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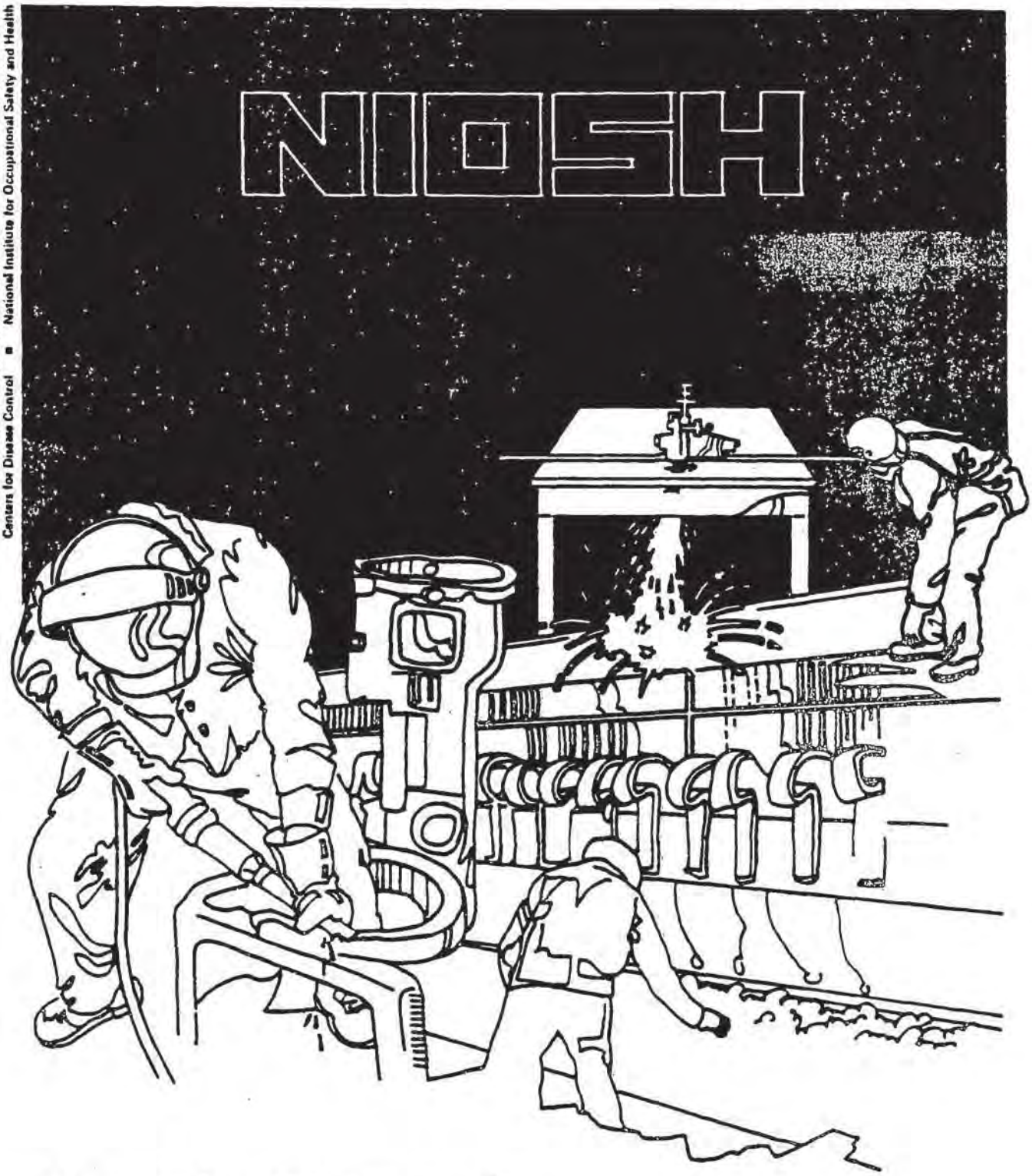
Centers for Disease Control ■ National Institute for Occupational Safety and Health



Health Hazard Evaluation Report

HETA 85-150-1767
WARWICK FIRE DEPARTMENT
WARWICK, RHODE ISLAND

PREFACE

The Hazard Evaluations and Technical Assistance Branch of 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 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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) 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.

