HETA 99-0062-2804
Newark Fire Department
Newark, New Jersey

Kevin C. Roegner, M.P.H.
Joel E. McCullough, M.D., M.P.H., M.S.

PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to Federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Kevin Roegner and Joel McCullough of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Greg Kinnes, DSHEFS. Desktop publishing was performed by Denise Ratliff. Review and preparation for printing were performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at the Newark Fire Department; the International Association of Fire Fighters (IAFF), Department of Occupational Health and Safety; IAFF Local 1860; and the New Jersey Public Employees Occupational Health and Safety Program. Single copies of this report will be available for a period of three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

NIOSH Publications Office
4676 Columbia Parkway
Cincinnati, Ohio 45226
800-356-4674

After this time, copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Highlights of the NIOSH Health Hazard Evaluation

Evaluation of American Ref-fuel Incident

In December of 1998, 37 Newark Fire Department (NFD) fire fighters were exposed to irritant gasses during a response to a fire at American Ref-fuel (AR). Following the incident, the IAFF asked NIOSH to investigate the events leading to fire fighters' exposures, and to review the medical care received by the fire fighters after the incident.

What NIOSH Did

- # Interviewed fire fighters who responded to AR about the response and their symptoms.
- # Looked at medical records, radio communication logs, fire fighter incident reports, and NFD procedures.
- # Went to AR to see the area where the incident occurred.

What NIOSH Found

- # Most fire fighters at the scene had some degree of irritation to their eyes, throat, or lungs.
- # Fire fighters were likely exposed to chlorine gas and nitrogen trichloride, and possibly very low levels of phosgene.
- # Fire fighters were initially provided with wrong information about the contents of the fire.
- # The hazardous materials (HAZMAT) company was committed to the incident in fire mode, so no HAZMAT response could be made.
- # Not using self-contained breathing apparatus (SCBA) all the time, poor communications, and poor building ventilation made exposures worse.
- # The treating physicians in the hospital emergency rooms were aware of the fire fighter chemical exposure, but did not know the specific substances.
- # The number of medical tests varied among hospitals, but this difference did not appear to cause worse health outcomes.

What the Newark Fire Department Can Do

- # Better enforce SCBA use at the scene of a fire.
- # Minimize gaps in HAZMAT coverage.
- # Improve communication with local hospitals.
- # Better educate fire fighters on decontamination procedures.
- # Better integrate surveillance medical records with acute occupational health services.

What the Newark Fire Department Fire Fighters Can Do

- # Use better judgement when removing SCBA at the fire scene.
- # Follow two-in, two-out rule.

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513/841-4252 and ask for HETA Report # 99-0062-2804

National Institute for Occupational Safety and Health
NIOSH

Health Hazard Evaluation Report 99-0062-2804
Newark Fire Department
Newark, New Jersey
February 2000

Kevin C. Roegner, M.P.H.
Joel E. McCullough, M.D., M.P.H., M.S.

SUMMARY

On December 22, 1998, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the International Association of Fire Fighters (IAFF) on behalf of fire fighters from the Newark Fire Department (NFD) to assess the incident response procedures followed during a fire in a refuse waste-to-energy facility (American Ref-fuel) on December 17,1998, in Newark, New Jersey. The IAFF indicated that several of the fire fighters responding to the incident were subsequently hospitalized due to smoke and chlorine gas inhalation.

NIOSH investigators conducted a site visit to the NFD on April 12-13, 1999, and again on June 24, 1999. NIOSH personnel conducted private interviews with several NFD fire fighters who responded to the incident and reviewed several incident-related records provided by the NFD, including the department's standard operating procedures (SOPs) and medical records. Self-administered questionnaires were distributed to fire fighters who were not present on the days of the NIOSH investigation. In addition to the medical interviews and questionnaires, medical records were reviewed from five hospitals where the fire fighters received medical care, and from the occupational medicine provider for the NFD. NIOSH investigators also visited American Ref-fuel.

On December 17, 1998, the NFD received a report of a fire in the refuse pit of American Ref-fuel. The fire was declared a hazardous materials incident as information became known that the fire had involved chlorine bleach cleaner which, according to the product's material safety data sheet, would liberate chlorine and phosgene as decomposition products. Fire fighters used the plant's showering facilities for decontamination purposes before all of the 37 responding fire fighters were sent to area hospitals for evaluation.

The medical survey showed that most fire fighters at the scene experienced some degree of acute upper respiratory tract irritation, and many experienced lower respiratory tract irritation as well. Fifteen had persistent symptoms at 24 hours, and 13 had symptoms at the time of the NIOSH investigation. Based on the combustion of chlorine-containing cleaner, the fire fighters' exposures probably consisted primarily of irritant gases, such as chlorine and nitrogen trichloride.

Medical records revealed that the treating physicians were aware that the fire fighters were exposed to chemicals at a fire and were concerned about the inhalation of toxic fumes and smoke. However, neither fire fighters nor treating physicians knew what specific toxins were present. The symptoms of the fire fighters were consistent in the different hospitals, however the diagnostic tests performed differed. The university-based hospital performed the most diagnostic tests on the fire fighters. The other hospitals performed fewer tests, but this did not appear to result in a greater rate of adverse health outcomes.

The elements leading to fire fighter exposures at the waste-to-energy plant on December 17, 1998, are complex and multi-factorial in nature. Clearly, fire fighters did encounter exposures to irritant gasses at the scene. The NFD approached the incident in fire mode, when in fact, a hazardous materials (HAZMAT) response approach would have been more appropriate.

Most fire fighters suffered irritant symptoms that were the result of exposures to irritant gases at American Ref-fuel. For those fire fighters who had recovered at the time of the NIOSH investigation or did not develop symptoms, it is unlikely that this exposure will result in further health problems. Those who developed more significant respiratory symptoms were being evaluated by health care providers. Several recommendations are offered for improving fire fighter health and safety, including recommendations for better integration of fire fighter medical surveillance information with acute care occupational medicine providers, better personal protective equipment (PPE) usage, and filling gaps in HAZMAT coverage.

Keywords: **SIC 9224** (Fire Protection), fire fighters, firefighters, incident command system, ICS, self–contained breathing apparatus, SCBA, hazardous materials

Table of Contents

INTRODUCTION

On December 22, 1998, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the International Association of Fire Fighters (IAFF). This HHE request was submitted on behalf of fire fighters from the City of Newark Fire Department (NFD) to assess the incident response procedures used during a fire in a refuse waste-to-energy facility (American Ref-fuel) on December 17, 1998, in Newark, New Jersey. The IAFF reported that 37 fire fighters responded to the incident, and that several of the responders were subsequently hospitalized due to smoke and chlorine gas inhalation. The IAFF requested that NIOSH review the response procedures used during this incident, investigate the potential chemical exposures that may have occurred, and determine the health effects that fire fighters may experience from the exposure.

In response to this request, NIOSH investigators conducted a site visit to the NFD on April 12-13, and again on June 24, 1999. On April 12, an opening conference was held to discuss the incident and the nature of the request with representatives of the NFD and IAFF Local 1860. During the remainder of the site visit, private interviews were held with NFD fire fighters and command staff who responded to the incident, and copies of several NFD standard operating procedures (SOPs) and other pertinent records were obtained for review.

This report summarizes response procedures as they affected the health and safety of the fire fighters, including the Incident Command System (ICS) and safety management. This report also discusses decontamination of fire fighters, assesses the level of care received by fire fighters at area hospitals, and provides recommendations.

BACKGROUND

The NFD employs 735 uniformed fire fighters, and serves a geographic area of 23 square miles. The department operates four shifts (tours), and is divided into four battalions. Each tour works an average of 42-hours per week on a schedule of two, 10-hour shifts on duty followed by a day off, then two, 14-hour shifts, followed by three days off. Shift changes occur at 0800 hours (hrs) and 1800 hrs. In 1992, the NFD initiated a policy of rotating four apparatus companies (one from each battalion) out of service on each tour. Truck 8 was retired from service in 1997, and the number of companies rotating out of service was reduced to three. In response to a working structural fire, the NFD will dispatch four engines, two trucks, a Battalion Chief (BC), a Deputy Chief (DC), a Safety Officer (SO), a rescue unit, and a rapid intervention team to the fire scene.

On December 17, 1998, the NFD responded to a fire alarm at the eleven-story, American Ref-fuel plant located in an industrial area outside of downtown Newark. The facility was constructed in 1990, and is segmented into several areas, each designed to play a role in converting non-hazardous waste into energy (Figure 1). At the west end of the facility is a large, open tipping hall, where trucks enter to deposit loads into the refuse pit. The refuse pit measures 280 feet (ft.) across, by 90 ft. front to back, by 45 ft. deep. The open space above the refuse pit spans several stories and is occupied by two 20-ton grappling cranes. The cranes, which are remotely operated from each of two control rooms that overlook the pit, homogenize the waste and move it from the pit and drop the waste into the waste charging hopper (7^{th} story). Once in the hopper, refuse is fed into the furnace. Heat generated by the combusting solid waste produces steam in a waterwall boiler, the pressure from which is used to drive a turbine generator. The plant is licensed to accept non-hazardous waste.

