



## Fire Fighter Dies at Home After Shift - Maryland

### SUMMARY

On December 18, 2003, a 55-year old, male, career Fire Fighter (FF) finished his 14-hour night shift at approximately 0700 hours and went home. He was supposed to return to duty at 1700 hours, but did not return to his station. Since he had not notified station personnel of taking time off, his station Captain contacted the fire station closest to the FF's home and requested their station personnel go to the FF's home and check on him. Upon arrival at the FF's home, fire personnel placed an extension ladder to a second floor bedroom window, ascended the ladder, and saw the FF lying in bed. Attempts to arouse the FF were unsuccessful and forcible entry was made into the home. Fire personnel assessed the FF and found him to be deceased for at least several hours. No resuscitation measures were attempted. An ambulance and police were summoned and upon arrival of the ambulance, he was pronounced dead. The death certificate and autopsy, completed by the Medical Examiner, listed "arteriosclerotic cardiovascular disease" as the immediate cause of death.

The following recommendations address some general health and safety issues. 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 arrest among fire fighters. These selected recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups. These recommendations would probably not have changed the outcome in this case.

Although unrelated to this fatality, the Fire Department (FD) should consider these recommendations based on health and economic considerations:

- *Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity*
- *Discontinue the routine use of annual chest x-rays unless specifically indicated*
- *Continue providing mandatory annual medical evaluations to ALL fire fighters consistent with NFPA 1582 to determine their medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others*

### INTRODUCTION & METHODS

On December 18, 2003, a 55-year-old male Fire Fighter did not return for duty at the appointed time. Fire personnel sent to his home found him deceased. No resuscitation measures were attempted. NIOSH

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. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. 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 [www.cdc.gov/niosh/firehome.html](http://www.cdc.gov/niosh/firehome.html) or call toll free 1-800-35-NIOSH



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*Fire Fighter Dies at Home After Shift - Maryland*

was notified of this fatality on December 23, 2003, by the United States Fire Administration. NIOSH contacted the affected Fire Department on January 26, 2004, to obtain further information. On May 17, 2004, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Maryland to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed:

- The Fire Chief
- The Division Chief
- The Union President
- Fire Investigator
- Health and Safety Officer
- The FF's wife

During the site-visit NIOSH personnel reviewed:

- FD policies and operating guidelines
- FD training records
- FD annual report for 2003
- FD investigative report
- Witness statements
- FD physical examination protocols
- FD ambulance records
- Death certificate
- Autopsy report

### **INVESTIGATIVE RESULTS**

On December 17, 2003, the FF reported for duty at his fire station (Station 6) at approximately 1630 hours. He was assigned to Engine 6. During the shift, the crew was dispatched to two alarms: an unconscious person call at 1647 hours and an electrical fire in a single-family dwelling at 1940 hours. During the emergency medical call, the FF performed cardiopulmonary resuscitation (CPR), assisted the ambulance crew in placing the patient on a long spine board, then onto a stretcher, carrying the patient to the ambulance, lifting the stretcher into the ambulance,

accompanied the ambulance to the hospital, and assisting the ambulance crew with patient care and transfer at the hospital. The call ended at 1705 hours. During the electrical fire, the FF, wearing full turnout gear and self-contained breathing apparatus (SCBA), assisted with investigation of fire origin, carried hand tools to assist with investigation and extinguishment, assisted with scene safety, and interfaced with the property owners. Throughout these incidents, the FF did not express any complaints of chest pain or any other symptoms of illness.

There were no additional responses for the remainder of the shift. The crew performed station maintenance and equipment checks.

Just prior to the FF's shift ending at 0700 hours, he spoke briefly with two crew members and then he went home. He arrived at his home at approximately 0720 hours and spoke with his wife prior to her departure for work. It is unknown what activities he performed throughout the day. At 1700 hours, he was supposed to report for duty at his station but did not arrive. At 1740 hours, his Captain became concerned that the FF had not arrived for work. The FF would typically arrive for work one hour early and had never been late. Several phone calls were made to the residence with no answer. The Captain contacted the fire station closest to the FF's home and requested a crew go to the FF's home and check on him. Engine 55 responded to the FF's home and upon arrival, noticed the home was locked and the FF's personal vehicle was parked in front of the home.