HETA 85-150-1767
JANUARY 1987
WARWICK FIRE DEPARTMENT
WARWICK, RHODE ISLAND

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I. SUMMARY

On January 23, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Association of Fire Fighters (IAFF) to evaluate health complaints of fire fighters from the Warwick Fire Department who were exposed to plastic products and pesticides during two separate fires in late December 1984 and early January 1985.

Between February 21, 1985 and February 25, 1985, investigators from the Rhode Island Department of Health administered a questionnaire to 115 out of a possible 131 fire fighters and one policeman who were present at the fires.

Shortly after the fires they experienced headache, cough, sore throats, shortness of breath, rash, dizziness and nausea. Six had acute symptoms immediately after exposure that caused them to miss work. All were symptom-free at the time of the survey (forty seven days after the last fire).

Based on the information collected during this survey, it was concluded that fire fighters experienced acute irritant symptoms apparently caused by smoke and chemical inhalation at two fires in December 1984 and January 1985. Recommendations concerning protective measures, medical surveillance and planning for potential future exposures are made in Section VIII of this report.

KEY WORDS: SIC 9224, fire fighters, smoke inhalation, pesticides, plastics.

II. INTRODUCTION

On January 23, 1985, the National Institute for Occupational Safety and Health (NIOSH) received a request from the International Association of Fire Fighters for an evaluation of the health effects of exposures to fire fighters in the Warwick Fire Department in Rhode Island. They were exposed to two fires: one in late December 1984 and the second in early January 1985. At the first (Winde McCormick, a wholesale distributor of building materials - Fire A), they were exposed to plastics products and at the second (Lakewood Hay and Grain, a hardware and building materials warehouse - Fire B), they were exposed to pesticides. The union also requested recommendations for pre-employment and periodic physical examinations and medical screening following future exposures to workplace hazards.

III. BACKGROUND

The following descriptions of each fire are based on 115 (out of 131) interviews with fire fighters who attended the fires and reports from the Warwick Fire Department. Some of the fire fighters did not wish to participate in the study.

Fire A. (Winde McCormick) - Occurred on December 3, 1984 in a 10-20,000 square foot structure that contained formica products, plastic bricks, formica cement, foam padding, K-Lux (latex material) and a substance called AFCO (similar in composition to formica).

The fire began at 0300 hours and was fought for approximately 19 hours. During this time, the outside air temperatures ranged from 28-36°F.

A total of 56 fire fighters were exposed at this fire. (These included 14 volunteer firemen, five fire fighters from a neighboring town and one policeman.) There was no pre-fire plan and the fire fighters were not familiar with the building or its contents.

Two incident reports were filed after the fire. (See Figure 1 for example of form). The first was filed by a fire fighter who had been at the fire for six hours and complained of headache, nausea, fatigue, dizziness, and rash after inhaling fumes. He had a fever the next day and was sent home after treatment in an emergency room. The second came from a fire fighter who was at the fire for 6 hours collecting tools and equipment. He had peeling of the skin on his hands following contact with chemicals. No medical treatment was required. Five other fire fighters experienced nausea and vomiting and one complained of flu like symptoms. Six other fires of varying degrees of intensity were fought on the same day by these fire fighters.

Fire B. (Lakewood Hay and Grain) - Occurred on January 10, 1985 in a building that housed pesticides, fertilizers, solvents, gasoline, oil base paint and stain, paint thinner, alcohol solvents and sulfuric acid - 37 days after Fire A.

The fire began at 1940 hours and lasted for approximately 17 hours. During this period, the outside temperatures ranged from 13-19°F.

Fifty nine fire fighters were exposed to this fire including 13 fire fighters who were also at Fire A. At this latter fire, unlike fire A, responding fire fighters were aware of the contents of the burning building.

There were 21 health reports filed after the fire. See Figure 1. Three were injuries - fractures and back pain as a

result of slipping on the ice and the remaining 18 were reports of "internal exposure to fire products." Complaints of fire fighters included headache, vomiting, sore throat and runny nose. Sixteen occurred within two hours and two within ten minutes of arrival at the fire.

None of the fire fighters who had fought at Fire A had symptoms.