At 2008 hrs, December 17, 1998, the NFD received a 9-1-1 telephone call reporting a fire in the refuse pit of the waste-to-energy facility. A full assignment, consisting of four engine companies, two truck companies, a rescue company, a BC, a DC, and an SO was dispatched to the scene. Engine Company 16 (EC16) was the first to arrive at 2012 hrs. In fire fighter interviews it was reported that plant employees indicated to arriving fire fighters that there were two fires: a fire on the seventh floor and a fire in the refuse pit. Truck one, the company which is also the hazardous materials (HAZMAT) unit company, was the second due truck for the response, and it arrived on site early in the incident. Several companies ascended the stairs and elevators to search for the reported fire on the seventh floor. They were, however, unable to locate a fire on the seventh floor. The BC arrived at the scene at 2017 hrs. The DC arrived at the scene at 2025 hrs, at which time he established a command post on the first floor. During most of the incident, it was unclear what was burning in the pit. When the BC and DC inquired about what was burning, plant employees indicated that it was garbage. Several fire fighters reported that the incident was complicated by an intermittent heavy smoke condition, which limited visibility into the refuse pit and across the upper floors. Fire fighters indicated that the smoke appeared white to yellowish-green, and would ebb and bank with the intermittent performance of ceiling exhaust fans located above the pit. The fire was declared under control at 2238 hrs, at which time it was declared a hazardous materials incident as information became known that the fire had involved chlorine-containing cleaner. The cleaner had been sent to the facility for disposal. The product's material safety data sheet, which reportedly was made available late into the incident, indicated that the cleaner would liberate chlorine and phosgene as decomposition products. Fire fighters used the plant's showering facilities for decontamination purposes before all of the 37 responding fire fighters were sent to area hospitals for evaluation.

METHODS

NIOSH investigators visited the NFD on two occasions, and the waste-to-energy plant to obtain information. During the first visit, NIOSH investigators held an opening conference with the local IAFF representative and representatives of the NFD. This meeting was arranged to discuss the structure and staffing of the NFD, review the incident chronology and the procedures used during the response, and review actions of the fire department subsequent to fire fighters raising concerns about possible exposures to chlorine and phosgene. The NIOSH investigators spent additional time during the two days interviewing fire fighters and command personnel who responded to the incident and reviewing incident-related records provided by the NFD. These records included the incident chronology report, transcripts of radio communications during the incident, SOPs followed by the NFD, and various other records pertaining to this incident. The NIOSH investigators also requested copies of the command reports submitted by each apparatus captain and others who assumed command functions to the NFD. During the second visit, NIOSH investigators inventoried the hazardous materials response unit and spoke with the on-duty captain of that unit. This meeting was followed by a visit to American Ref-fuel where NIOSH investigators met with the plant manager and viewed the area where the incident occurred. Telephone interviews were conducted with NFD personnel not available during our site visit. The incident response reports, transcripts from NIOSH interviews with fire fighters, and other pertinent information were used to reconstruct events and procedures used during the incident.

On April 12-13, confidential interviews were conducted with fire fighters who were present at the scene of the incident. The fire fighters who responded to the incident and were at work on the days of the NIOSH investigation were interviewed by NIOSH investigators. Also, self-administered questionnaires (accompanied with NIOSHaddressed and postage-paid envelopes) were distributed by a union representative to fire fighters who were not present on the days of the NIOSH investigation. The fire fighters were asked about their job activities at the scene, their use of personal protective equipment (PPE), decontamination procedures, the amount of time at the scene spent with and without PPE, health symptoms that began at the scene, persistent health symptoms, and the medical care they received. In addition to the medical interviews and questionnaires, medical records from the five hospitals where the fire fighters received medical care, and from the occupational medicine provider for the department, were reviewed.

EVALUATION CRITERIA

Fire fighters work in varied and complex environments that increase their risk of on–the–job death and injury. Every day, fire fighters in the United States are injured in the line of duty.[1] According to the IAFF, 45 professional fire fighters died in the line of duty in 1998, and an additional 39 professional fire fighters died as a result of occupational diseases directly related to fire fighting.[2] When compared to data compiled for private industry by the Bureau of Labor Statistics (BLS), the incidence of fire fighter job-related injury is nearly 4.5 times that of workers in private industry; 32.4 percent (%) of fire fighters were injured in 1998 compared to only 7.1% of private industry workers.[2] In terms of severity, fire fighter injuries caused 4,342 lost work hours per 100 workers.[2] Fire fighters face many health hazards, including: inhalation of a wide variety of toxic combustion products; chemical exposures by direct skin and eye contact; physical hazards, including heat, cold, noise, and falling objects; and exposure to carcinogenic chemicals or combustion products. The hazardous exposures most relevant to the American Ref-fuel incident are discussed in further detail below.

Smoke Inhalation

Smoke is the volatilized product of combustion. It varies according to temperature, oxygen availability, and composition of the material being burned.[3] The inhalational toxins in smoke are chemicals in the form of gases, vapors, aerosols, particulate, and fumes.[4] Upon combustion, synthetic and natural polymers may produce respiratory irritants (nitrogen and sulfur oxides, aldehydes, halogenated compounds, and organic acids), simple asphyxiants (carbon dioxide, oxygen-deficient atmospheres), and cellular asphyxiants (carbon monoxide, hydrogen cyanide).[5]

Each component of smoke may contribute to respiratory damage in different ways. Although smoke inhalation is often referred to as a pulmonary burn, true thermal injury to the lower respiratory tract appears to be unusual. The upper airway is very effective in protecting against injury by heat below the tongue (the trachea and bronchial tubes). Even in the absence of recognizable symptoms or disease, fire fighters often have subclinical effects that may persist for weeks or months, as evidenced by both restrictive and obstructive lung changes on spirometry testing.[6]

The irritant gases and asphyxiants generated during combustion account for virtually all of the clinically recognized respiratory effects of smoke inhalation. Most of the irritant gases that cause direct pulmonary injury are highly reactive acids or bases which, upon inhalation and hydration within the lung, result in the denaturation or oxidation of cellular components.[5,6] Highly water-soluble agents, such as ammonia, sulfur dioxide, hydrogen fluoride, or acrolein, cause injury to the proximal airway and mucosa, and their noxious nature is more likely to be recognized by exposed persons. By contrast, agents with intermediate or lower water solubilities (e.g., phosgene or nitrogen oxides) are more likely to result in subtle presentations, with delayed onset of respiratory damage. In this instance, fewer warning symptoms may result in prolonged exposures and damage to distal airways and alveolar membranes.[5, 6]

The vast majority of inhalation victims (90% to 95%) acutely complain of shortness of breath, cough, or hoarseness. Symptoms such as cough, sore throat, or hoarseness suggest upper airway injury and the potential for life-threatening airway obstruction. Shortness of breath and wheezing suggest lower respiratory tract damage. Headache, nausea, vomiting, dizziness, confusion, chest pain, palpitations, and loss of consciousness may suggest systemic poisoning or simple asphyxiant effects. The age of the victim and past medical history are important risk factors for the development of inhalation injury. Those with asthma or chronic respiratory diseases may be more susceptible to the effects of irritant gas inhalation.[3]

All victims of smoke inhalation should begin treatment with supplemental oxygen, which should be adjusted based on arterial blood gases and clinical history. The observation period for asymptomatic patients without significant risk factors for chronic obstructive pulmonary disease or coronary artery disease is 4 to 6 hours. Those who remain asymptomatic during the observation period can be discharged from the health care facility with appropriate follow-up instructions.[7]

If initial clinical findings are minimal, but there is a history of smoke inhalation, arterial blood gases (ABGs) should be obtained. ABGs, which usually include carboxyhemoglobin levels, are an essential early part of nearly every evaluation of a fire fighter with smoke inhalation.[8] Although pulse oximetry is a convenient way to continuously monitor oxygenation in patients, it is unreliable or falsely normal in patients who have dyshemoglobinemias (e.g., carboxyhemoglobinemia or methemoglobinemia) because it measures only oxygen dissolved in the blood and not the status of tissue oxygenation. In patients who have altered hemoglobin, the pulse oximetry does not reflect the impaired oxygen carrying or delivery capacity of the red cells. Pulse oximetry does not distinguish between carboxyhemoglobin (COHb) and oxyhemoglobin (O_2Hb). In these situations, a Co-oximeter should be used to measure specific levels of hemoglobins that are unable to transport oxygen efficiently.[9]

