



NIOSH
Fire Fighter Fatality Investigation
and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation

August 15, 2003

Fire Fighter Dies From Progressive Respiratory Failure - Massachusetts

SUMMARY

On September 19, 2002, a 51-year-old male career District Fire Chief (DC) responded to a fire in the basement and attic of a three-story, multiple family dwelling. While acting as incident commander (IC), he was exposed to heavy smoke from the fire. Approximately two weeks later, the DC responded to a hazmat incident as a member of the State Hazardous Materials Response Team. The hazmat incident involved a spill of 2-chlorotoluene, 2-butanone (methyl ethyl ketone), and 1,2,4-trimethylbenzene. Two days after the spill (October 4), the DC developed a cough for which he was evaluated by his primary care physician (PCP) the next day. His respiratory condition worsened and, on October 15, he was admitted into the hospital. Despite intensive hospitalized care, his respiratory function continued to deteriorate until October 24, when he died. The autopsy and death certificate listed “progressive respiratory failure and clinical history of adult respiratory distress syndrome due to inhalational injuries” as the immediate cause of death.

The following recommendations address some general health and safety issues. 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.

- ***Ensure that fire fighters exposed to smoke have access to medical evaluations if they develop respiratory or any other unusual symptoms; and***
- ***Implement the annual medical evaluations mandated by the State in 1996***

INTRODUCTION & METHODS

On October 15, 2002, a 51-year-old male District Chief was admitted to the hospital due to his worsening respiratory condition. He had been exposed to heavy smoke at a fire in a three-story multiple family dwelling and had responded to a hazmat incident 13 days later. Despite treatment in two hospitals, the victim died. NIOSH was notified of this fatality on November 4, 2002, by the United States Fire Administration. NIOSH contacted the affected Fire Department the same day to initiate the investigation. On February 24, 2003, a Safety and Occupational Health Specialist from the NIOSH Fire Fighter Fatality Investigation Team traveled to Massachusetts to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed:

- The Fire Chief
- The Training Officer
- The Union Vice-President
- The victim’s wife

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 or call toll free **1-800-35-NIOSH**



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During the site-visit NIOSH personnel reviewed:

- Fire Department policies and operating guidelines
- Fire Department training records
- The Fire Department annual report for 2002
- Fire Department incident report
- State hazmat incident report
- Hospital reports
- Fire Department physical examination protocols
- State hazmat physical examination protocols
- Death certificate
- Autopsy record
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On September 19, 2002, the District Chief (the victim) reported to work at approximately 0730 hours. The day was spent performing administrative duties. At 1842 hours, Engine 2, Engine 3, Engine 9, Ladder 4, Rescue 1, and Car 2 (the District Chief) (15 personnel total) were dispatched to a structure fire. Units arriving on the scene (1845 hours) reported “smoke showing.” See Table 1 for a timeline of the response.

The structure was a 14,400 square foot, three-story and cellar, nine-family apartment building of balloon construction and vinyl siding. An exposure of similar size and construction was situated approximately five feet away. The fire began in the cellar and had spread up the walls into the attic. At 1900 hours, a second alarm was transmitted and, at 1957 hours, a third alarm was transmitted. There were a total of 32 fire personnel on the scene.

Crews extinguished the fire in the cellar and then evacuated the building. Fire had spread to the attic area and ladder pipes were put into service. The fire produced heavy smoke conditions outside at ground level. The DC was exposed to the smoke on several occasions, thereby causing him to cough severely. The DC was on the scene for 108 minutes

wearing his turnout gear but no self-contained breathing apparatus (SCBA), acting as IC outside the structure. The smoke from the fire contained typical combustion by-products. No other fire fighters reported prolonged respiratory symptoms that resulted in their seeking medical evaluation. The fire was declared under control at 2033 hours.

The DC worked three more shifts, during which time he was not subjected to hazardous or toxic smoke, and was off-duty for two days. On October 2, 2002, at 1215 hours, an initial activation occurred for a Tier 1 hazmat response to a hazmat spill in a town located in another part of the state. Hazmat Truck 11 (Technical Operations Module) (TOMS) and Truck 13 (Operations Response Unit) (ORU) were dispatched. The FD in the town was on-scene and had isolated the contaminated area. Since the substance involved in the spill was an unknown irritating substance and Level A suits were required to gain entry into the area, a Tier 2 response (Truck 12) was activated at 1304 hours. The DC was notified at 1310 hours. Truck 13 was delayed due to a mechanical problem and Truck 12 was requested. There would eventually be 22 personnel on the scene including the DC. The DC arrived on the scene at 1433 hours and was assigned to the TOMs unit analyzing samples.