Figure 1

Providence
Fire Fighters

Thomas J.Johnston
President

Local 799

5

Robert J.Waters
Health & Safety
Representative

Injury & Exposure
Report

Name_____ Date_____

Company & no.of men manning apparatus_____ 3_,4_,other__

Location of incident_____ _____

Exposure to hazardous material Yes_ No_

Injury Yes_ No_

What exposure or type injury did you experience?_____

_____

What other members were exposed to the hazardous material or witnessed the incident or injury?_____

_____

_____

What in your opinion could be done to prevent this incident or injury from recurring?_____

_____

If you can provide any additional helpful information,use this space and reverse._____

_____

Please Print or Type

IV. METHODS - MEDICAL

A questionnaire (see Appendix 1) was administered to the exposed fire fighters. The following information was obtained from each: details of individual training and experience, use of protective clothing, exposures at the fire, symptoms experienced before, during and after the fire, and lost work time. Medical reports from the local hospital, emergency room and the fire departments' basic casualty reports were also reviewed.

V. EVALUATION CRITERIA

Fire fighters may be exposed to a variety of toxic products of combustion.[1] These vary according to the chemical composition of the burning materials, their temperature and the presence or absence of oxygen.[2,3] Examples of the toxic substances to which they may be exposed is given in Appendix 2.

The health effects of these exposures may be more subtle than the direct effects of exposure to heat and flames. Mixtures of toxic gases and vapors of unknown concentrations are produced and it is difficult to attribute health effects to any one substance.[4]

A primary hazard in fighting any pesticide fire is the potential for inhalation and skin absorption of non-decomposed pesticide vapors and liquids mixed with steam and smoke.[5,6] Special consideration must also be given for containment of contaminated run-off water and decontamination of protective clothing and fire fighting equipment after the fire is brought under control.[7]

Table 1 shows the substances that might be generated from combustion of the identified materials in the two fires.[8]

Table 1
Suspected Toxic Gases and Vapors
of Combustion at Fires A & B in Rhode Island[8,11,12]
1984/85

Substance Group:	Combustion Products
Hydrocarbons carbon dioxide, carbon monoxide* Wood, Cellulose	carbon monoxide*, aldehydes, formaldehyde
Silk, Wool, Nylon	hydrogen cyanide
Cellulose Nitrate, Celluloid	nitrogen oxide
Melamine	ammonia
Plastics	phosgene
Polyvinyl Chloride	hydrogen chloride (principal product), carbon monoxide*, chlorine, phosgene (from electrical fires), aldehydes
Pesticides: Organophosphates Carbamates Chlorinated compounds	chlorine, carbon monoxide*, hydrogen cyanide, hydrogen sulfide, nitric acid, ammonia
Rubber and Asphalt	polynuclear aromatic hydrocarbons (PNAs)
Cellulose nitrate	nitrogen dioxide
Polystyrene	styrene vapor*

*Responsible for the majority of deaths in building fires

Fire fighters exposed to pesticides at a lawn and garden center warehouse fire in 1977 experienced shortness of breath, nausea and dizziness and some required subsequent medical treatment. There was no information about subsequent chronic health effects following this exposure. Recent studies conducted by NIOSH have demonstrated a high prevalence of respiratory symptoms in fire fighters after fighting major fires at a chemical warehouse and hotel.[8,9]

Many pesticides are particularly toxic to the nervous system, but little information is currently available about delayed behavioral and physiological effects of acute exposure. Organophate pesticides act as irreversible inhibitors of the enzyme cholinesterase. Mild organophosphate poisoning causes headache, fatigue, dizziness, blurred vision, excessive sweating, nausea, vomiting, stomach cramps, diarrhea and salivation. Symptoms are normally noted within 12 hours after exposure. Carbamates cause similar but reversible inhibition of cholinesterase and the effect may be immediate or delayed.[10,11]

VI. RESULTS

A. Questionnaire Analysis

1. Demographics

Questionnaires were administered to 43 persons who were only present at Fire A; 46 who were only at Fire B and 13 fire fighters who filled out two questionnaires since they were involved in both fires. These included one policeman and 14 volunteer fire fighters. Thirteen others who were identified as exposed to the fires were either unavailable or refused to participate.

The average age, number of years worked and months of training received were similar for persons present at both fires. The incidence of symptoms were similar for each group (Fire A - 67%, Fire B - 55%). Because both groups were similar and the qualitative exposures at both fires are unknown - the groups were considered together for the purposes of this analysis.

