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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

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SUMMARY

On November 12, 1996, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Association of Fire Fighters (IAFF) Local 416 on behalf of 78 fire fighters involved in a chemical warehouse fire that took place in Indianapolis, Indiana, on October 12, 1996. Fire fighters dispatched to the fire scene experienced chemical exposures and injuries. NIOSH was asked to provide technical assistance in reviewing the circumstances surrounding fire supression and overhaul activities, evaluate the overall incident command structure, and investigate chemical exposures and injuries experienced by fire fighters. Records were reviewed for 19 fire fighters who experienced acute health effects during and after fire suppression; these health effects included frequent headaches, chemical burns, irritation on face and hands, nose bleeds, cough, and a metallic taste in the mouth. Injuries experienced by two other fire fighters included a fractured pelvis and a concussion. This medical information was summarized in a letter dated May 23, 1997.

Numerous reports and notes from the Indianapolis Fire Department's (IFD) Health and Safety Office, the Indianapolis Fire Investigation Unit, the local health department, and a local hospital were collected and later reviewed. Some fire fighters were interviewed (confidentially) in person and others interviewed by telephone to gather additional details of the incident. Deficiencies that contributed to injuries and illnesses were identified. Response activities, including medical care and monitoring, were reviewed to reconstruct events both during and after the fire incident.

On the basis of the information obtained and reviewed, NIOSH investigators concluded that a variety of acute symptoms experienced by fire fighters were associated with occupational exposures in the course of fire suppression. Skin irritation temporally associated with the use of equipment previously used at the UCR fire could be due to residual chemical contamination of the equipment. Recommendations are offered in this report to address safety and health deficiencies of the overall incident command system and activities, and to improve the medical evaluation system for fire fighters.

Keywords: SIC 9224 (Fire Protection), fire fighters, firefighters, industrial fire, chemical fire, chemical warehouse, incident command system, ICS, health effects, self–contained breathing apparatus, SCBA, PPE, contamination, overhaul.

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INTRODUCTION

In November 1996, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from the International Association of Fire Fighters (IAFF) Local 146 on behalf of the Indianapolis Fire Department (IFD) and Perry Township Fire Department (PTFD) personnel who were exposed to chemicals or injured during and after fire suppression activities at UCR, Incorporated, a chemical warehouse located in Indianapolis, Indiana. NIOSH was asked to review the circumstances surrounding the fire, evaluate the overall incident command system, and investigate chemical exposures and injuries experienced by fire fighters. NIOSH investigators met with IFD management and union representatives on January 28, 1997. An interim letter describing the medical record review was sent to management and union representatives on May 23, 1997.

BACKGROUND

The fire incident took place on October 12, 1996, at UCR, Incorporated, which occupied a one–story warehouse made of block and frame construction located in an urban, residential setting. With 10 to 15 employees, UCR is a metal finishing company that uses large quantities of organic and inorganic chemicals. (See the Appendix of this report for the inventory of chemicals present at the time of the fire.) The fire (later ruled accidental) was caused by the ignition of insulation by a welder's torch while he was constructing a handrail on a stairway leading to chemical mixing tanks. When IFD arrived at the fire scene there was no placarding on the exterior of the building, as required by the National Fire Protection Association (NFPA) Standard 704.[1] The NFPA placarding requirement is intended to alert or notify outsiders, such as fire fighter personnel, about the presence of hazardous materials stored at the facility.

At 1549 hours, three engine and two ladder companies from IFD were dispatched to the fire scene. At 1552 hours, the first unit to arrive on scene was engine company #26 and they established a command post. At 1601 hours, the first of two explosions occurred inside the warehouse, creating a large, multicolored cloud which immediately came down as fallout on fire fighter personnel at the established incident command post. This explosion thrusted a fire fighter against a fire engine truck and caused him to lose consciousness (this fire fighter was later felt to have suffered a concussion). Several fire fighters were inside the facility performing search and rescue functions at the time of the explosion but escaped safely. Consequently, a defensive mode of attack on the fireground was declared, and the command post was re–established at a safer distance away from the fire. Prior to this explosion, the Hazardous Materials (HAZMAT) Program Coordinator at the fire scene had forewarned that the initial command post was established too close to the burning facility.