At the scene was an area measuring 8 feet by 5 feet of a substance that had soaked into the ground but was emitting pungent and irritating vapors. A nearby resident had been taken to the hospital with respiratory distress, nausea, and dizziness. A construction worker had placed his hand into the substance and found it to be irritating and subsequently washed off the material, however, the odor persisted on his hand. He was later transported to the hospital for evaluation along with the initial firefighters who responded. A total of 19 persons were seen at two local hospitals. They were exhibiting symptoms that included dizziness,



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headache, nausea, and watery eyes. They were treated with humidified oxygen, observed for a short time, and released.

By 1500 hours, the hazmat team positioned themselves up wind from the spill site, and began medical screening for the entry teams. Entry teams were needed to determine the extent of the spill, take direct readings, and to obtain samples for analysis. Three entries were made (1514 hours to 1908 hours) to obtain samples. All entries were made in Level A personal protective equipment which consisted of a totally encapsulating suit with SCBA. The spill samples revealed a mixture of 2-Butanone (MEK), 2-Chlorotoluene, and 1,2,4-Trimethylbenzene.

2-Butanone, also known as Methyl Ethyl Ketone (MEK), is a ketone and is used as an analytical reagent.¹ It is an extremely flammable liquid and vapor, causes irritation to the respiratory tract, eyes, and skin and causes damage to the lungs, peripheral nervous system, respiratory tract, skin, eyes, and central nervous system.¹ The NIOSH Recommended Exposure Limit (REL) is a ceiling value of 200 parts per million (ppm)¹ (a level that should not be exceeded at any time). The scene soil sample revealed 200,000 micrograms per kilogram ($\mu\text{g}/\text{Kg}$) (200 ppm), but no air samples were taken. The NIOSH REL is for airborne exposures and cannot be compared to soil samples.

2-Chlorotoluene, also known as Orthochlorotoluene, is used as a chemical intermediate and a solvent.² It is a combustible liquid and may cause irritation by all routes of exposure and symptoms of central nervous system depression including headache, dizziness, nausea, loss of balance, and drowsiness.² The NIOSH REL is 50 ppm as an 8-hour time weighted average (TWA), and the 15-minute short-term exposure limit (STEL) is 75 ppm.³ The scene soil sample revealed 5900 ppm, but no air samples were

taken. Again, the NIOSH REL is for airborne exposures and cannot be compared to soil samples.

1,2,4-Trimethylbenzene, also known as Assymetrical Trimethylbenzene, psi-Cumene, or Pseudocumene, is a Class II flammable liquid and an additive in protective coatings, unleaded gasoline, among others.^{4,6} Exposure may cause irritation to the skin, eyes, nose, throat, respiratory system, headache, drowsiness, nausea, etc.⁴ The NIOSH REL is 25 ppm as an 8-hour TWA.⁴ The scene soil sample revealed 110 ppm, but no air samples were taken. Again, the NIOSH REL is for airborne exposures and cannot be compared to soil samples.

It was determined that independent contractors could safely clean up the scene and that there would probably be no need for another entry. Between 2130 and 2200 hours, the response was downgraded from a Tier 2 to a modified Tier 1. The DC left the scene during this time and returned home. The DC was probably not exposed to any amount of the spill material. He was never down wind of the spill nor did he enter the contaminated area to obtain samples. The majority of the time on-scene, the DC was inside the TOMs unit analyzing samples. The incident response was conducted in accordance with the State Hazardous Materials Response Policies and Guidelines Manual.⁷

The DC was off-duty the next day, October 3, and returned to work on Friday, October 4 for the day shift. On Saturday, October 5, due to a lingering cough, the DC visited his primary care physician (PCP). He was diagnosed with pharyngitis/bronchitis, and was prescribed an antibiotic (that treats bacterial infections), an antihistamine, and a corticosteroid (inhaler)(which prevents wheezing, shortness of breath, and troubled breathing caused by severe asthma and other lung diseases). A chest x-ray revealed no focal consolidation and bilateral emphysematous changes. He also began having eye



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itching, discharge and tearing, which was diagnosed as allergic conjunctivitis and given a prescription for antibiotic eye drops. His cough persisted, and, on October 9, he was diagnosed with asthmatic bronchitis and prescribed a bronchodilator and a different antibiotic.

On October 11, he visited his PCP for cough, congestion, hives, and body aches. The hives began after taking the new antibiotic and he was advised to discontinue its use and was re-prescribed the first antibiotic. On October 14 his cough and rash worsened and a chest x-ray revealed multiple patchy ill-defined areas of increased density which had developed in both lungs, more pronounced in the right lower lobe region; most likely aggressive pneumonia. His laboratory test results were normal and a test for lyme disease was negative. He was diagnosed with pneumonia and shingles and a different antibiotic was prescribed.