Eighty eight percent of the fire fighters had received pre-employment medical examinations and 67% of these had pulmonary function tests. Four 3.5% had emphysema and asthma diagnosed and 21 (18.3%) were currently taking medication (ulcer, blood pressure) on a regular basis. Forty-five (39%) were current smokers and 63 (55%) former smokers.

B. Protective Equipment:

During the fires, all fire fighters reportedly wore protective clothing, i.e., coats, boots and gloves, but only 22.6% used self-contained breathing apparatus while exposed to either of the fires. Two types of helmets were used, shielded helmets worn by the city fire fighters and shieldless helmets (no face mask covering) worn by the volunteer fire fighters.

C. Occupational History:

Ninety nine (86%) of the fire fighters had part-time jobs while employed at the fire department but none of these jobs involved any apparent hazardous chemical exposures.

Seventy five (55%) of the combined total of 115 persons exposed to the fires had new acute symptoms within a mean of 8 hours after exposure to the fire. None had aggravation of previous symptoms.

These were as follows: headaches (45%), cough (37%), sore throat (36%), wheezing (8%), shortness of breath (8%), rash (8%), dizziness (7%) and nausea (5%). Blurred vision (3%) and numbness (39%) were reported only by fire fighters in Fire B. Six persons lost a total of 14 days of work following exposure.

Those with symptoms were compared with unaffected individuals to investigate factors that may predispose to illness following exposure to fires. The number of persons involved in the study were small but there were no significant differences in terms of age, work experience, months of training between the two groups.

There were also no significant differences with respect to principal activity at the fire (eg., ladder or ground, cleanup or support; time spent inside or outside the burning building; training in the use of a respirator; use of a respirator; wearing protective clothing (coat and type of helmet); skin exposure to chemicals; past medical history and medications and smoking behavior.

Eating at the scene of Fire A and breathing fumes at Fire B showed an association with symptoms but these were not statistically significant.

VII. CONCLUSION/DISCUSSION

The information obtained in this study is based on recall responses to a questionnaire and is, therefore, limited in its usefulness. Clinical evaluation of the exposed fire fighters was not undertaken because considerable time had lapsed since the exposures and there had been other fires in the interim. Health affects were acute and transient. No permanent health effects were detected. This investigation highlights the need for improved training for all team members and routine practice drills, for protocols to identify routine medical evaluation of fire fighters, and the need for state of the art personal protective equipment.

The Warwick fire fighters who fought the warehouse fire in December 1984 and the pesticide fire in January 1985 apparently experienced acute symptoms related to smoke and chemical inhalation during the fire. It is impossible to predict any long term health effects in those exposed fire fighters resulting from toxic exposures experienced from these fires. There is a need for clear guidelines for prevention of fire-related exposures and use of protective equipment, a need for surveillance information about contents of buildings and plans for fighting fires similar to what is utilized by the Danbury, Ct. Fire Department.*

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*Document: Danbury, Ct. Fire Department Computerized Study of the Control of Hazardous Substances. Jack Kozuchowski, M.D., Danbury Health Department, Danbury, Ct., 1985.

VIII. RECOMMENDATIONS

1. Fire fighters should not enter burning structures unless properly protected with NIOSH-approved SCBAs operated in a positive pressure mode and with other appropriate protective equipment.[14] This will prevent fire fighters from receiving undue exposure during these incidents.

2. Prefire planning, which involves compiling a list of flammable and toxic substances used and stored at all businesses that keep, store, use or handle explosive, flammable, combustible or other substances involving fire or life hazard serviced by the fire department should be done. These could be prepared by a responsible person in the fire department and reviewed for approval by the fire chief. This provides fire fighters with necessary information, prior to a fire so they can effectively prevent injury to their health and protect the environment during a chemical or pesticide fire.[9]

3. Conventional turnout clothing may not provide adequate protection from pesticide contaminated smoke, mist, and run-off water. Therefore, full protective equipment must be worn at any pesticide emergency scene. This includes gloves to decrease chemical absorption through the skin. Self-contained breathing apparatus is essential to reduce the possibility of inhalation of toxic chemicals and to also minimize absorption through the eyes.