A thorough eye exam in the emergency department is indicated for those suspected of having smoke inhalation injury or exposure to corrosive substances. Eyes contaminated by smoke, aerosols, and particulates should be treated similarly to splash injuries and liberally irrigated with plain water or normal saline. A thorough eye exam should be performed following irrigation. Ophthalmologic consultation is indicated in those presenting with more than minor complaints or physical findings.[8]

Chlorine

Chlorine is a yellow-green gas with a sharp or pungent odor at room temperature. Chorine is only slightly soluble in water, but on contact with moisture it forms hypochlorous acid (HClO) and hydrochloric acid (HCl). The unstable HClO readily decomposes, forming oxygen-free radicals. Because of these reactions, water substantially enhances chlorine's oxidizing and corrosive effects.[10]

Chlorine's odor and irritant properties generally provide adequate warning of hazardous concentrations. However, prolonged, low-level exposures can lead to olfactory fatigue and tolerance of chlorine's irritant effects. Mucous membrane irritation may occur at 0.2 to 16 parts per million (ppm); eye irritation occurs at 7 to 8 ppm, throat irritation at 15 ppm, and cough at 30 ppm.[11] Inhalation of high concentrations of the gas causes necrosis of the lining of the trachea and bronchi as well as pulmonary edema, emphysema, and damage to the pulmonary blood vessels. Exposure to 500 ppm can be lethal over 30 minutes, while 1000 ppm can be lethal within a few minutes.[12]

The severity of the damage to the respiratory tract is determined by the concentration and duration of exposure. With high exposures, laryngeal edema with signs of obstruction of the breathing passages, acute tracheobronchitis, and chemical pneumonitis have been described. Following acute exposure to chlorine gas, both obstructive and restrictive lung disease may occur.[11] Moderate to severe exposure often results in residual pulmonary dysfunction, most notably hyperreactive airways and low residual volumes. The pulmonary function usually returns toward baseline within 7 to 14 days. Although complete recovery generally occurs, symptoms and prolonged pulmonary impairment may persist, especially after massive chlorine exposures.[13,14] Reactive airways dysfunction syndrome (RADS) may occur. Chronic exposure may cause moderate reduction in pulmonary function and corrosion of the teeth.[14]

Chlorine may irritate the skin and can cause burning pain, inflammation, and blisters. Direct contact with liquid chlorine or concentrated vapor causes severe chemical burns. Low concentrations in air can cause burning discomfort, spasmodic blinking or involuntary closing of the eyelids, redness and tearing of the eyes. Corneal burns may occur at high concentrations.[10, 15]

Exposure to elevated levels of chlorine should be terminated as soon as possible by removal to fresh air. The skin, eyes, and mouth should be washed with large amounts of water.[15] A 15- to 20-minute wash may be necessary. If irritation, pain, swelling, or tearing persists, medical care should be sought as soon as possible. Contaminated clothing should be removed and isolated. Contact lenses should be removed to avoid prolonged chemical contact with the eyes.[12]

Phosgene

Phosgene is a colorless gas with an odor similar to musty hay. It may be formed by the "cracking" of chlorinated hydrocarbon molecules at high temperature. Phosgene may be a decomposition product of other chlorinated chemicals. Phosgene reacts with moisture and slowly forms HCL and carbon dioxide.[16]

Inhalation is the major route of phosgene exposure. The onset of severe respiratory distress may be delayed for up to 72 hours depending on the concentration and duration of exposure. Olfactory fatigue may occur.[17] The low irritant properties of phosgene are not sufficient to warn individuals of toxic concentrations. This allows deep inspiration of high concentrations, causing HCl to form in the lower respiratory tract.[18] HCl can damage surface cells and cause cell death in the bronchi and bronchioles. This causes congestion and pulmonary edema, which may be quickly fatal. Direct toxicity to the cells leads to an increase in capillary permeability, resulting in large shifts of body fluid and decreasing plasma volume. Early symptoms of overexposure include chest constriction, painful breathing, and bloody sputum. Respiratory and circulatory failure are the common clinical findings in cases of phosgene poisoning that result in death.[16, 17]

If the patient survives the initial 48 hours after exposure, recovery is likely. Sensitivity to irritants may persist, resulting in bronchospasm and chronic inflammation of the bronchi. Lung tissue destruction and scarring may lead to chronic dilation of the bronchi and increased susceptibility to infection (bronchiectasis). Also, pulmonary fibrosis and emphysema may develop after chronic exposure.[18]

Phosgene may also damage the skin and eyes. When phosgene gas contacts moist or wet skin, it may cause irritation and erythema. High air concentrations can also cause corneal inflammation and cloudy vision. Eye damage beyond the initial irritation is uncommon in vapor exposure.[16, 17]

Treatment measures would include moving the patient to fresh air and monitor for respiratory distress. Monitoring for 12 to 24 hours after exposure has been recommended. Exposed areas should be washed thoroughly with soap and water. Exposed eyes should be irrigated with copious amounts of tepid water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persists, the patient should be seen in a health care facility.[16, 17] There is no evidence that phosgene is either carcinogenic or teratogenic.[17]

Nitrogen Trichloride

Nitrogen trichloride (NCl_3) is a brownish-yellow gas with a pungent, offensive chlorine-like odor. It is the most irritating of the chloramines and can impart an odor at concentrations above 0.02 ppm.[19] It is the by-product of several reactions, including the reaction between chlorine and nitrogenated substances. NCl_3 decomposes to ammonia and hypochlorous acid. Hypochlorous acid reacts rapidly with ammonia to form monochloramine.[20]

NCl_3 is a strong irritant, but little else is known about its toxicology. Exposure to its fumes produces excess tearing, irritation of the mucous membranes of the respiratory tract, and nausea. The acute inhalation toxicity of NCl_3 is similar to that of chlorine.[20]

Animal studies have found that the respiratory tract is the primary site of damage in rats exposed to NCl_3. Rats exposed for prolonged periods to concentrated NCl_3 died of pulmonary edema. No chronic health effects have been demonstrated in humans exposed to these fumes.[21]

Incident Command System (ICS)

Management of fire department day–to–day activities is usually vested in a Fire Chief or other titled person who serves as the commander of the fire suppression forces and their activities, including the safety of the fire fighters.[22] To assist in the management (especially in the operation, coordination, and effectiveness) of wide–scale fire suppression activities, a system has been developed for controlling personnel, facilities, equipment, and communications. This system is known as the ICS.[23] This is a system of unified command and control designed to assure the smooth implementation of operational procedures by all agencies on scene in a coordinated manner.[24] A further refinement of the ICS by fire service organizations addresses all types of emergency incidents and includes performance criteria for the components of a system that incorporates specific safety and health objectives. This has been developed into a nationally recognized standard known as the Incident Management System (IMS).[25] Some common components of an IMS are: modular organization, integrated communications, common terminology, unified command structure, and consolidated action plans.[26] The National Fire Protection Association has documented the consequences of operating without such an IMS which have resulted in numerous deaths and injuries of fire fighters.[27] The National Fire Service has also published model procedures for an IMS that is specific for high–rise fire fighting.[28]

In establishing and utilizing the IMS, the first priority must be life safety.[29] The responsibility for this priority issue is that of the officer in command of the emergency incident.[27,29] The incident commander is responsible for the overall safety of all members and all activities occurring at the scene. The Fire Chief, however, bears the ultimate responsibility for the safety and health of all members of the department.

FINDINGS AND DISCUSSION

Preplanning and Information

First due companies (companies who respond first) commented in their interviews with NIOSH that they had previously been to American Ref-fuel for preplanning exercises. Through this preplanning they were familiar with the facility. Some fire fighters indicated that the plant's management had always been very accommodating during such visits and forthcoming with information about the process and facility. One fire fighter indicated that a trust had been fostered through these visits. It was also suggested that second and third due companies did not have this preplanning at the facility, and extending preplanning to include second and third due companies in light of companies rotating out of service would be beneficial.

Under Title III of the Superfund Amendments Reauthorization Act (SARA), the owner or operator of a facility is required to disclose the presence of hazardous chemicals if they are kept on the property at greater than a threshold quantity. This reporting is to be carried out annually through Tier I or Tier II reporting as indicated in 40 CFR part 370 of the Code of Federal Regulations (CFR). SARA Title III, Tier II reporting is retrospective; facility operators are required to report quantities of hazardous materials on site during the preceding year. The cleaner present in American Ref-fuel's refuse pit would need to be reported under Tier II, but not until March 1999. Although the reporting requirements are a good means for emergency response personnel to receive information about chemicals at a facility, the reporting system would typically not provide responders with such information about chemicals that are on site for the first time. This system, though beneficial, would not have been effective for preplanning in this case.

Although the main ingredient of the cleaner, sodium dichloroisocyanurate, would be classified as a hazardous waste, the composite mixture does not meet the definition. The material reportedly meets the definition of a non-hazardous waste. This may have been a source of mis-communication between plant employees and fire fighters as to the contents of the fire.