A tactical support unit arrived on scene at 1602 hours to provide support activities of replacing depleted supply–air cylinders and performing equipment repairs. The first of four fire rescue units arrived on the scene at 1605 hours (later accompanied by medics from a local hospital) and established a triage area for rehabilitation and medical monitoring of fire fighters who suffered chemical–related illnesses, injuries, or heat–related disorders (i.e., thermal burns, heat exhaustion).

Minutes after the first explosion, a second explosion occurred, spraying a green cloud of an unidentified chemical material on some fire fighters that were near the burning facility. The appearance and nature of the fire indicated the involvement of large quantities of hazardous chemicals. Three HAZMAT teams were then dispatched, and the first team arrived at 1610 hours. A decontamination area was immediately established to decontaminate chemically exposed fire fighters.

The building's Site Safety Plan and Material Safety Data Sheets (MSDS) (acquired from an employee

contact) were reviewed by the Incident Commander and the HAZMAT Coordinator to identify and locate chemical materials stored in the burning facility. The most hazardous chemicals present in the burning building were copper cyanide, sodium cyanide, methanol, propanol, and corrosive materials. To impede the fire from spreading in the middle area of the building where the cyanide chemicals were stored, a mobile foam truck was dispatched. It arrived at 1637 hours and fire fighters applied an aqueous (alcohol–based) to suppress the fire.

On the afternoon of the fire, the local weather conditions included temperatures as high as 68°F with an average wind speed of 11 miles per hour (light breeze) from the south and southwest directions. The fire created a plume of smoke which, as a precautionary measure to the public, warranted the evacuation of some neighboring residents from the neighborhood by the local police department.

Due to water runoff possibly containing hazardous chemicals, containment areas outside the burning facility were identified and cordoned off by fire fighters and other emergency personnel. A field sheet from the local health department indicated that air testing (using a chemical vapor analyzer and detector tubes) done on the fireground during the fire did not measure chemical levels higher than background levels. The local health department's information sheet concerning the incident indicated that sampling of the water runoff from the fire revealed the presence of cyanide and chromium and a pH that ranged from 9.5 to 11.5 (moderately caustic). Analysis of soil samples believed to be exposed to the water runoff did not have elevated levels of those compounds.

The fire was declared under control at about 1905 hours. During overhaul, fire fighters experienced chemical splashes when hot spots were being hosed down, and at times fire fighters walked through runoff water that was a greenish color with an ammonia odor.

During and after fire suppression and overhaul activities, seven fire fighters were transported to a local hospital to receive medical treatment for injuries. Most injuries were minor chemical burns, but one fire fighter was admitted overnight. Another fire fighter suffered a fractured pelvic bone as a result of being pinned against a door of a moving fire engine truck. In the weeks following the fire incident some fire fighters continued to report health problems. Some fire fighters reported skin irritation while using personal protective equipment (PPE) that had not been properly inspected and decontaminated following the UCR fire.

EVALUATION METHODS

On January 28, 1997, NIOSH investigators met with IFD management, IAFF's Joint Safety Committee, with representatives from Perry Township and Warren Township fire departments also present. This meeting was arranged to discuss the nature of the request, the chronology of events, fire suppression activities, and medical issues. Numerous reports and notes from IFD's Health and Safety Office and the Indianapolis Fire Investigation Unit were collected and later reviewed. These included: (1) the Incident History Detail log; (2) field notes and incident reports by the Safety Officer and the HAZMAT Coordinator; (3) field sheets from the Department of Water Quality and Hazardous Material Management; (4) field sheets from the local health department; (5) an inventory of the 106 chemicals present at UCR; (6) medical records of the 11 IFD and 8 Perry Township fire fighters who received medical treatment, and (7) and other pertinent letters and documents.

Some fire fighters were interviewed (confidentially) in person, and others by telephone, to gather additional details of the incident. This information was used to reconstruct events and review procedures followed during the incident, to identify deficiencies that may have contributed to injuries and illnesses, and to review the medical care and monitoring provided to injured and ill fire fighters.