4. Soon after a fire all equipment contaminated with chemicals should be properly cleaned and disposed of to prevent unnecessary exposure later.[5]

5. A medical surveillance program should be implemented for all fire fighters. See Appendix 3.

   The program should include: (1) periodic assessment of cardiac and pulmonary function through medical histories, physical examinations, including an electrocardiogram and pulmonary function tests, as appropriate[15]. Special examinations should be available after a fire that involves known or suspected exposures to toxic substances. This should include cholinesterase levels after a fire involving pesticides exposure. See Special Tests Section of Appendix 3.

6. An educational program about toxic chemicals exposure to fire fighters should be established. This should include discussions of the basic properties of toxic substances, their routes of absorption, and how they affect human health. This should be linked to a training program concerned with procedures for fighting chemical fires.

7. Substances to which fire fighters are exposed may be brought home on work uniforms, and can affect family members. Work uniforms should be cleaned and kept at the fire station. Uniforms should be laundered routinely using a separate washer and dryer from the ones used to launder bed linens and towels. For those occasions when fire fighters respond to fire alarms from their homes, a backup uniform should be kept at home.

8. Respiratory protective equipment should be available in sufficient quantities for all those requiring them. Respiratory protection programs should be established[13]. See Appendix 4.

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APPENDIX 1

RHODE ISLAND FIRE FIGHTERS QUESTIONNAIRE

February 1985

Instructions: Print your answers clearly. Where there are coding boxes, enter one (1) letter or number per box. The numbers on the side of the form are for computer purposes and should be ignored.

office use only

☐☐☐☐ Office Use: Checked by_____ I.D.# _ _ _ _

Date of Interview (Month/Day/Year): |_|_| - |_|_| - 19 |_|_|

I. Subject Identification

1. Name (Last): |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|

(First): |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|

(Middle Initial): |_|

2. Address: Street: |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|

City: |_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|_|

State: |_|_| Zip Code: |_|_|_|_|_|

3. Telephone: Area Code |_|_|_| - |_|_|_| - |_|_|_|_|

☐☐ 4. Date of Birth (Month/Day/Year): |_|_| - |_|_| - 19 |_|_| Age (Last Birthday) _____

☐ 5. Sex: 1__Male 2__Female

☐ 6. Race: 1__Alaskan or American Indian
2__Asian or Pacific Islander
3__Black, not of Hispanic Origin
4__Hispanic
5__White, not of Hispanic Origin

☐☐☐ 7. Height _____ feet _____ inches

☐☐☐ 8. Weight (pounds): |_|_|_|

e use only

II. Occupational History

☐ 1. What is your occupation?

____ firefighter

____ policeman

____Other Specify:_____

If you are not a firefighter, skip to question 6.

☐ 2. If you are a firefighter, which fire department do you work for?

____Warwick

____Cranston

____Volunteer Specify town _____

____Other Specify _____

☐ 3. How many years have you been a firefighter?

____years

☐ 4. Have you had any formal training as a fire fighter?

____ Yes ____ No

☐☐ 5. If yes, how long was your training?

____months

☐ 6. Have you been instructed in the use of a respirator?

____ Yes ____No

☐ 7. Have you been fitted for a respirator?

____ Yes ____ No

8. List your occupation before becoming a firefighter and any additional current occupations you may have.

_____

_____

_____

_____

office use only

9. Have you ever worked at a job where you were exposed to the following:

   a. Asbestos __ Yes __ No __ Don't Know
   b. Silica dust __ Yes __ No __ Don't Know
   c. High levels of dust __ Yes __ No __ Don't Know

10. At what time did you arrive at the scene of the _____fire?
    Time: ____:____ Circle AM or PM

11. At what time did you leave the scene of the _____fire?
    Time: ____:____ Circle AM or PM

12. What was your principal job location?

__ Ladder - firefighting

__ Ground - firefighting

__ Cleanup and Salvage after the fire

__ Support activities (administration, organization, directing, engine maintenance, traffic, etc.)

__ Bystander

__ Other (specify) _____

13. How far were you from the fire during your principal activity?

_____feet

14. How long were you inside or outside the building which was involved in the fire?

____ Inside _____ How long? (hours)

____ Outside _____ How long? (hours)

15. Did you breathe smoke or fumes from the fire?

____ Yes ____No

16. Were you wearing any type of protective clothing?

____ Yes ____No

17. Did you use any respiratory equipment during the fire?

____ Yes ____No

18. List any additional protective equipment you wore during the fire?

____ Shield helmet
____ Coat
____ Gloves
____ Boots

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☐☐ 19. How long were you exposed to smoke while not wearing a respirator?