Based on fire fighters' reports, there seemed to be confusion throughout the incident as to the location and contents of the fire. Much of the confusion stemmed from misinformation provided by employees of American Ref-fuel. When the first engine arrived on the scene, fire fighters noted that employees of the facility had begun to apply water to the refuse pit with a 1-inch hose line. They prepared to augment this effort with a 2 ½-inch hose line. While they were preparing for this, the BC arrived on the scene and reportedly was informed by an American Ref-fuel employee that there was a fire on the seventh floor rack. The BC asked the employee what was burning and was told that it was just garbage; however, several fire fighters reported that they had smelled a chlorine-like odor during the incident. One fire fighter remained with the engine to man the hose line while the other fire fighters and the BC proceeded to the seventh floor in search of the fire that was reported there. Fire fighters were unable to locate a fire on the seventh floor.

Incident Command System (ICS)

The NFD operates under the ICS. Department programs reviewed by NIOSH are consistent with the ICS. The department's SOPs indicate that the NFD has established a succession of command based on rank. That is, command is initially assumed by the first ranking person/officer on scene. A command post is set up and its location and the incident commander are identified to the dispatcher. Command is passed along to the next higher ranking officer that arrives, including the deputy fire chief and fire chief. According to reports, this system was followed during the incident.

When the BC arrived at the scene he assumed a mobile command. This allowed the BC to operate in the command role while he moved around the scene to size up the incident. Reportedly this approach is commonly used in the NFD for full alarm responses. When the DC arrived on the scene, he established the command post in an office area on the first floor. The DC indicated that he particularly liked this location because the office had a telephone system which he could use to communicate with fire fighters in various locations in the facility. At some point into the incident, the BC recommended that the DC relocate the command post to the seventh floor. The rationale for this recommendation is unclear. The DC started to the seventh floor to determine if a relocation of the command post would be beneficial. As the DC ascended the stairs he reportedly encountered a strong chlorine odor on the third floor. At this time, the DC decided to stop, and to keep the command post at the ground-floor office location.

Interviewed fire fighters indicated that they were always aware of who was in command during the incident. One fire fighter further indicated that the DC takes a strong command and that it is clear that he is making the decisions.

Hazardous Materials Response Unit

The HAZMAT response unit consists of a four- or five-person company and two apparatus (a response apparatus and spill/decontaminaton apparatus). This unit is housed at the fire station located at 188 Mulberry Street. Two persons bring the spill/ decontamination apparatus, and two or three persons bring the response apparatus to HAZMAT scenes. The HAZMAT team is augmented with a rescue unit (Rescue 1), which responds to all full alarms, and a fire company trained to conduct the decontamination. In addition to being the designated HAZMAT response, the HAZMAT company responds to fire calls. The company will respond to a fire in a ladder truck (truck 1), as they responded to this incident. This approach leaves a two-fold gap in HAZMAT response coverage. First, the HAZMAT response team, while occupied fighting the fire, is unavailable to efficiently respond to a concurrent HAZMAT incident at a different location within the city. Second, as was the case at American Ref-fuel, if the incident commander at the scene of the fire determines that the hazards of the incident dictate a change in response approach from fire mode to HAZMAT mode, the HAZMAT team may already be committed/contaminated. The former Captain of the HAZMAT company indicated that there have been situations where the company was enroute (in fire mode) and has had to turn truck 1 back and get the HAZMAT apparatus.

Gaps in HAZMAT coverages were compounded during the American Ref-fuel incident due to the NFD's policy of rotating companies out of service. In January of 1997, truck 8 went from being rotated out of service on the second tour to being retired from service. Having a truck company out of service increases the area that the other truck companies, including truck company 1, are expected to cover. A full alarm will trigger two truck companies to respond. Interviewed fire fighters indicated that, given the location of American Ref-fuel, truck company 8 would have been the second due to the incident scene. Because, however, truck company 8 is out of service, truck company 1 became second due. The result of this is the latter of the two gaps in coverage discussed above; a HAZMAT response was compromised when the company was committed to the incident scene in fire mode. Although the incident was declared HAZMAT only at the very end, any attempts to make the declaration sooner would have been complicated by the fact that the HAZMAT company was already committed to the scene and potentially contaminated with the chemicals involved. This deficiency was manifest in the make-shift decontamination procedures used at the incident.

The Newark Hazardous Materials Annex indicates that the NFD is the lead agency for hazardous materials emergency responses, and that the NFD will handle the initial response to HAZMAT incidents. Meeting this responsibility requires the NFD to be fully prepared to respond to a HAZMAT incident at any time. Ideally, this requirement would be met by providing fire companies solely dedicated to hazardous materials response, rather than a company that responds in either fire mode or HAZMAT mode, depending upon early indications about the incident. Accordingly, incident commanders would have the option to change from a fire to HAZMAT mode without the logistical concerns of having no HAZMAT team readily available.

Safety Management

The IMS encourages the delegation of authority, but not responsibility, for the safety function at an incident to a fire fighter or other competent person, who is specially trained and knowledgeable in safe emergency operations.[30] The failure to delegate may cause conflict between the positions of command and safety. IMS guidelines generally recommend that the command officer, who is responsible for managing the incident on the strategic level, establish and operate from a stationary command post as soon as possible after arriving on the scene.[29] In contrast, the delegated SO must routinely observe operations at the scene of an incident. This means he must have full authority to move around the incident scene (fire ground) to observe and control safety concerns.[29] This safety officer would also have the emergency authority to stop and/or prevent unsafe acts. If the department safety officer is also routinely responsible for other tasks, an assistant SO may need to be designated to address incident safety functions.

The NFD has a policy for dispatching an incident safety officer to all full alarm fires. The policy gives the SO the authority to correct safety and health hazards, immediately if they are deemed to be an imminent hazard to personnel, and through the incident commander if they are not deemed to be an imminent hazard. Consistent with National Fire Protection Association (NFPA) 1500 standard, the NFD places general responsibility for fire fighters' safety and health with the Fire Chief or incident commander.

An SO was dispatched to this incident. There is not much documentation indicating what actions the SO took during the incident. The SO's incident report indicates that he worked to assure that companies remained intact. NIOSH investigators interpret this to indicate that the SO was working to keep companies accountable for their members. It was indicated to NIOSH through interviews that some fire fighters roamed free during the incident and were isolated from their company. The recent revision of the Occupational Safety and Health Administration's (OSHA) respiratory protection regulation (29 CFR 1910.134), as adopted by the New Jersey Public Employees Occupational Safety and Health (PEOSH) program, includes measures designed to protect fire fighters while working inside burning buildings.[31] The rule, referred to as a "double buddy system" or more commonly the *2 in/2-out rule*, states that whenever fire fighters enter a burning structure, they must do so in teams of at least two and remain in direct voice or visual contact with each other at all times. Also, at least two other fully equipped and trained fire fighters must remain outside the structure to monitor those inside and be prepared to rescue them. This regulation was not in effect at the time of the incident, but the practice is a good safety precaution that has been followed by many fire departments prior to the date on which the regulation came into enforcement.

Training

The training requirements for persons who will engage in hazardous materials response activities are outlined in 29 CFR 1910.120 (q).[32] This paragraph states that the training shall be based on the duties and the functions to be performed by each responder of an emergency response organization. Five levels of training are outlined in the paragraph: 1) first responder awareness level, trained to initiate an emergency response sequence by notifying the proper authorities of the release; 2) first responder operations level, trained to protect persons, property or the environment from the effects of a hazardous material release; 3) hazardous materials technician, trained to assume an offensive role in stopping the release; 4) hazardous materials specialist, provide support to hazardous materials technicians; 5) on scene incident commander, assume control of the incident beyond the first responder awareness level. Trainers who teach any level of training shall have satisfactorily completed a training course for teaching the subjects they are expected to teach, such as the course offered by the National Fire Academy.

Communications

Fire department communications can be ineffective or even completely unusable in a high–rise building.[28] At some locations within a high–rise building it is difficult to send or receive messages using portable radios. Successful radio transmission may become intermittent as the sender or receiver of a radio message moves within the building.[28]

The NFD used portable radios during the incident. They also had the use of an on-site telephone system that was used to call to the seventh floor from the command post. It was indicated to NIOSH investigators that portable radio communications were poor at times during the incident. This was evidenced in radio transcripts when the BC attempted to communicate information about the contents of the fire to the DC. Reportedly, about 25 minutes into the incident, an employee of the plant approached the BC on the seventh floor and indicated to the BC that the plant had received a shipment of Drano® that day and that this was the material that was burning. At this time, the BC attempted to notify the DC of this information via portable radio. At 2030 hrs, 18 minutes after the first company had arrived on site, the BC indicated to the DC, "One of the workers reports they had a load of Drano® come in today"......no response from the DC. "One of the workers reports that the substance was Drano®, a large amount came into the plant today."....no response from the DC. The radio transcripts show no further mention of the Drano®. Transcripts documenting telephone communications were not available.