EVALUATION CRITERIA

Fire fighters work in varied and complex environments that increase their risk of on–the–job death and injury.[2] In 1993, according to the Bureau of Labor Statistics, the fatal on–the–job injury rate was three times the national average and was highest among the protective service occupations.[3] In 1996, the National Fire Protection Association (NFPA) reported 92 death occurring in the line–of–duty. In addition, there were 101,500 fire fighters injured in the line of duty in 1993.[2] According to 1992 National Safety Council statistics, the occupational injury and illness incidence rate for fire fighters was 8.2 cases per 100 full–time employees, with 3.5 cases per 100 employees involving days away from work and deaths.[4] In over 200 residential fires in Boston, air monitoring (which focused on a small fraction of the possible combustion products) found varying air concentrations of carbon monoxide, carbon dioxide, hydrogen cyanide, benzene, nitrogen dioxide, hydrogen chloride, and acrolein.[5,6] Other toxic components of smoke can include ammonia, acrylonitrile, halogen acids, sulfur dioxide, aldehydes, isocyanates, methylene chloride, particulates, and hydrocarbons.[7–9] In addition to thermal and chemical burns, fire fighters may also experience heat exhaustion and cold stress. Other health and safety problems may include injuries caused by falling objects or debris, muscle strains from heavy lifting, exposure to high noise levels, electrical shock, puncture wounds, bruises, and communicable diseases from rendering medical services.

Exposures to respiratory irritants such as acrolein, hydrogen chloride, and nitrogen dioxide may lead to acute and chronic respiratory problems. There is an increasing concern about a fire fighter's exposures to carcinogens released from the combustion of synthetic materials used in building construction.[11]

FINDINGS AND DISCUSSION

Incident Command Activities

According to the HAZMAT Coordinator's field notes, the command post established at the UCR fire incident was established too close to the burning warehouse. Only after the first explosion, which resulted in chemical exposure to fire fighters, was the command post re–established to a safer location. Customary hot, warm, and cold zones for HAZMAT incidents also were not adequately established on the fireground. Individual working areas such as the command post, decontamination, and rehabilitation were reportedly established too close to each other, which may have contributed to disorganization and confusion during the incident.

Administrative Communications

There was an inadequate system for PTFD fire fighters to report health–related issues to PTFD management officials. PTFD's fire fighters involved in the UCR incident had not formally reported health problems to their management until weeks later when a local newspaper covered a story about health problems experienced by IFD's fire fighters during the same incident. Therefore, some fire fighters did not receive medical attention until that time.

Personal Protective Equipment (PPE)

Because much of the fire suppression activities occurred outdoors, with fire fighters attacking the fire from a defensive mode, a fire fighter at the scene reported that some fire fighters felt comfortable with not wearing their self–contained breathing apparatus (SCBA) in established hot and warm zones. 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 presents a health hazard. A contributing factor to fire fighters' exposures may have been the lack of enforcement of PPE requirements by a delegated safety officer who must routinely observe operations at the scene of an incident to ensure safe work practices.

A fire fighter's complete turnout gear typically worn during the incident consists of a helmet, hood, turnout coat, turnout pants, boots, gloves, and SCBA with a personnel accountability system (PAS) device. SCBAs 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°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. PPE made of a material that is both fire– *and* chemical–resistant currently does not exist.

Following the UCR fire, IFD's quartermaster replaced 110 items that could not be decontaminated, and 32 bunker pants and coats were cleaned. Because the PTFD had an *Allowance* system in place, instead of a *Quartermaster* system, PTFD fire fighters involved in the UCR fire experienced problems with replacing turnout gear that was either permanently damaged or chemically contaminated. There were reports that some chemically contaminated turnout gear was still in use weeks following the incident. The use of this gear may have resulted in skin irritation when worn by fire fighters at other fire scenes. 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.

The UCR warehouse did not have the exterior placarding as required by the NFPA Standard 704.[1] (Appropriate placarding on the building would have notified or alerted the Incident Commander about the potential for a chemical fire.) Only after fire fighters were exposed to chemicals as a result of an explosion (and after an employee provided MSDSs for chemical inside the burning) did the Incident Commander become aware of chemical storage. Although chemical exposure to fire fighters could not have been totally avoided during the incident, placarding would have forewarned the first fire fighters who arrived on the scene to take appropriate precautions. In addition, support units (i.e., mobile foam unit) would have been dispatched sooner.

According to the HAZMAT Coordinator's incident report, industrial fires involving chemicals should be extinguished with a foam material, not water. Under certain circumstances application of water to a chemical fire may prove effective in fire control, but not in extinguishing the fire. Dry chemicals, foams, carbon dioxide, or halogenated agents are generally used for chemical fires. Water usage alone greatly contributes to runoff that may result in chemical exposure of emergency response personnel and may cause environmental damage to nearby surrounding areas.