On October 15, his condition worsened and he was admitted into a local hospital. The course of treatment included ruling out erythema multiforme, varicella pneumonia, and legionella. A chest x-ray on October 16 revealed bilateral infiltrates in both lower lobes, lingular, and the right middle lobe. A chest x-ray performed on October 18 revealed dense consolidation in the lower lobes bilaterally. He was transferred to a regional hospital where his condition deteriorated and he was intubated (breathing tube placed into his throat to assist his breathing). Tests for pneumocystitis, cytomegalovirus, and respiratory syncytial virus were negative.

Over the next six days his respiratory condition worsened despite intensive care and on October 24 he was pronounced dead at 0443 hours.

Medical Findings. The death certificate, completed by the Medical Examiner, listed

“Progressive respiratory failure and clinical history of adult respiratory distress syndrome” due to “inhalation injuries” as the immediate cause of death. Pertinent findings from the autopsy, performed by the Medical Examiner, on October 30, 2002, included:

- Pulmonary congestion
 - Tracheobronchial tree is diffusely obstructed by mucoid-type material
- Areas of squamous metaplasia in the mid-trachea
- A chronic inflammatory infiltrate within the mucosa and submucosa of the lungs
- Diffuse alveolar damage in the reparative phase
- Interstitial fibrosis of the lungs
- No significant narrowing of the coronary arteries
- Cardiomegaly (enlarged heart)(466 grams)

The District Chief had an annual physical examination (September 23, 2002) given to all State hazardous materials response team members. The comprehensive exam was normal and spirometry revealed an FVC of 91% and an FEV₁ of 101%. He was subsequently cleared for “hazmat duty with no restrictions.” According to his wife and crewmembers, prior to the structure fire on September 19, 2002, the victim had no respiratory complaints. He began coughing the day after the structure fire and grew progressively worse over the next month.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 216 uniformed personnel and served a population of 92,500 residents in a geographic area of 42 square miles. There are 6 fire stations. The FD staffs each of the 8 engines, 3 ladders, and 1 heavy fire rescue with three personnel. Automated external defibrillators are carried on all fire apparatus. Fire fighters work



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the following 8-week schedule: day shift (0730 hours to 1730 hours), night shift (1730 hours to 0730 hours), off-duty, day shift, night shift, off-duty, off-duty, and off-duty. Emergency Medical Service is a separate City division within the Fire Department.

In 2001, the Department responded to 4,035 calls: 188 grass/brush fires, 181 structure fires, 145 vehicle fires, 114 trash/rubbish fires, 7 outside fires, 16 explosions, 3 overpressure/rupture calls, 373 emergency medical calls, 148 rescue calls, 472 hazardous condition calls, 19 aircraft standby calls, 154 service calls, 2,166 false alarms, and 49 other calls.

Training. The Fire Department requires all new fire fighter applicants to pass a written civil service test and an interview prior to being given a condition of employment. The candidate must then pass a background check, a physical examination, and a physical ability test (given by the Civil Service Commission) prior to being hired. Newly hired fire fighters are on probation for one year. They receive an initial 8 week training program in conjunction with the MA Fire Fighting Academy. Company officers monitor new hire training and at the end of the one year probation period, the Fire Fighter has achieved training to the Fire Fighter II and First Responder level.

Recurrent training occurs daily on each shift. Half of the Department trains while the other half performs fire safety inspections. The State minimum requirements for fire fighter certification are: (1) the candidate must be at least 18 years of age, (2) possess a high school diploma or GED, (3) be a member of the MA fire service, and (4) complete the State Fire Fighter I and II and First Responder course. There is no State requirement for fire fighter recertification. The victim was certified as a Fire Fighter II, Fire Officer 1, Hazardous Materials Operations, Fire Service Instructor, and Fire

Investigator. He had 25 years of fire fighting experience.

Preplacement Evaluations. The Department requires a preplacement medical evaluation for all new hires, regardless of age. Components of this evaluation include the following:

- A complete medical history
- Vital signs
- Physical examination
- Pulmonary function test (PFT)
- Audiogram
- Vision screen
- Additional tests where indicated

These evaluations are performed by a contract physician with guidance from the State Human Resources Division. Once this evaluation is complete, the physician makes a determination regarding medical clearance for fire fighting duties and forwards this decision to the City's personnel director.

Periodic Evaluations

Periodic medical evaluations are not required by this Department. In 1996, the State passed an unfunded mandate for annual fire fighter physical examinations. Additionally, the State mandates that fire fighters are not permitted to smoke cigarettes or cigars.

The State requires all Hazardous Materials Response Team members to pass an annual physical evaluation. Components of the evaluation include the following:

- Interim medical and occupational history
- Interim physical examination
- Vital signs
- Blood tests: complete blood count, liver and kidney function, HDL, and total cholesterol
- Pulmonary function test
- Urinalysis



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- Audiogram
- Vision screen
- Testing for occult blood

A contract physician performs both the new hire and annual medical evaluations for Hazardous Materials Response Team members. Once these evaluations are complete, the physician makes a determination regarding medical clearance for hazardous materials response duties and forwards this decision to the State's Office of Hazardous Materials Response.