Respiratory and Other Personal Protective Equipment (PPE)

Because the smoke was not very dense at times during the incident, and the crane operation rooms seemed to be isolated from the smoke, a few fire fighters at the scene reported that they felt comfortable removing their self–contained breathing apparatus (SCBA) in certain areas of the facility. While a properly operating SCBA worn by a well-trained individual offers adequate protection against smoke and chemical inhalation, even brief exposure without respiratory protection may present a health hazard. Fire fighting requires strenuous physical exertion, which increases oxygen demand and respiratory rate and thus increases the risk of exposure to inhalational toxins and hypoxia.[33] Although fire fighters are equipped with respiratory protective equipment, it is not always used, especially during the final extinguishment or overhaul phases, when smoke intensity and assumed exposures are thought to be low. Inadequate respiratory protection at the fire scene is an important risk factor in the development of toxicity from smoke inhalation.[34] One study reported that 70% of fire fighters remove their mask at some time during knockdown and that as many as 30% wear their masks less than half the time.[35]

A fire fighter's complete turnout gear typically worn during a fire incident consists of a helmet, hood, turnout coat, turnout pants, boots, gloves, and a SCBA with a personnel alert safety system (PASS) device. SCBA's provide the highest level of protection against inhalation exposures, even in atmospheres considered immediately dangerous to life and health. Turnout gear is made of fire-resistant material that will provide protection against flashover temperatures up to 1500 degrees Fahrenheit (°F) for brief periods. Although turnout gear has the ability to withstand some types of chemical contact, during a chemical fire it may not provide protection against chemical exposure. Skin exposure is very likely because turnout gear material is not impermeable to many chemicals. Currently, PPE made of a material that is both fire- and chemical-resistant does not exist.

Following the incident, turnout gear was tested for surface contamination by wetting the surface and using litmus paper. This would indicate if there was surface contamination present on the gear that was either an acid or a base. The tests indicated that the surfaces were neither acidic nor basic. According to interviewed fire fighters, the gear was placed in truck one after the incident and returned to the fire stations the following morning. Reportedly, the gear was replaced with clean turnout gear a few days later. Some fire fighters indicated they had worn the turnout gear in the interim. The use of chemically-contaminated gear may result in skin irritation when worn by fire fighters at other fire scenes.[36] The NFD uses a *Quartermaster* system to supply fire fighters with their gear. Elements of a *Quartermaster* system should include the replacement, repair, laundering, and decontamination of turnout gear. If feasible, an adequate supply of replacement turnout gear should be made available to fire fighters while necessary replacement, repairs, or laundering is rendered.

Medical

Confidential interviews were obtained from 20 fire fighters, and self-administered questionnaires were completed by an additional 8 fire fighters (37 fire fighters were at the scene). The average amount of time spent at the scene was 3.7 hours (range: 2 - 6 hours). The average amount of time spent at the scene without respiratory protection was 2 hours (range: 0.25 to 5.50). Twenty-one fire fighters (75%) reported that they smelled a chlorine-like odor while they were at the scene. All reported that they wore SCBA for some amount of time at the scene. The most common symptom reported was burning or irritation of the eyes (18 participants, 64%). The next most common symptoms were throat irritation or hoarseness (15, 54%) followed by cough (12, 43%). Eight fire fighters (29%) reported a burning sensation in their chest. Three fire fighters (11%) reported that they began wheezing at the scene. Five fire fighters (18%) reported that they developed no symptoms at the scene or afterward.

Decontamination of the fire fighters occurred after it was determined that the scene was a hazardous materials incident. Decontamination took place in the shower facilities of American Ref-fuel. All fire fighters reported that they decontaminated themselves by showering with water from 2 to 10 minutes. In addition to showering, 7 (25%) reported that they flushed their eyes with water while in the shower. There were complaints that the water was too cold and this decreased the decontamination time. They also reported that there was an inadequate number of towels to dry themselves and inadequate clothing to protect against the cold weather. Many fire fighters continued to wear their under garments while in the shower.

The 37 fire fighters were transported to five local hospitals. Most were transported by emergency medical services (EMS), but others drove themselves to the hospital. Twenty-two hospital medical records from the five hospitals were reviewed. The number of medical records received from each hospital ranged from three to five. These records revealed that the treating physicians were aware that the fire fighters were exposed to chemicals at a fire, and the physicians were concerned about the inhalation of toxic fumes and smoke. However, it was unclear to the treating physicians in most circumstances what specific toxins were present at American Ref-fuel. Several medical records specifically mentioned "possible phosgene" and "possible chlorine gas exposure."

Fire fighters' symptoms were consistent in the different hospitals; however, the extent of diagnostic testing differed. The university-based hospital performed the most diagnostic tests on the fire fighters. The tests included chest x-rays (CXR), electrocardiograms (EKG), arterial blood gases (ABG), pulse oximetry, carboxyhemoglobin levels, methemoglobin levels, serum electrolyte levels, and complete blood counts (CBC). Pulmonologists were also consulted for further evaluation of the fire fighters' pulmonary status. The fire fighters were monitored for a median of 24 hours to assess late pulmonary effects of the inhaled exposures.

The other hospitals performed consistently fewer tests. One hospital performed only pulse oximetry, while others performed pulse oximetry plus carboxyhemoglobin level or chest x-ray. Some hospitals contacted the New Jersey Poison Control Center, while others did not. These hospitals did not perform prolonged monitoring to assess the late pulmonary effects of the inhalation exposures. In the non-university hospitals, the fire fighters were monitored a median of 3.75 hours.

Two of the 37 fire fighters were admitted to separate hospitals from the emergency departments. The hospitalizations were reported to be the result of the inhalation exposure at the scene. One of the fire fighters was hospitalized for five days and the other for six days. A third fire fighter had persistent respiratory symptoms, and he was placed on limited duty for 3 weeks and continued to take medications for his respiratory condition at the time of the NIOSH interview (4 months later).

Several fire fighters had persistent symptoms for several days to weeks. The most common persistent symptom was burning eyes. Several reported that they saw an ophthalmologist for their eyes and were given antibiotic drops. One fire fighter reported that he did not remove his contact lenses at the scene and his eye symptoms persisted up to the time of the NIOSH interview. Others complained of persistent burning in their chests and coughing, which lasted a few days to a week after the incident.

Seven fire fighters made an appointment to be seen at the occupational medicine provider for the NFD. Five medical records were reviewed from this clinic. Chest x-ray and pulmonary function tests (PFT) were ordered on all five fire fighters. Two of the PFT's showed evidence of mild obstructive disease, and the others were normal. There were no comparison PFT's that were available. Surveillance examinations, including PFT's, are performed at another clinic and not at this clinic.

Three fire fighters had more severe lower respiratory tract injury. One of these fire fighters had a severe viral infection on the day of the incident, and perhaps this illness could have made his respiratory tract more vulnerable to the irritants that were present. The reason the other two developed more severe symptoms is unclear. They may have received a higher dose of the irritant gases, but their description of their job activities, PPE, and location does not differ significantly from those with less severe pulmonary injury.

The medical evaluation of fire fighters differed by hospital. The university-based hospital performed consistently more tests than the other hospitals. The evaluations at the university-based hospital were consistent with recommendations and guidelines on medical evaluation of fire fighters after exposure to toxic substances and smoke.[5,6,7,8,9,10,15,34] However, from our interviews and review of the medical records, it appears that the differences in the medical evaluations did not result in worse clinical outcomes among the fire fighters receiving fewer tests. Thus, it is likely that most fire fighters did not receive sufficient doses of the toxins to cause significant pulmonary or systemic health effects; however, this information was not known at the time of the hospital evaluations.