Following fire suppression activities, overhaul activities are sometimes undertaken without adequately protecting the safety and health of fire fighters. Personnel performing overhaul and investigations (for cause of fire) are potentially exposed to combustion products that may cause acute and long–term health effects or encounter safety hazards. Physical hazards may include slips/trips, poor visibility, extreme temperatures, and building collapse. Fires may produce carbon soot and pyrenes. Gases and vapors (e.g., hydrogen cyanide, oxides of nitrogen, aldehydes) are known to adsorb onto the surface of particles and may pose a health hazard when inhaled. Disturbance of burned building materials may lead to exposures to lead paint and asbestos.

MEDICAL

The information from the IFD Health and Safety Office indicated that seven IFD fire fighters were transported to a local hospital after the incident (one was admitted, six were treated and released). The information from the IFD also indicated that soon after the incident the IFD had identified all personnel present at the fire and educational activities and record–keeping regarding exposures and symptoms related to the UCR incident had begun. The letter from the Indiana Poison Center indicated that the chemicals present at the UCR fire were likely to primarily cause acute irritant effects (such as nosebleeds) and recommended that all symptomatic fire fighters receive a medical evaluation. There was no information available which documented exposure of fire fighters (or others potentially exposed) to any specific substance during the fire.

Medical Evaluations of IFD Fire Fighters

Review of the 11 medical records and personal statements regarding IFD fire fighters revealed that four fire fighters experienced chemical burns on exposed areas of skin, three experienced nosebleeds, and three experienced upper respiratory irritation or congestion. One fire fighter suffered a fractured pelvis after being pinned against the door of a moving fire truck. Approximately one month after the UCR fire, one fire fighter developed increased shortness of breath and was found to have a paralyzed right hemidiaphragm. One fire fighter developed Bell's palsy (facial paralysis) approximately two months after the UCR fire. Two months after that diagnosis, the medical record indicated improvement (but not complete resolution) of the facial paralysis in that fire fighter. Another health effect noted was an elevation of the enzyme gamma–glutamyltranspeptidase (GGT) in one fire fighter.

Paralysis of the hemidiaphragm is not likely related to an environmental exposure; the most common cause is nerve damage due to cancer.[12] If a person with paralysis of the hemidiaphragm does not have a cancer, the cause of the paralysis is often not discovered. Bell's palsy is defined as idiopathic facial paralysis (facial paralysis due to unknown causes). Some cases of Bell's palsy have been shown to be related to a virus,[13] and many researchers believe that reactivation of viral infections present in some persons is the main cause of Bell's palsy.[13,14] Other factors thought to be involved include genetic, metabolic, autoimmune, vascular, and structural factors.[13] Toxic (environmental or occupational) etiologies of Bell's palsy have not been documented in the medical literature. The enzyme GGT is often included in a group of blood tests performed to evaluate liver function. Elevation of the GGT can be caused by many types of conditions and disorders and is not specific for exposure to any particular substance.[12]

Medical Evaluations of Perry Township Fire Fighters

Review of the eight medical records and personal statements regarding Perry Township fire fighters revealed that three fire fighters were in the vicinity of the explosion that occurred at the UCR fire; one of those fire fighters reported a period of loss of consciousness and was later diagnosed with a concussion. A variety of symptoms were reported by all eight fire fighters, the most common being headache. In some instances the headaches were reported to persist one to two months past the date of the fire. All eight fire fighters were evaluated by a physician in February 1997, approximately four months after the UCR fire. At that time, all received a general examination, pulmonary function test, urinalysis, several blood tests, and a chest x–ray; all results were reported as being within normal limits. There was no information which indicated that these eight fire fighters had received any medical evaluation prior to the examinations mentioned above.

Medical Program for Fire Fighters

The following sections briefly review information which may be applicable to medical programs for both hazardous materials (HAZMAT) and regular–duty fire fighters.