Crew members placed an extension ladder to the bedroom window and a fire fighter ascended the ladder to look inside the window. The fire fighter saw someone lying in bed. After attempts at knocking on the window to arouse the FF were unsuccessful, forcible entry was made into the home. Crew members entered the home and found the FF in bed. After assessing the FF and

*Fire Fighter Dies at Home After Shift - Maryland*

finding him to be deceased (cool skin and rigor mortis), no resuscitative measures were attempted. Police and an ambulance were summoned and, upon arrival of the ambulance, he was pronounced dead by ambulance personnel at 1755 hours.

**Medical Findings.** The death certificate, completed by the Medical Examiner, listed “arteriosclerotic cardiovascular disease” as the immediate cause of death. The carboxyhemoglobin level (a measure of exposure to carbon monoxide) was not measured. Pertinent findings from the autopsy, also performed by the Medical Examiner, on December 19, 2003, included:

- Severe arteriosclerotic cardiovascular disease
  - 80-90% stenosis in the left anterior descending artery
  - 60% stenosis in the circumflex artery
  - 80% stenosis in the right coronary artery
- Old subendocardial infarct of left ventricle
- Biventricular dilatation
  - Left ventricle cavity measured 5 x 8.5 centimeters (cm)
  - Right ventricle cavity measured 5.5 x 3.5 cm
  - Left ventricular free wall thickness of 1.2 cm [(normal is 0.76-0.88 cm)<sup>1</sup>(normal echographic measurement is 0.6 to 1.1 cm)<sup>2</sup>]
  - Right ventricular free wall thickness of 0.6 cm (normal is 0.3-0.5 cm).<sup>3</sup>
- Cardiomegaly (heart weighing 550 grams with normal less than 400 grams<sup>4</sup>)
- Aortic atherosclerosis
- Cardiac valves were unremarkable
- No thrombi were found
- Drug and alcohol tests were negative

According to the FF’s wife and FD personnel, the FF was seldom sick, and he walked regularly.

A FD physical examination, conducted in July 2003, revealed a height of 73" and a weight of 191 pounds,

giving the FF a body mass index (BMI) of 25 kilograms per square meter (kg/m<sup>2</sup>), which is considered normal).<sup>5</sup> Blood pressure, glucose, cholesterol, and triglyceride levels were within normal limits. Due to the fact that the FF was over the age of 45 and had been a former smoker, the physician recommended an exercise stress test (EST) be performed. The FF died prior to the EST being performed.

According to his wife and crew members, prior to this incident, the FF had no complaints of chest pains or any symptoms suggestive of acute heart-related problems.

**DESCRIPTION OF THE FIRE DEPARTMENT**

At the time of the NIOSH investigation, this combination FD consisted of 1,100 uniformed career and 2,000 volunteer personnel. The Department served a population of 800,000 in an area of 610 square miles. There are 26 career fire stations, 33 volunteer fire stations, and two volunteer rehabilitation units. The FD also provides advanced life support (ALS) medical service. Career fire fighters work the following schedule: two 10-hour shifts 0700 hours to 1700 hours, two 14-hour shifts 1700 hours to 0700 hours, then are off-duty for four days.

In 2003, the FD responded to 176,760 calls, including: 87,036 fire calls and 89,724 medical calls.

**Training.** The FD requires all new career applicants to pass a written test, physical ability test, a pre-placement physical examination, a drug test, and a background investigation prior to being given a conditional offer of employment. Most employees are hired as probationary emergency medical technicians (EMTs), then are sent to a 9-week Academy to become certified as an emergency



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*Fire Fighter Dies at Home After Shift - Maryland*

medical technician. Employees must attend the Fire Fighter Academy on their own to become certified fire fighters. Employees hired as fire fighters must have Fire Fighter II, infection control, hazardous materials operations, and EMT certifications prior to being hired.

Recurrent training occurs daily on each shift. The FD requires all fire fighters to receive continuing education in EMT, breathing apparatus, infection control, and hazardous materials operations annually. The State requires all fire fighters to complete a basic 24-hour fire fighter course. There is no State requirement for annual recertification. The FF was certified as a Fire Specialist, Driver/Operator, EMT, Hazardous Materials Operations, Fire Service Instructor II, Fire Investigator I, Fire Inspector I, and Public Fire Educator. He had 35 years of fire fighting experience.