Appropriate diagnostic studies for symptomatic patients with smoke inhalation and asymptomatic patients with significant risk factors (from history of exposure and past medical history) include pulse oximetry, arterial blood gas (ABG) analysis, chest x-ray, electrocardiogram and cardiac monitoring, and carboxyhemoglobin (COHb) level.[6] Carboxy-hemoglobin level is important because it is the most direct biological measure of exposure to carbon monoxide (CO). COHb levels should be measured in all patients with smoke inhalation and cannot be inferred reliably from clinical signs and symptoms. Elevated COHb level should raise the concern for CO poisoning as well as potential exposure to other smoke inhalation toxins, such as coexisting asphyxiants and irritants.[4]

Chest radiographs are a low-yield procedure and are commonly normal in the early course of smoke inhalation.[5, 6] Most often, abnormal findings such as local, patchy, or diffuse infiltrates are not evident until 24 to 36 hours after exposure.[37] Subtle findings such as perivascular haziness, peri-bronchial cuffing, bronchial wall thickening, and subglottic edema may be apparent within 24 hours of exposure. Serial chest x-rays may be useful in monitoring severe smoke inhalation.[38]

Pulmonary function testing can aid in the medical evaluation of patients with toxic pulmonary insults. Pulmonary function testing is an informative but underutilized source of diagnostic information in the acute setting. Obstructive ventilatory defects, characterized by reduced expiratory flow volumes and flow rates are early findings that are related to primary airway injury. Also, these abnormalities generally precede chest x-ray findings or arterial blood gas alterations and permit early identification of patients at increased risk for more severe subsequent pulmonary disease.[5, 6]

In 1992, University of Medicine and Dentistry of New Jersey (UMDNJ) Robert Wood Johnson Medical School, in conjunction with U.S. Public Health Service, Division of Employee Occupational Health, and the New Jersey Department of Health, produced “Guidelines for the Emergency Management of Firefighters.”[39] These guidelines were produced to assist emergency departments and other health care providers to recognize and treat various conditions for which a fire fighter is occupationally at risk. These guidelines were written because toxic exposures in fire fighters are not often recognized, and morbidity and mortality may be lessened through early recognition and treatment of medical problems.

Subsequent to the testing performed in the acute care setting, few fire fighters had additional medical tests performed to assess the long term health effects of their exposures at American Ref-fuel. Seven fire fighters reported that they were evaluated by the department’s occupational health provider. The most persistent health concern was burning eyes which lasted several weeks after the incident. Also, a few fire fighters had persistent pulmonary symptoms. However, the surveillance medical evaluations were performed by another health care provider. This information was not available to the occupational medicine provider when they were evaluated after the American Ref-fuel incident because the two providers do not routinely share medical records unless requested. The surveillance information would be helpful to determine if there were differences between current and previous evaluations, such as pulmonary function tests.

The decontamination procedures at American Ref-fuel were not consistent with guidelines. It was fortunate that the shower facilities were available at the facility. Skin decontamination was acceptable in most cases, but there was inadequate flushing of the eyes in most cases. Most fire fighters reported that they were not aware that they should flush their eyes with water. Guidelines recommend flushing the eyes for at least 15 minutes after such exposure, and this may take place during showering or at other early phases of the delivery of health care.[10, 15]

CONCLUSIONS

The elements leading to fire fighter exposures at American Ref-fuel on December 17, 1998, are complex and multi-factorial in nature. Clearly, fire fighters did encounter exposures to irritant gasses at the scene. The NFD approached the incident in fire mode, when in fact, a hazardous materials response approach would have been more appropriate. The reasons for using a fire mode at the scene stem largely from misinformation provided to the arriving fire fighters about the true nature of the materials involved. Early into the incident, the BC was provided information about the chemical nature of the fire. This information would have provided justification for revising the strategy employed. Efforts by the BC to communicate this information to the DC via portable radio were unsuccessful. It is not known if this information was communicated in person or via the American Ref-fuel telephone system. Controls, which should have limited exposures, either failed or were circumvented. Exhaust ventilation at the plant was reported to have operated only intermittently, occasionally allowing the smoke and gas to concentrate in the areas where fire fighters were working. This intermittent smoke condition, coupled with several reports of fire fighters removing their respiratory protection during the incident, ultimately led to the inhalation of harmful concentrations of smoke and gas.

Most fire fighters suffered irritant symptoms that were the result of their exposures to irritant gases at American Ref-fuel. Those fire fighters who did not develop symptoms or who had recovered are unlikely to develop health problems in the future because of this exposure. These irritant gases may produce chronic respiratory diseases, but only in those with high exposures and severe acute symptoms. The fire fighters who suffered more severe injuries continued to receive medical care at the time of the NIOSH investigation.

Health care providers were uncertain of the specific exposures of the fire fighters, even when they were discharged from the emergency departments. Obtaining fewer medical tests did not appear to adversely affect the health outcome of the fire fighters who received care at those hospitals. However, following the guidelines developed by the New Jersey Department of Health for evaluating fire fighters after acute respiratory exposures would be preferable in the future. Decontamination procedures were less than optimal at the scene. Inadequate flushing may have resulted in persistent irritation of the eyes in some fire fighters. Also, the persistent irritation may be due to the initial chemical injury to the mucous membranes of the eye.

RECOMMENDATIONS

The following recommendations are based on the findings of this survey, previous HHEs, and the current scientific literature. These recommendations are intended to reduce the potential for work-related injuries and illnesses to fire fighters of the NFD.

1. The NFD should ensure personnel are trained to handle the duties and functions they may be called upon to perform in a hazardous materials response. These training requirements are outlined in 29 CFR 1910.120 (q). At a minimum, all members of the fire department should be trained to the first responder awareness and operations level. Members of the HAZMAT team should be trained to the hazardous materials technician level. Anyone who may be called upon to assume incident command over a hazardous materials response should be trained to the on scene incident commander level. This should include all captains of the HAZMAT unit and chiefs. This training should be followed up with annual refresher training as indicated in 29 CFR 1910.120 (q).

2. Department records indicated that the responsibility for HAZMAT operations did not consistently fall with one person. Rather, responsibility for HAZMAT operations and/or training appears to have shifted among a few different persons. There should be a clear line of command for the administrative aspects of the HAZMAT operation. This person should have ultimate responsibility for assuring that the HAZMAT unit is stocked with appropriate and operational

equipment, which is maintained in good working order. Clear command over all HAZMAT tours should be established to assure consistent and adequate training beyond the training provided by the individual HAZMAT captains.

3. Fire fighters may often face chemical exposures when responding to incidents such as the American Ref-fuel chemical fire because they lack appropriate protective equipment. No PPE currently exists that will protect against both fire and the chemical exposures associated with such an incident. To reduce the likelihood of fire fighters sustaining undue chemical exposures during these types of incidents, all fire fighters should properly wear all PPE while in established hazard zones (i.e., hot, warm, and cold).

4. The Newark Hazardous Materials Annex indicates that the NFD is the lead agency for hazardous materials emergency responses. Ideally this requirement would be met by providing fire companies who are solely dedicated to hazardous materials response, rather than a company that responds in either fire mode or HAZMAT mode, depending upon early indications about the incident. An increase in resources would need to be directed to HAZMAT in order to meet the increased staffing a dedicated unit would require. Short of providing a fully dedicated HAZMAT unit, the NFD should consider modifying response protocol so that HAZMAT companies are less likely to be occupied by fire calls. For example, not having truck company 1 respond as first or second due to a fire would offer the IC the option to change from a fire mode without having compromised the HAZMAT company.

5. Reports indicate that some fire fighters were alone at times during the incident. The SO's report suggests that he was trying to follow a double buddy system or some other form of accountability. The NFD should implement and enforce a fire fighter accountability consistent with PEOSH's two-in-two-out rule.

6. Immediately following fire suppression and overhaul activities involving chemical fires, all potentially contaminated PPE should be thoroughly inspected, tested, and laundered in a timely fashion. Fire fighters should also be instructed to promptly discontinue the use of any potentially contaminated PPE and equipment. Whether a *Quartermaster* system or an *Allowance* system is used, an adequate supply of backup equipment should be available to fire fighters.[36]

7. Since fire fighting is a highly hazardous occupation, safe work habits and use of PPE is strongly emphasized. During a fire incident, the assigned Safety Officer must have full authority to move around the scene to observe and address safety and health hazards, including such unsafe practices of not wearing respiratory protection in hot and warm zones. At future fire incidents, the Safety Officer should enforce the use of all necessary PPE in hot and warm zones and also identify other unsafe practices on the fireground.

8. The NFD should consider issuing a written "Alert" to small businesses to inform them about fire protection issues, including emergency response preplanning and the importance of reporting any chemical storage and use at their facility to the fire department. Businesses should be encouraged to report the initial or intermittent use of chemicals, which the NFD would be unaware of until the subsequent SARA III reporting period.

9. Communication between the NFD and local emergency departments and hospitals should be improved. At this point there is no standard procedure to relate fire fighter exposure information from the NFD to local hospitals. This could be accomplished by assigning a liaison between the fire department and the hospital(s).

10. Fire fighter medical surveillance information should be better integrated with acute care occupational medicine services. The medical surveillance examinations will have baseline health results. Acute changes in health conditions may

be noticed more readily if this information is available to the acute care provider. This could be accomplished by making surveillance information readily available to the occupational medicine provider who provides acute medical care.

11. Decontamination procedures stress the importance of flushing the eyes and other exposed mucous membranes when exposed to contaminants capable of causing damage in those parts of the body.

12. In the aftermath of acute chemical exposure, fire fighters should undergo exams to determine if they have any acute health effects related to that exposure. The components of the exams should be determined by the nature of the chemical exposure.