OSHA Standards

The Occupational Safety and Health Administration (OSHA) standards on hazardous waste operations and emergency response (29 CFR 1910.120) and respiratory protection (29 CFR 1910.134) may both be applicable for these workers. (Although federal OSHA standards do not legally apply to public employees, Indiana has an approved State Plan, with equivalent standards that apply to public employees). The hazardous waste standard requires medical examination of workers exposed to hazardous substances and members of HAZMAT teams: (1) prior to assignment; (2) at least every 12 months (every 24 months at the discretion of an attending physician); (3) at termination of assignment; and (4) when an employee develops signs or symptoms of exposure, or is exposed above a specific exposure limit. The content of the medical examinations is determined by the examining physician, but must include a medical and work history and a fitness for duty evaluation (including ability to wear personal protective equipment under anticipated work conditions [including extreme temperatures]). Under the OSHA respiratory protection standard, a physician must annually evaluate a worker's ability to use a respirator.

NFPA Standard 1582

The NFPA Standard 1582 on Medical Requirements for Fire Fighters[15] recommends preplacement, periodic, and return–to–duty medical evaluations. The periodic medical evaluations include a history, physical examination, audiometry, vision testing, and pulmonary function tests, with lab tests, diagnostic imaging, and electrocardiography to be performed if indicated. The standard also lists medical conditions that are absolute or relative contraindications for work as a fire fighter. Periodic medical examinations are recommended every one to three years, depending on the age of the firefighter.

NIOSH Publication

A document jointly issued by NIOSH, OSHA, the US Coast Guard, and the Environmental Protection Agency (EPA) discusses a recommended medical program for hazardous waste workers which includes: (1) medical surveillance; (2) medical treatment; (3) record keeping; and (4) program review.[16] The general components of each of these aspects of the medical program are discussed in that document and can be applied to HAZMAT and regular duty fire fighters. Recommendations for medical evaluation of workers exposed to several specific toxicants are provided in that document. Other recommendations regarding the prevention of injuries and deaths of firefighters are published in a NIOSH Alert.[17]

Literature Review

Occupational medical surveillance involves the longitudinal, periodic examination of workers who are potentially exposed to health and safety hazards. The goals of medical surveillance include: (1) establishing baseline clinical data against which future changes can be measured; (2) detection of medical conditions that predispose to work–related illness or injury; (3) monitoring of exposure; (4) evaluation and reinforcement of other health and safety measures; and (5) detection of early stages of work–related illness and injury.[18] Various clinical and diagnostic tests can potentially be used to detect predisposing conditions, evaluate degree of exposure to agents, and detect pre–symptomatic changes in health status. The types of medical tests indicated in any particular situation may be identified by using the following approach for selecting a test:[16] (1) general medical tests based on an individual's past medical history and an assessment of likely potential occupational exposures; (2) medical tests to monitor exposure to specific toxicants an individual is likely to be exposed to; and (3) pre–placement blood or

urine samples frozen for later testing (limited to specific situations).

Medical surveillance for both regular–duty and HAZMAT fire fighters is challenging due to the fact that fire fighters may be exposed to multiple hazardous agents, the identity of which may be unknown, under uncontrolled conditions. These exposures can rarely be quantified, and they may vary greatly in time and place. A great deal has been written discussing the recommended medical programs for workers potentially exposed to hazardous materials,[18–22] but little information is available documenting the utility of performing specific medical tests in these groups. A recent study concluded that, among the tests used to evaluate a group of HAZMAT fire fighters over a two– to three–year period, baseline and periodic audiometry and spirometry were useful in medical surveillance; the authors further recommended that these tests be included as components of a medical surveillance program for regular duty fire fighters.[20]

CONCLUSIONS AND RECOMMENDATIONS

The records which we reviewed regarding the UCR fire in October 1996, indicated that a number of fire fighters experienced acute health effects related to occupational exposures in the course of fire suppression. We were unable to identify environmental exposures related to any specific adverse health effect. Skin irritation temporally associated with the use of equipment previously used at the UCR fire could be due to residual chemical contamination of the equipment. Several other medical conditions were diagnosed among some of these fire fighters that were not likely related to occupational exposures. Information was not available to evaluate the possibility of ongoing health problems related to exposures at the fire. The available records were not sufficient to assess the adequacy of the formal medical program for the fire fighters involved.

Incident Command Activities

1. The establishment and location of individual work areas (i.e., decontamination, rehabilitation) on the fireground is an important factor which may impact upon the health and safety of personnel responding to a fire. During the initial phase of a fire, the *Isolation and Protective Distances* guidelines should be followed to ensure proper location of the incident command post and individual support areas during the initial phase of a fire incident, in accordance with the Emergency Response Guidelines[23] book.

