legal considerations in applying the standard. Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs of dealing with the medical evaluation results. NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, addresses these issues in Chapter 8-7.1 and 8-7.2.<sup>17</sup> The success of medical programs hinges on protecting the affected fire fighter. The Agency must (1) keep the medical records confidential, (2) provide alternate duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically qualified to return to active fire fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

***Recommendation #2: Reduce risk factors for cardiovascular disease and improve cardiovascular capacity by phasing in a***

***mandatory wellness/fitness program for fire fighters.***

NFPA 1500, Standard on Fire Department Occupational Safety and Health Program, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.<sup>17</sup> In 1997, the International Association of Fire Fighters and the International Association of Fire Chiefs joined in 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 with a video detailing elements of such a program.<sup>23</sup> NFES 1596, Fitness and Work Capacity, was developed to help forestry workers and wildland fire fighters achieve health, fitness, and work capacity.<sup>24</sup> The Agency currently utilizes NFES 1594, NFES 1596, and NFES 2072 in their health and safety programs. The Agency should also review NFPA 1500 and the IAFF/IAFC wellness/fitness initiative to identify applicable elements for their use. Other large-city negotiated programs can also be reviewed as potential models. The Agency had recently implemented a mandatory annual timed-walk fitness test after this victim's death. However, there was no mandatory wellness/fitness program in place.

***Recommendation #3: Provide portable radios with local emergency frequencies for use when operating away from a base station or mobile radio.***

The first unit to arrive at a fire or other emergency incident should notify the communications center by radio of its arrival and give a brief description of the conditions visible and the precise location of the incident.<sup>27</sup> As soon as conditions allow, the incident



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commander should report supplementary information to the communications center and should make additional progress reports if operations keep the fire units at the emergency beyond a few minutes.<sup>27</sup> Currently, the Agency workers notify the Dispatch Center of their arrival on the scene, a scene description, the size of the fire, and what resources will be required to combat the fire.

When the Forestry Specialist realized the victim's situation, he had to run to his truck, which was parked 100 yards away and uphill, to notify the local 911 communications center. If a portable radio with local emergency frequencies had been available, the call for help could have been sooner. However, due to low-lying areas, portable radios can be ineffective in transmitting.

***Recommendation #4: Provide training to staff and develop procedures regarding when and how to respond to medical emergencies.***

Although CPR, first aid, and standards for survival training are required for all Agency workers, additional training might help forestry workers respond to medical emergencies. Current Agency training includes assessment of the situation to determine what medical emergency exists and which interventions to perform (first aid or CPR). Additionally, notification procedures for local emergency response agencies and radio equipment tests could be added to ensure the response agencies are identified and that the radio equipment is in working order.

In this incident, the victim's chances for survival were dismal given the remote location and the time required for the paramedics to arrive by ambulance.

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**INVESTIGATOR INFORMATION**

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