13. Although the NFD conducted an internal audit of their communications systems in 1997, which determined that the portable radios used by the fire department were “state of the art” and that there was “little that could or should be done to improve their performance,” the NFD should periodically review the radio technology available that may serve to improve communications in high-rise structures and update the departments communications equipment as more effective radios become available.

REFERENCES

1. Karter MJ, LeBlanc PR [1998]. 1997 U.S. fire fighter injuries. NFPA Journal, Vol. 92(6), November/December. Quincy, MA: National Fire Protection Association, pp. 48.

2. IAFF [1999]. 1998 death and injury survey. Washington, DC: International Association of Fire Fighters.

3. Nelson GL [1987]. Regulatory aspects of fire toxicology. Toxicology 47:181-90.

4. Lui D, Olson KR [1991]. Smoke inhalation. CMCC Crit Care Toxicol 1:203-24.

5. Orzel RA [1993]. Toxicological aspects of firesmoke: polymer pyrolysis and combustion. Occup Med 8(3):415-29.

6. Haponik EF [1993]. Clinical smoke inhalation: pulmonary effects. Occ Med 8(3):432-67.

7. Teixidor HS, Rubin E, Novick GS, Alonzo DR [1983]. Smoke inhalation: radiographic manifestations. Radiol 149:383-7.

8. Gochfeld M, Szenics J, Boesch R, Fontus H [1992]. Guidelines for the emergency management of fire fighters. Division of Occupational Health, UMDNJ- Robert Wood Johnson Medical School, Piscataway, NJ.

9. ATSDR [1994]. Introduction. In: Managing hazardous materials incidents. Vol. III, Medical management guidelines for acute chemical exposures. Agency for Toxic Substances and Disease Registry. Washington, DC: U.S. Government Printing Office.

10. ATSDR [1994]. Chlorine. In: Managing hazardous materials incidents. Vol. III, Medical management guidelines for acute chemical exposures. Agency for Toxic Substances and Disease Registry. Washington DC: U.S. Government Printing Office.

11. Proctor NH, Hughs JP, Fishman ML [1996]. Chlorine. In Chemical hazards of the workplace. 4th ed. New York, NY: Van Nostrand Reinhold.

12. Wexler P [1998]. Chlorine. In: Encyclopedia of Toxicology. Vol. I. San Diego, CA: Academic Press.

13. Parkes WR [1994]. Non-metallic gases, vapors, and mists. In: Occupational Lung Disorders. 3rd ed. Oxford, England: Butterworth Heinemann.

14. Das R, Blanc PD [1993]. Chlorine gas exposure and the lung: a review. Toxicol Ind Health 9(3):439-55.

15. Poisindex® [1999]. Toxicological Management: Chlorine gas. Micromedex Inc. Englewood, CO.

16. ATSDR [1994]. Phosgene. In: Managing hazardous materials incidents. Vol. III, Medical management guidelines for acute chemical exposures. Agency for Toxic Substances and Disease Registry. Washington DC: U.S. Government Printing Office.

17. Proctor NH, Hughs JP, Fishman ML [1996]. Phosgene. In: Chemical hazards of the workplace. 4th ed. New York, NY: Van Nostrand Reinhold.

18. Poisindex® [1999]. Toxicological Management: Phosgene. Micromedex Inc. Englewood, CO.

19. Kroschswitz MH, ed. [1993]. Chloramines and Bromines. In: Encyclopedia of chemical technology. 4th ed. Vol. 5. New York, NY: John Wiley and Sons.

20. Barbee SJ, Thackara JW, Rinehart WE [1983]. Acute inhalation toxicology of nitrogen trichloride. Am Ind Hyg Assoc 44(2):145-6.

21. Massin N, Bohadana AB, Wild P, Hery M, et al. [1998]. Respiratory symptoms and bronchial responsiveness in lifeguards exposed to nitrogen trichloride in indoor swimming pools. Occup Environ Med 55:258-63.

22. NFPA [1989]. Recommendations for developing fire protection services for the public. Boston, MA: National Fire Protection Association, NFPA 1201–1989.

23. NFA [1987]. The incident command system. Emmitsburg, MD: U.S. Federal Emergency Management Administration, U.S. Fire Administration, National Fire Academy, NFA–ICS–SM.

24. NFPA [1992]. Hazardous materials response handbook. Quincy, MA: National Fire Protection Association, p. 711.

25. NFPA [1990]. Standard on fire department incident management system. Quincy, MA: National Fire Protection Association, NFPA 1561–1990.

26. IFSTA [1998]. Essentials of fire fighting. 4th ed. Oklahoma State University: International Fire Service Training Association, p. 14.

27. NFPA [1987]. Standard on fire department occupational safety and health. Quincy, MA: National Fire Protection Association, NFPA 1500–1987.

28. NFS [1996]. Model procedures guide for high–rise fire fighting. 1st ed. Stillwater, OK: Fire Protection Publications, Oklahoma State University, National Fire Service Incident Management Consortium.

29. NFPA [1987]. Fire command. Boston, MA: National Fire Protection Association.

30. Oklahoma State University [1983]. Incident command system. Stillwater, OK: Oklahoma State University.

31. CFR [1998]. OSHA 29 CFR 1910.134. Respiratory protection. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

32. CFR [1999]. OSHA 29 CFR 1910.120. Hazardous Waste Operations and Emergency Response. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

33. Terrill JB, Montgomery RR, Reinhardt CF [1978]. Toxic gases from fires. Science 200: 1343-9.

34. Hung OL, Shih RD [1997]. Firefighters. In: Greenberg MI, Hamilton RJ, Phillips SD, eds. Occupational, Industrial, and Environmental Toxicology. St. Loius, MO: Mosby.

35. Jankovic J, Jones W, Burkhart, Noonan [1991]. Environmental study of firefighters. Ann Occup Hyg 35:581-602.

36. NIOSH [1998]. Health hazard evaluation report: International Association of Fire Fighters (IAFF), Indianapolis, IN. HETA 97-0034-2683. Cincinnati, OH: US DHHS, CDC, NIOSH.

37. Teixidor HS, Rubin E, Novick GS, Alonzo DR [1983]. Smoke inhalation: radiographic manifestations. Radiol 149:383-7.

38. Lee MJ, O'Connell DJ [1988]. The plain chest radiograph after acute smoke inhalation. Clin Radiol 39(1):33-7.

39. Gochfeld M, Szenics J, Boesch R, Fontus H [1992]. Guidelines for the emergency management of firefighters. Division of Occupational Health, UMDNJ- Robert Wood Johnson Medical School, Piscataway, NJ.

Glossary of Medical Terminology

Airways. Any part of the respiratory tract (e.g., lungs and windpipe) through which air passes during breathing.

Alveoli. Microscopic air sacs in the lungs in which gas travels between the blood and the lung.

Arterial blood gas. A procedure that measures the oxygen content, carbon dioxide content, and the pH in arterial blood.

Asphyxiant. An agent, especially a gas, that will cause the insufficient intake or utilization of oxygen.

Asthma. A chronic health condition in which constriction of the bronchial tubes occurs in response to irritation, allergy, or other stimuli.

Atelectasis. Partial collapse of the lung.

Bronchiectasis. Chronic dilation of a bronchus or bronchi, with a secondary infection that usually involves the lower portion of the lung.

Bronchus (bronchi). Large division of the windpipe that carries air to and from the lungs.

Bronchiole. A small diameter airway branching from a bronchus.

Bronchitis. Inflammation of the mucous membrane of the bronchial tubes, usually associated with persistent cough and sputum production.

Bronchospasm. Contraction of the smooth muscle of the bronchi, causing narrowing of the bronchi. This narrowing increases the resistance of air flow into the lungs and may cause a shortness of breath and wheezing.

Bronchotracheitis. Inflammation of the membrane lining of the bronchi and trachea.

Carboxyhemoglobin. Compound formed in the blood from hemoglobin upon exposure to carbon monoxide.

Complete blood count. Enumeration of the components of the whole blood, such are red blood cells and white blood cells.

Conjunctiva. The delicate mucous membrane that covers the exposed surface of the eyeball and lines the eyes.

Conjunctivitis. Inflamation of the conjunctiva; can result in redness, irritation, and tearing of the eye.

Co-oximeter. A device that is used to measure oxygen saturation in samples of arterial blood. It uses at least four wavelengths of light and is capable of distinguishing oxyhemoglobin, deoxygenated hemoglobin, carboxyhemoglobin, and methemoglobin.

Cornea. Transparent membrane that covers the anterior part of the eye.

Corrosive. A substance with the ability to destroy the texture or substance of a tissue.

Decontamination. The process of removing hazardous material from exposed persons and equipment.

Dermal. Relating to the skin.

Dermatitis. Inflammation of the skin.

Dyspnea. Shortness of breath; difficult or labored breathing.