2. The establishment of HAZMAT response teams should not preclude *First Responders Awareness* training for fire fighting units to handle chemical fire incidents. Often these units arrive on–scene at such incidents before HAZMAT response teams and may be commanded to perform support activities. The NFPA 472, *Standard for Professional Competence of Responders to Hazardous Materials Incidents,* set the minimum competencies expected of first responders to perform certain tasks during a HAZMAT incident. *First Responder Awareness* is for those (such as the first fire fighters who arrived at the UCR fire scene) who are likely to discover the release of a hazardous material. Responders should never attempt to perform tasks beyond their level of training and competency.

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

4. The recent revision of the OSHA respiratory protection regulation (CFR 1910.134) includes measures designed to protect fire fighters while working inside burning buildings and should be

implemented.[24] 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.

5. Immediately following fire suppression and overhaul activities involving chemical fires, fire fighters should have all potentially contaminated PPE thoroughly inspected, tested, and laundered in a timely fashion. They should also be instructed to promptly discontinue the use of any potentially contaminated PPE and equipment. While the IFD had a *Quartermaster* system in place to manage their supplies and equipment issues, PTFD had adopted an *Allowance* system. Whether a *Quartermaster* system or an *Allowance* system is used, an adequate supply of backup equipment should be available to fire fighters.

6. 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.

7. Fire fighters and fire investigators involved in overhaul operations should take precautions to protect themselves from physical and chemical hazards. If SCBAs are not used, management should require the use of full–face respirators equipped with a combination of organic vapor/acid gas chemical cartridges and a high–efficiency particulate air (HEPA) filter. Training and planning may help to minimize other unique hazards that may be present during overhaul operations.

8. Inter–departmental communication should be improved to address safety issues and concerns (e.g., contaminated equipment). Shortly after incidents, such as the UCR fire, that require cooperation of more than one fire department, a meeting should be held among fire chiefs, incident commanders, safety officers, and possibly other personnel to discuss, share, and document information about lessons learned, near misses, safety, and administration problems that were encountered.

9. Emergency response preplanning documents were only available at the central HAZMAT office of IFD. For better preparation and availability to these documents, each fire station should have copies for all businesses that store sufficient quantities of hazardous materials in their area. Furthermore, a system could be computerized by address, so that when an alarm occurs for a certain address, a unique warning signal will notify the central HAZMAT office and dispatched fire stations about the potential for chemical fire.

10. The IFD and PTFD 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 their local fire department, in accordance with NFPA standard 704. The UCR fire incident (or other similar incidents) and its consequences could be included as an example.

Medical

1. Fire fighters who participated in the UCR fire and who continue to be symptomatic should receive medical follow–up as part of a formal medical program (see #3 below).

2. Fire fighters who were in the vicinity of the explosion at the UCR fire should have follow–up audiometric testing.

3. A formal medical program for routine medical evaluation should be established and made available to all fire fighters (as well as other emergency and

rescue personnel) responding to hazardous material incidents. Although this applies directly to HAZMAT fire fighters, a similar, if not identical, medical program should be available for regular–duty fire fighters as well. Regular–duty fire fighters may respond to chemical fires and HAZMAT incidents, and as initial responders to these incidents, regular fire fighters may be exposed to dangerous conditions before the hazards are appreciated.

a. The basic components of this type of program have been outlined previously[16] and include: *(i)* medical surveillance, including pre–placement, periodic, and termination medical examinations; *(ii*) medical treatment, including emergency and non–emergency treatment; *(iii*) record keeping; and *(iv*) program review.

b. The baseline (pre–placement) medical examination should include a medical and occupational history and a physical examination, with focus on the cardiovascular and pulmonary systems. The extent and type of laboratory and other medical testing to be included should be determined with the help of occupational health professionals experienced in performing medical surveillance exams and with consideration of the potential exposures faced by any specific group of workers. Baseline testing should in most cases include: *(i*) vision testing; *(ii*) audiometry; and *(iii*) spirometry. A recent evaluation of HAZMAT fire fighters[20] suggested that audiometry and spirometry are useful tests to repeat periodically in an ongoing manner to potentially detect auditory (hearing) and pulmonary (lung) effects due to exposure to noise and pulmonary irritants.