☐☐ ____hours or ____minutes

☐ 20. Were any chemicals from the fire splashed on your skin?

____Yes ____No

☐ 21. Did you eat or drink at the scene of the fire?

____Yes ____No

office use only	Indicate which of the following symptoms you have experienced <u>since</u> attending the fire.	How soon after the fire did they begin?	How long did the symptom(s) last?
☐ ☐☐ ☐☐	__Headache	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Wheezing	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Cough.	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Shortness of breath.	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Nose or throat irritation.	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Skin rash.	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Numbness or tingling	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Dizziness.	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Nausea or vomiting	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Blurred or double vision	___hours or ___ days	___hours or ___days
☐ ☐☐ ☐☐	__Other (specify)_____. . . .	___hours or ___ days	___hours or ___days

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Did you miss at least one (1) day of work from any of the following? If so, how many days.

☐ ☐☐ ____headache. . . . . _____ days

☐ ☐☐ ____wheezing. . . . . _____ days

☐ ☐☐ ____cough . . . . . _____ days

☐ ☐☐ ____shortness of breath . . . . . _____ days

☐ ☐☐ ____nose or throat irritation . . . . . _____ days

☐ ☐☐ ____skin rash . . . . . _____ days

☐ ☐☐ ____numbness or tingling. . . . . _____ days

☐ ☐☐ ____dizziness . . . . . _____ days

☐ ☐☐ ____nausea or vomiting. . . . . _____ days

☐ ☐☐ ____blurred or double vision. . . . . _____ days

☐ ☐☐ ____other (specify)_____. . _____ days

Did you have any of these symptoms before attending the fire?

☐ ____headache

☐ ____wheezing

☐ ____cough

☐ ____shortness of breath

☐ ____nose or throat irritation

☐ ____skin rash

☐ ____numbness or tingling

☐ ____dizziness

☐ ____nausea or vomiting

☐ ____blurred or double vision

☐ ____other (specify)

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After you left the scene of the fire, did you seek medical attention for symptoms related to smoke or fumes?

☐ _____Yes _____No _____Don't Know

If yes, please indicate the doctor or hospital you visited and the date of your visit, and please sign the release of medical information forms.

Name of Hospital_____ Date_____

Name of Doctor _____ Date_____

IV. Other fires

☐☐☐ 1. Approximately how many fires or chemical spills did you attend during the calendar year 1984? _____

☐☐ 2. Indicate the number of fires or chemical spills you attended since the _____ fire. _____

V. Medical History

☐ 1. Did you receive a pre-employment physical examination?

_____Yes _____No

☐ 2. Have you ever had your lung function measured?

_____Yes _____No

☐ 3. Are you currently using any prescription or non-prescription medications regularly?

_____Yes _____No

If yes, please list the names of the medicines and dosages, if known.

_____

_____

_____

_____

_____

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☐ 4. Do you have any history of chest disease, such as asthma, bronchitis, or emphysema?

_____Yes _____No

☐ 5. Have you ever smoked cigarettes?

_____Yes _____No (No means less than 100 cigarettes in your entire life.)

☐ 6a If yes, do you smoke cigarettes now? _____Yes _____No

☐☐ b For how many years have you been smoking, or, if you have quit smoking, for how many years did you smoke? _____years

☐☐ c Average number of cigarettes smoked per day - ____ cigarettes

Appendix 2

Common Toxic Exposures for Fire Fighters [2,17]