*Pre-placement Evaluations.* The FD requires a pre-placement medical evaluation for all fire fighter candidates, regardless of age. Components of the evaluation include:

- A complete medical history
- Physical examination
- Vital signs
- Vision screening
- Audiogram
- Blood analysis: comprehensive metabolic panel (Chem 20) complete blood count with differential lipid panel
- Urinalysis dipstick
- Urine drug screen
- Pulmonary function test (spirometry)
- Chest x-ray
- Audiogram
- Vision screening
- Tetanus
- Hepatitis B Titer
- Hepatitis C antibody screening

- PPD (tuberculosis Mantoux) test
- Occupational Safety and Health Administration respirator questionnaire
- Respirator physical examination
- Exercise stress test

These evaluations are performed by a contract physician hired by the County, who then makes a decision regarding medical clearance for fire fighting duties. This decision is forwarded to the County Human Resources Director.

*Periodic Evaluations.* Periodic medical evaluations (beginning in 2003) are currently required by this FD. The components of which are the same as the pre-placement medical evaluation. Continuation in 2004 is dependent upon budget.

If the screening identifies any health problems, the fire fighter is advised to see their personal physician. The contract physician provides a summary to the FD, including fire fighter clearance and respirator clearance forms. Medical clearance for respirator use is required. A physical ability test is required annually beginning in 2003.

If an employee is injured at work, or is ill and off work for more than two days, the employee must be evaluated by their personal physician, who forwards their recommendation regarding “return to work” to the County contract physician, who makes the final determination. If the County contract physician is not available, the employee’s supervisor may allow the employee to return to duty until the contract physician becomes available.

The FF was seldom sick and had not missed work in recent history.

Exercise (strength and aerobic) equipment is located in most fire stations. The FD is in the processing of purchasing exercise equipment for the remainder of

*Fire Fighter Dies at Home After Shift - Maryland*

its fire stations. Voluntary wellness/fitness programs are in place for the FD, however the type of exercise performed is left to the individual fire fighter. Health/wellness maintenance information is available from the County. The FF exercised regularly by walking.

**DISCUSSION**

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.<sup>6</sup> Risk factors for its development include increasing age, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity/physical inactivity, and diabetes.<sup>7,8</sup> The victim had three of these risk factors (increasing age, male gender, and smoking). However, he smoked only about two cigarettes per shift.

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.<sup>9</sup> However, the growth of these plaques probably occurs in a nonlinear, often abrupt fashion.<sup>10</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>11</sup> This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques.

It is possible that the FF suffered a heart attack. The term “possible” is used because autopsy findings (thrombus formation), blood tests (cardiac isoenzymes), or ECG findings are required to “confirm” a heart attack [myocardial infarction (MI)]. The victim did not have a blood clot on autopsy, cardiac isoenzymes were not tested, and he had no heart beat to show the characteristic findings of a heart attack on an EKG. However, he had severe

coronary atherosclerotic disease and evidence of an old MI on autopsy.

Firefighting is widely acknowledged to be one of the most physically demanding and hazardous of all civilian occupations.<sup>12</sup> 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.<sup>13-15</sup> Even when energy costs are moderate (as measured by oxygen consumption) and work is performed in a thermoneutral environment, heart rates may be high (over 170 beats per minute) owing to the insulative properties of the personal protective clothing.<sup>16</sup> Epidemiologic studies have found that heavy physical exertion sometimes immediately precedes and triggers the onset of acute heart attacks.<sup>17-20</sup> During his shift, the FF performed CPR, assisted with lifting a patient, and wore full turnout gear and SCBA while investigating an electrical fire. This is considered a moderate level of physical exertion.<sup>21-23</sup> The physical stress of performing moderate physical exertion and his underlying atherosclerotic CAD contributed to this fire fighter’s cardiac arrest, and sudden death. Most life threatening arrhythmias associated with MI’s occur during the 24 hours after symptoms first began.<sup>24-26</sup>

To reduce the risk of sudden cardiac arrest or other incapacitating medical conditions among fire fighters, the NFPA has developed guidelines entitled “Standard on Comprehensive Occupational Medical Program for Fire Departments,” otherwise known as NFPA 1582.<sup>27</sup> To screen for CAD, NFPA 1582 recommends an exercise stress test (EST) for asymptomatic fire fighters with two or more risk factors for CAD [family history of premature (less than age 60) cardiac event, hypertension (diastolic blood pressure greater than 90 mmHg), diabetes mellitus, cigarette smoking, and hypercholesterolemia



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*Fire Fighter Dies at Home After Shift - Maryland*

(total cholesterol greater than 240 mg/dL)].<sup>27</sup> This recommendation is consistent with recommendations from the American Heart Association/ American College of Cardiology (AHA/ACC) and the Department of Transportation (DOT) regarding EST in asymptomatic individuals.<sup>28,29</sup> Since the deceased had only one CAD risk factor (smoking) for EST determination, the performance of an EST would not have been recommended by NFPA 1582 or the AHA.