Medical clearance for self-contained breathing apparatus (SCBA) use and for fire suppression is not required for fire fighters; however, it is required for State Hazardous Materials Response Team members.

Fire fighters may voluntarily participate in an annual physical examination as part of their personal health insurance program. If an employee is injured at work, or is ill and off work for more than one shift, the employee is evaluated by their personal physician, who forwards their recommendation regarding "return to work" to the FD Personnel Officer (Deputy Chief of Operations), who makes the final determination. Exercise (strength and aerobic) equipment is located in the fire stations. However, no wellness/fitness programs are in place for the Department. Health maintenance programs are available from the City.

The victim was last cleared for Hazardous Materials Response Team duty by the contract physician in September 2002. He exercised regularly by walking.

DISCUSSION

The DC had a progressive respiratory disease ending in a syndrome known as Adult Respiratory Distress Syndrome (ARDS). ARDS is a severe form of lung injury mediated by an excessive inflammatory response. The mortality rate of patients with ARDS range from 50 to 70%.⁸ A number of direct and

indirect conditions can cause ARDS (Table 2). From this list, the most likely causes of the DC's ARDS are a diffuse pulmonary infection and/or a toxic inhalation.

In the September 2002 house fire, the DC had exposure to smoke. Breathing this smoke caused the DC to immediately cough, thus the smoke was most likely a pulmonary irritant. However, his coughing was relatively mild, it did persist for several weeks. Nonetheless, it would be very unusual for this smoke exposure to result in a toxic inhalation severe enough to cause ARDS four weeks later.

The DC response to the hazmat incident fits the time frame much better for toxic inhalation causing his ARDS. In addition, the chemicals present at the spill are known to cause pulmonary irritation. However, by all accounts, the DC's exposure to the toxic spill was minimal since his participation was limited to the TOMS unit which was positioned upwind to the site.

Finally, while a diffuse pulmonary infection could have caused the DC's ARDS, cultures from his lung and sputum were negative. In addition, he was prescribed a variety of antibiotics which would have treated many lung pathogens.

In summary, it is not possible to definitively determine what caused this fire fighter to develop ARDS. However, NIOSH investigators consider a toxic inhalation to be the most likely scenario. It cannot be determined whether this toxic inhalation occurred during the house fire in September, the Hazmat spill in October, or some other unidentified exposure during the first few weeks of October.

RECOMMENDATIONS

The following recommendations address health and safety generally. It is unclear if any of these



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recommendations could have prevented the tragic death of this District Chief.

Recommendation #1: Ensure that fire fighters exposed to smoke have access to medical evaluations if they develop respiratory or any other unusual symptoms.

Fire fighters who are exposed to toxic smoke and gases and develop respiratory or other unusual symptoms should have access to fire department or city medical evaluations for urgent treatment.

Recommendation #2: Implement the annual medical evaluations mandated by the State in 1996.

The City and Union should **work together** to establish the content and frequency in order to be consistent with the State regulations.

REFERENCES

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2. Material Safety Data Sheet. Orthochlorotoluene, Occidental Chemical Corporation, Dallas, Texas, 01-01-1998.

3. National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical

Hazards: 0-Chlorotoluene; <http://cdc.gov/niosh/npg/npgd0135.html>

4. National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards: 1,2,4-Trimethylbenzene; <http://cdc.gov/niosh/npg/npgd0638.html>

5. Material Safety Data Sheet. 16214 S/P Urethane Ind. En. Signal Green. General Paint Corporation, Vancouver, British Columbia, Canada. 02-10-2002

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8. Moss M and Ingram R, Jr [2001]. Acute respiratory distress syndrome. 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. pp. 1523 1526.

INVESTIGATOR INFORMATION

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Table 1. Incident Response Timeline

1842 hours: First alarm (E2, E3, E9, L4, R1, C2) dispatched
1845 hours: Units arrived on the scene
1851 hours: E4 and Squad 1 dispatched
1900 hours: Second alarm (E6, Duty Executive Chief) dispatched
1920 hours: Order given to evacuate the building
1930 hours: L2 dispatched
1935 hours: two Deputy Chiefs dispatched
1957 hours: Third alarm (E5 for brand patrol)
2033 hours: Fire declared under control

Table 2. Conditions That May Cause ARDS.⁸

1. Direct Injury
 - A. Aspiration of gastric contents
 - B. Diffuse pulmonary infection
 - C. Near drowning
 - D. Pulmonary contusion
 - E. Toxic Inhalation

2. Indirect Injury
 - A. Sepsis syndrome
 - B. Severe nonthoracic trauma
 - C. Hypertransfusion
 - D. Pancreatitis
 - E. Cardiopulmonary bypass