Chest x–ray, electrocardiogram, and other medical testing should be performed as part of this exam if clinically indicated.[16] Some authors[19,20] recommend these types of tests as part of the preplacement examination, although their effectiveness in documenting work related problems in a medical surveillance program has not been demonstrated.

c. The utility of performing other medical tests (baseline and/or periodic) should be determined by the health professionals involved with the medical program for any specific group of workers. These other medical tests could include specific markers of exposure to (or health effects from) hazardous materials that may be encountered by that group of workers. Freezing of blood and urine (archived specimens) may theoretically be useful in certain instances to provide a baseline measurement for use after a specific exposure has occurred, but it may be of little practical value unless the post–exposure specimen is obtained soon after the baseline measurement.

d. The frequency of periodic re–evaluations should be determined by the level of exposure or other relevant clinical factors; annual or biannual re–evaluations are generally considered reasonable approaches.

4. The availability of proper emergency and episodic medical care should be a component of the medical program, including prompt evaluation of personnel who are symptomatic after an incident and also evaluation of asymptomatic persons believed to have potentially received a significant toxic exposure. Fire department management should ensure incident reports are completed in a timely manner by all fire fighters who experience injuries or illnesses on duty, or who have potentially received a toxic exposure. Fire fighters who are symptomatic should be re–evaluated in an ongoing manner as clinically indicated. Medical personnel and others involved in administering the medical program should be aware that all health effects may not be immediate and that delayed health effects can result from occupational exposures.

5. Continuity of care is important in providing occupational health services to groups of workers, so to the extent possible, the same medical provider should be used over time.

REFERENCES

1. NFPA [1984]. 704: Standard system for the identification of the fire hazards of materials. Quincy, MA: National Fire Protection Association.

2. Karter MJ, LeBlanc PR [1994]. U.S. fire fighter injuries in 1993. NFPA Journal, November/December. Quincy, MA: National Fire Protection Association, pp. 57–66.

3. Toscano G, Windau J [1994]. The changing character of fatal work injuries. Monthly Labor Review, October. Washington, DC: Bureau of Labor Statistics, pp. 19–20.

4. NSC [1993]. Accident Facts, 1993 Edition. Itasca, IL: National Safety Council, pp. 51.

5. Treitman RD, Burgess WA, Gold A [1980]. Air contaminants encountered by fire fighters. Am Ind Hyg Assoc J 41:796–802.

6. Gold A, Burgess WA, Clougherty EV [1978]. Exposure of fire fighters to toxic air contaminants. Am Ind Hyg Assoc J 39:534–539.

7. Boettner EA, Ball G, Weiss B [1969]. Analysis of the volatile combustion products of vinyl plastics. J Appl Polymer Sci 13:377–395.

8. Montgomery RR, Reinhardt CF, Terrill JB [1975]. Combustion toxicology. J Fire Flammability Combustion Tox 2:179–185.

9. Hartzell GE, Packham SC, Switzer WG [1983]. Toxic products from fires. Am Ind Hyg Assoc J 44:248–255.

10. Committee on Fire Toxicology [1986]. Fire and smoke: understanding the hazards. Washington: National Academy Press.

11. Washburn AE, Le Blanc PR, Fahy RF [1997]. 1996 fire fighter fatalities. NFPA Journal 91(4): 46–60.

12. Isselbacher KJ, et al. (Eds.) [1994]. Harrison's Principles of Internal Medicine. 13th Edition, McGraw–Hill, Inc., New York, NY.

13. Bauer CA, Coker NJ [1996]. Bell's palsy: a herpes simplex neuritis? Otolaryngologic Clinics of North America 29(3):445–446.

14. Murakami S, et al. [1996]. Bell palsy and herpes simplex virus: identification and viral DNA in endoneurial fluid and muscle. Ann Int Med 124(1):27–30.

15. NFPA [1992]. 1582: Standard on medical requirements for fire fighters. Quincy, MA: National Fire Protection Association.

16. NIOSH, OSHA, USCG, EPA [1985]. Occupational safety and health guidance manual for hazardous waste site activities. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, (NIOSH) Publication No. 85–115.

17. NIOSH [1994]. Request for assistance in preventing injuries and death of fire fighters. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, (NIOSH) Publication No. 94–125.