Edema. Accumulation of fluid in the body cells or tissues; usually identified as swelling.

Electrocardiogram (EKG). A record of the electrical activity of the heart.

Electrolytes. Ionized salts in the blood. Commonly measured electrolytes include sodium, potassium, chloride, and bicarbonate.

Emphysema. A chronic lung disease characterized by increase in size of air spaces beyond the terminal bronchiole with destructive changes in their walls.

Hemoglobin. The iron-containing pigment of red blood cells. Its function is to carry oxygen from the lungs to the tissues.

Hypoxia. Condition in which below normal levels of oxygen are present in the air, blood, or body tissues.

Inadequate warning property. Characteristic (e.g., odor, irritation) of a substance that is not sufficient to cause a person to notice exposure.

Irritant. An agent which produces an inflammatory reaction upon contact.

Lacrimation. Secretion of tears, especially in excess.

Larynx. The enlarged upper end of the trachea below the root of the tongue.

Methemoglobin. A transformation product of hemoglobin in which normal iron is oxidized. Methemoglobin contains oxygen that if firmly bound to the oxidized iron, which prevents release of oxygen to the tissues.

Necrosis. Death of one or more cells or a portion of a tissue or organ.

Obstructive lung disease. Increased resistance to the passage of air in and out of the lung due to narrowing of the bronchial tree.

Ocular. Pertaining to the eye.

Olfactory fatigue. Temporary loss of the sense of smell due to repeated or continued stimulation.

Oxidation. To increase the positive valence (usually by adding oxygen), or to decrease the negative valence (usually by the loss of electrons).

Photophobia. Unusual intolerance of light, usually painful.

Pneumonitis. Inflammation of the lungs.

Pulmonary. Concerning or involving the lung.

Pulmonary edema. Accumulation of excess fluid in the lungs that impairs gas exchange; usually due to either increased pulmonary artery pressure or leaky pulmonary capillaries.

Pulmonary function test. A procedure that measures the flow of air through the lungs.

Pulse oximeter. Photoelectric device for determining the amount of oxygen in the blood. Usually done by measuring the amount of light transmitted through a translucent part of the skin.

Reactive airways dysfunction syndrome. Increased or excessive constriction of the bronchial tubes in response to chemical exposure.

Respiratory. Pertaining to breathing.

Rhinitis. Inflammation of the mucous membranes of the nose.

Routes of exposure. The manner in which a chemical contaminant enters the body (e.g., through the lungs or gastrointestinal tract).

Secondary contamination. Transfer of a harmful substance from one body (primary body) to another (secondary body), potentially permitting adverse effects to the secondary body.

Stridor. A harsh, high-pitched respiratory sound often heard in acute respiratory obstruction.

Toxic. Having the ability to harm the body especially by chemical means.

Trachea. The tube that runs from the larynx to the bronchial tubes. Also called the windpipe.

Wheezing. A whistling or sighing sound resulting from narrowing of the respiratory passages.

Typical American Ref-Fuel Waste-to-Energy Facility

Figure 1
Newark Fire Department
Newark, New Jersey
HETA 99-0062-2804

1. Collection trucks enter the site at a computer-controlled weigh station and are directed to an enclosed tipping hall.

2. Waste from collection vehicles is unloaded directly into the refuse bunker.

3. The overhead refuse crane mixes the waste and transfers it from the bunker and drops it into the waste charging hopper.

4. The charging hopper holds a ready supply of waste for charging the grate system.

5. The ram feeder pushes the solid waste onto the uppermost roller of the Duesseldorf Roller Grate.

6. The constant rotation of the set of rollers tumbles and distributes the waste evenly along the downward slope of the roller grate to promote thorough combustion. The speed of the rollers, the quantity of combustion air provided and the speed of the ram feeder are individually controlled to maintain optimum furnace conditions.

7. After combustion of the solid waste on the roller grate, the remaining ash falls off the final roller into the water-filled ash quench trough.

8. A conveyer carries the ash to further processing for ferrous and other materials recovery (optional) and then to the ash storage area. A front-end loader is used to remove and load the ash into trucks in an enclosed building.

9. The control room houses the computerized central monitoring and control network for the facility.

10. The heat generated by burning the waste produces steam in the waterwall boiler.

11. Approximately 10 percent of the energy produced by the turbine generator is used to operate the plant and the balance is sold to the energy customer.

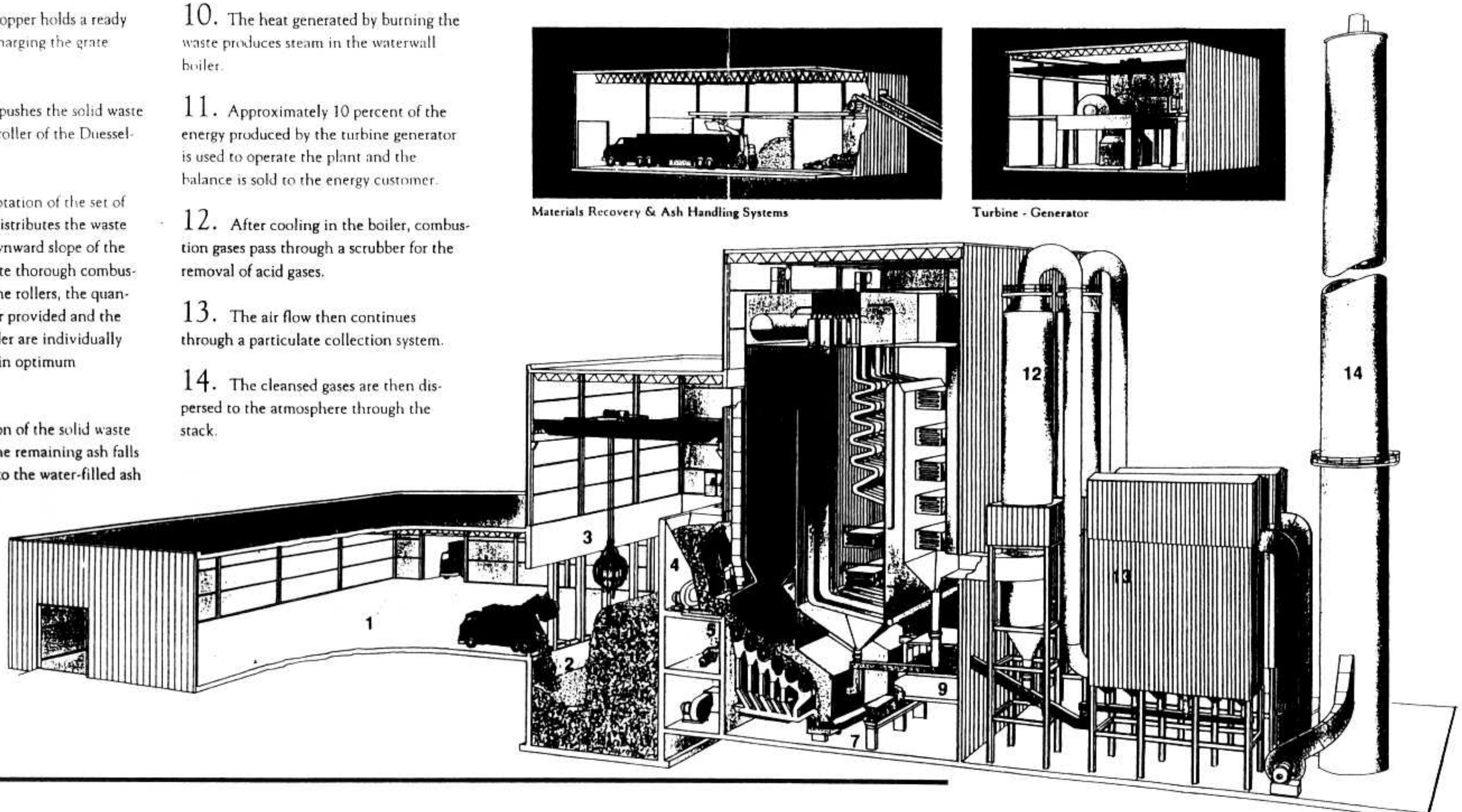
12. After cooling in the boiler, combustion gases pass through a scrubber for the removal of acid gases.

13. The air flow then continues through a particulate collection system.

14. The cleansed gases are then dispersed to the atmosphere through the stack.

Additional materials recovery and pollution abatement subsystems may be incorporated in the facility as required.

AMERICAN REF-FUEL™



Materials Recovery & Ash Handling Systems

Turbine - Generator

☆U.S. GOVERNMENT PRINTING OFFICE: 2000 650-337/20011

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4674)
or visit the NIOSH Web site at:
www.cdc.gov/niosh

National Institute for Occupational Safety and Health
NIOSH

Delivering on the Nation's promise:
! Safety and health at work for all people through research and prevention