The deceased had biventricular hypertrophy on autopsy. Hypertrophy of the heart's left ventricle (left ventricular hypertrophy) is a relatively common finding among individuals with long standing high blood pressure (hypertension), a heart valve problem, or cardiac ischemia (reduced blood supply to the heart muscle). However, the deceased was never known to have high blood pressure, and, on autopsy, did not have any valve abnormalities. He did have CAD, therefore cardiac ischemia is a distinct possibility, particularly given his extensive atherosclerotic disease. On the other hand, unexplained cardiac hypertrophy is one form of hypertrophic cardiomyopathy (HCM). This diagnosis of HCM was made by his: a) large heart, and b) thickened left heart ventricles.

Hypertrophic cardiomyopathy (HCM) is a relatively rare heart condition, affecting approximately 0.2% of the population.<sup>30</sup> The majority of patients are asymptomatic, and sudden cardiac death is often its first clinical manifestation, particularly among patients less than 30 years of age.<sup>31</sup> Risk factors for sudden death among HCM patients include young age (<30 years old) at diagnosis, a family history of HCM with sudden death, an abnormal blood pressure response to exercise, severe symptoms, non-sustained ventricular tachycardia, marked hypertrophy, marked left atrial dilatation, and genetic abnormalities associated with increased prevalence of a sudden death.<sup>30-32</sup>

Approximately half of the HCM cases are transmitted genetically, typically in an autosomal dominant trait with disease loci on at least eight different chromosomes.<sup>33</sup> Unfortunately, genetic testing is not routinely available and remains largely a research tool. The causes of HCM in the other half of patients is unknown.<sup>31</sup> Medical evaluation of first degree relatives is warranted to determine whether screening tests are appropriate.

Dilated cardiomyopathy, is characterized by dilatation of the heart chambers and impaired ventricular contraction (pumping). Microscopic findings are non-specific, typically being myocyte hypertrophy [best appreciated as nuclear hypertrophy (e.g. "box-car nuclei")] with varying degrees of interstitial fibrosis.<sup>34,35</sup> Although most cases of dilated cardiomyopathy are of unknown etiology (idiopathic), a variety of acquired or hereditary disorders can cause the disorder. These secondary and potentially reversible forms are listed in Table 1.<sup>35</sup>

Idiopathic cardiomyopathy (IDC) is not rare. Its age-adjusted prevalence in the United States averages 36 cases per 100,000 population,<sup>36</sup> and it accounts for 10,000 deaths each year.<sup>37</sup> Most patients are first seen between the ages of 20 and 50 years presenting with symptoms of moderate heart failure [shortness of breath on exertion, palpitations (fast heart beats), diminished exercise capacity] and advanced heart failure [shortness of breath upon lying down, and swelling of the ankles].<sup>35</sup> The deceased had sudden death. Although sudden death is rarely the initial presentation,<sup>38,39</sup> it is a common cause of death among IDC patients accounting for 28 percent of all IDC deaths.<sup>35</sup>

The prognosis for IDC is poor. Early studies reported one- and five-year death rates of approximately 25 and 50 percent respectively,<sup>40,41</sup> but recent studies report an average five-year death rate of 20 percent.<sup>38,39,42,43</sup> This improved survival probably

*Fire Fighter Dies at Home After Shift - Maryland*

reflects the earlier detection of disease, a shift to population-based studies, and better treatment.<sup>39,44</sup> Although a variety of symptoms and medical tests can provide prognostic information, patients at greatest risk of sudden death or in need of anti-arrhythmic therapy cannot yet be prospectively identified.<sup>35</sup> Given the inability to identify patients at high risk for sudden death, the low degree of efficacy of anti-arrhythmic agents for IDC, the numerous side effects of these anti-arrhythmic agents, and the lack of symptoms in the deceased, it is unclear if an earlier diagnosis could have prevented his sudden death.