18. Favata EA, et al. [1990]. Clinical experiences: development of a medical surveillance protocol for hazardous waste workers. Occupational Medicine: State of the Art Reviews 5(1):117–125.

19. NIOSH [1988]. Health hazard evaluation report: International Association of Fire Fighters (IAFF), Los Angeles, CA. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, (NIOSH) Publication No. 85–375–1861.

20. Kales SN, et al. [1997]. Medical surveillance of hazardous materials response fire fighters: a two–year prospective study. JOEM 39(3):238–247.

21. Melius JM [1986]. Medical surveillance for hazardous waste workers. JOM 28(8):679–683.

22. Gochfeld M [1990]. Medical surveillance of hazardous waste workers: principles and problems. Occupational Medicine: State of the Art Reviews 5(1):1–7.

23. US DOT [1996]. Emergency response guidebook. Chicago, IL: U.S. Department of Transportation.

24. Code of Federal Regulations [1998]. OSHA 29 CFR 1910.134 respiratory protection. Washington, DC: U.S. Government Printing Office.

APPENDIX

INVENTORY OF CHEMICALS STORED AT URC, INC.
INDIANAPOLIS, INDIANA
HETA 97–0034–2683

BROMOCRESOL
BUTOXYNE
1,4–BUTYNEDIOL
CADMIUM
CALCIUM NITRATE
CELOSOLVE ACETATE
CELLOSOLVE SOLVENT
CHROMIC ACID
CITRIC ACID
CHLOROHYDRATE
CHLOROBENZALDEHYDE
COLBALT CHLORIDE
DC ANTIFOAM H–10
DENATURED CHLORAL HYDRATE
DEXTROSE
DICALITE
DIMETHYLAIMINOPROPYLAMINES
DISODIUM PHOSPHATE ANHYDRIDE
DODECYL BENZENE SULFONATE
DRISNATE TX
EDTA
ETHANE
ETHOMEEN
ETHYENE DIAMINE
FLORAL BRAND SURFACTANT
FERRIC CHLORIDE ANHYDROUS
FERRIC SULFATE
FIBRE DRUMS
FORMALDEHYDE
FORMIC ACID
GLACIAL ACETIC ACID
GLYCOL ETHER
GOLPANOL BMP
HEXAFLOC AM26
HYDROCHLORIC ACID
HYDROFLUORIC ACID
HYDROFLURSILICIC ACID
IGEPAL 730
IGEPAL 630
IGEPAL 887
IMIDAZOLE POLYMER
ISOPRPYL ALCOHOL
LIQUID CAUSTIC POTASSIUM
MARASPERSE N–22
METHANOL
MONOETHANOLAMINE
MURIATIC ACID
NACONNAL 90
NBC–25
NICKEL CHLORIDE
NIAPROOF SURFACTANT
NITRIC ACID
NS–10
NTA
ORTHO–CHLOROBENZEALDEHYDE
PAILS
PETRO
PHOSPHPORIC ACID
POTASSIUM FERRICYANIDE
POTASSIUM METABISULFTE
POTASSIUM TRIPOLYPHOSPHATE
POTASSIUM CHLORIDE
POTASSIUM IODIDE
POTASSIUM NITRATE
PROARGYL ALCOHOL
ROCHELLE SALTS
SULFOBETAINE
SACCRINE
SODIUM FLUOROSILICATE
SODIUM METASILICATE
SODA ASH
SODIUM ACETATE
SODIUM ACID PYROPHOSPHATE
SODIUM BENZOATE
SODIUM BICARBONATE
SODIUM BICHROMATE
SODIUM BISULFITE
SODIUM CITRATE
SODIUM FLUORIDE
SODIUM GLUCONATE
SODIUM LIGNOSULFONATE
SODIUM NITRATE
SODIUM NITRITE
SODIUM TOLSULFONATE
SODIUM SULFATE
SODIUM TETRASULFIDE
SODIUM THIOSULFATE
SYN–FAC 8118
TETRAETHYLENEPENTAMINE
TETRASODIUM PYROPHOSPHATE
THIOUREA
TRIBUTYL PHOSPHATE
TRITON CF–10
TRITON DF–16
TRITON X100
TRITON DF–20
TRI–VALENT (BLUE)
WCA (CHROME MIST0
ZINC NITRATE
ZINC OXIDE

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