Investigations into the pathogenesis of IDC have focused on four basic mechanisms:

(1) inherited factors, (2) viral myocarditis and other cytotoxic insults, (3) immune abnormalities, and (4) metabolic, energetic, and contractile abnormalities. These mechanisms are not mutually exclusive, and several may combine to produce clinical disease in susceptible patients. The inherited factors account for approximately one third of all IDC cases,<sup>45-47</sup> and 20 percent of patients with IDC have at least one first-degree relative with a decreased ejection fraction and cardiomegaly.<sup>45</sup> Although IDC can be transmitted as a recessive or X-linked trait, autosomal dominant inheritance occurs most frequently and exhibits both clinical variability and genetic heterogeneity.<sup>48</sup> It is unclear if this victim's IDC was due to inherited factors or due to post-viral myocarditis. In either case, first-degree relatives of this fire fighter should consult with their physicians regarding when, or if, an echocardiogram is warranted to screen for IDC. IDC is often accompanied by conduction system disease and genetic studies have identified individual loci on chromosomes responsible for these cases.<sup>48</sup> The reported conduction systems diseases associated with IDC are sinus bradycardia, atrioventricular conduction block (first-, second-, and third-degree), and atrial arrhythmias.<sup>48</sup> Except for family history, no clinical or histopathological characteristics can distinguish familial from nonfamilial disease.<sup>35</sup> Future

molecular genetic studies may lead to the identification and treatment of asymptomatic carriers who are at risk for symptomatic dilated cardiomyopathy.<sup>48</sup>

It is unclear if a more timely EST could have identified his underlying condition.

Had the deceased's HCM or IDC been identified during the FD's periodic medical evaluation, would he have been denied employment as a fire fighter? Neither HCM or IDC is specifically addressed in NFPA 1582. However, it would most likely be considered a Category B Medical Condition, defined as "a medical condition that, based on its severity or degree, **could** (our emphasis) preclude a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others."

Had the deceased's HCM been identified, would this have prevented his death? Although a variety of symptoms and medical tests can provide prognostic information, patients at greatest risk of sudden death or in need of anti-arrhythmic therapy are hard to identify. Given the deceased's few above mentioned risk factors for sudden death, the low degree of efficacy of anti-arrhythmic agents and their numerous side effects, and the lack of symptoms in this fire fighter, it is unlikely that a diagnosis would have led to treatment. Therefore, it is unclear if his tragic sudden death would have been prevented even if his condition was identified.

HCM, IDC, or CAD/MI are all possibilities for his sudden cardiac death; the exact cause cannot be determined.

**RECOMMENDATIONS AND DISCUSSION**

The following recommendations address health and safety generally. This list includes some preventive



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*Fire Fighter Dies at Home After Shift - Maryland*

measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH, but represent published research, or consensus votes of technical committees of the NFPA or fire service labor/management groups.

Although unrelated to this fatality, the Fire Department (FD) should consider these recommendations based on health and economic considerations:

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

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity, or lack of exercise, is associated with other risk factors, namely obesity and diabetes.<sup>49</sup> 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>50</sup> NFPA 1583, Standard on Health-Related Fitness Programs for Fire Fighters, provides the minimum requirements for a health-related fitness program.<sup>51</sup> 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.<sup>52</sup> The Fire Department and the Union should review these materials to identify applicable elements for their

Department. Other large-city negotiated programs can also be reviewed as potential models. Wellness programs have been shown to be cost effective, typically by reducing the number of work-related injuries and lost work days.<sup>53-55</sup> A similar cost savings has been reported by the wellness program at the Phoenix Fire Department, where a 12-year commitment has resulted in a significant reduction in their disability pension costs.<sup>56</sup>

***Recommendation #2: Discontinue the routine use of annual chest x-rays unless specifically indicated.***

According to NFPA 1582, “chest x-rays shall include an initial baseline and shall be repeated every 5 years or as medically indicated.”<sup>27</sup> The chest x-rays being conducted by the Fire Department expose incumbents to unnecessary radiation and represent an unnecessary expense for the Fire Department, and are not recommended by the OSHA Hazmat standard unless indicated.<sup>57</sup>

***Recommendation #3: Continue providing mandatory annual medical evaluations to ALL fire fighters consistent with NFPA 1582 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 frequency of periodic medical evaluations and examinations for fire fighters can be found in NFPA 1582, Standard on Comprehensive Occupational Medical Program for Fire Departments,<sup>27</sup> and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.<sup>52</sup> The Department is not legally required to follow any of these standards.

The success of medical programs hinges on protecting the affected fire fighter. The Department must 1)

*Fire Fighter Dies at Home After Shift - Maryland*

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.

The current annual medical evaluation program began in 2003 and was funded by a grant. The status of the program in 2004 is dependent on the budget.

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*Fire Fighter Dies at Home After Shift - Maryland*

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*Fire Fighter Dies at Home After Shift - Maryland*

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*Fire Fighter Dies at Home After Shift - Maryland*

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