Substance	Source	Type of Toxicity	Clinical Aspects
Ammonia	Wool, silk Nylon, melamine	Direct respiratory structures and skin	Readily identifiable by its pungent odor, conjunctivitis and lacrination are noted early, producing temporary blindness. Restlessness, chest tightness, a frothy sputum and cyanosis with collapse may be noted. These appear at concentrations greater than 1000 ppm. At greater than 1500 ppm, laryngospasm and immediate death may occur. Victims usually complain of intense pain in eyes, mouth and throat, and manifest a feeling of suffocation. There may be an inability to speak secondary to laryngeal edema, with stridor noted. Ammonia increases respiratory secretions. Skin contact will produce local irritation or burns.
Hydrogen cyanide	Polyurethane poly-acrylonitrile	Systemic (cellular poison) respiratory eye	Inhalation of large doses hydrogen cyanide (HCN), a gas caused by thermal decomposition, causes death by asphyxiation through inactivation of certain enzyme systems that are essential in the cellular respiratory process. The main symptoms are loss of consciousness and cessation of respiration. Lower levels of exposure may cause weakness, headache, confusion, nausea, and vomiting. Local effects of exposure to hydrogen cyanide are

Appendix 2 (Continued)

Hydrogen Chloride (gas) Hydrochloric Acid (Aqueous solution)	Polyvinyl-chloride retardant treated material	Direct Pulmonary irritant mucous membrane eye	Both the acid and the gas are in high concentrations extremely corrosive to skin, and mucous membranes and can cause skin burns, ulcerations and dermatitis. The irritant effect of the vapors on the respiratory system may produce laryngitis, glottal edema, bronchitis, pulmonary edema, and death.
Formaldehyde	Plastic melamine	Systemic mucous membrane eye	Inhalation of formaldehyde gas has also been reported to cause urticaria. Systemic intoxication at high concentrations is unlikely to occur since intense irritation of upper respiratory passages compels workers to leave areas of exposure. However, if inhalation of high concentrations does take place, it results in coughing, breathing difficulties and pulmonary edema. Carcinogenic properties have been determined in studies of laboratory animals exposed to formaldehyde.
Nitrogen Oxides (gas) Nitric Acid (aqueous solution)	Cellulose nitrate celluloid	Eye mucous membrane	At sufficient concentrations cause eye and mucous membrane irritation and if dissolved in water is an extremely corrosive liquid which causes severe burns and ulcers. High concentrations of nitrogen oxides can result in severe pulmonary irritation and methemoglobinemia followed by pulmonary edema. Prolonged exposure may lead to emphysema.

Appendix 2 (Continued)

Phosgene	Plastics	Systemic	Choking, cough, chest pain, hemoptysis
Carbon Monoxide	Incomplete Combustion of carbon compounds (smoldering fires)	Systemic	The toxic effects of Carbon Monoxide are due to its high affinity for the oxygen transporting elements of blood. Since this affinity is higher than for oxygen, carbon monoxide replaces oxygen and thereby blocks the transportation system for oxygen in the body. Inhalation of high concentrations of carbon monoxide usually result in death or very severe brain damage. Intermediate concentrations may cause irreversible brain damage, whereas prolonged exposure to low concentrations has epidemiologically been associated with the development of atherosclerosis and heart disease.
Carbon Dioxide	Produced at almost every fire	Systemic	Causes suffocation simply by being in the air and reducing the amount of oxygen breathed into the lungs and distributed throughout the body (Prevents oxygen from getting to lungs).

Adopted from: Dinerman, Norman, Toxic Exposures and Other injuries to Fire Fighters and Fire Victims, Jan. 1981.

Appendix 3
Protocol for Medical Screening of Fire Fighters[19]

I. Purpose

The intent of an occupational medical screening program is to provide early detection of signs, symptoms, laboratory abnormalities and disease states that result from exposures at work. When harmful exposures are identified other workers can then be protected from similar health effects.

It must be emphasized that such a program provides no protection from adverse effects of exposure. This can only be accomplished by limiting exposure through protective clothing and good work practices so that no adverse health effects occur.

Fire fighters are exposed intermittently to mixtures of toxic substances and there's little information available about the long term health effects of these. The following program reflects the current state of knowledge about the health effect of toxic substances and should be updated as more information is available.[3,16,17]

II. Program

A. Baseline Examination

An initial preplacement physical examination and then an annual examination unless an unusual exposure or abnormal examination finding dictates more frequent evaluation. Tests such as Pulmonary Function testing, EKG, blood and urinalysis should be performed routinely. Special tests such as neuropsychological, behavioral or sophisticated metabolic test should be conducted as indicated by clinical findings or specific exposures.

1. History of Exposure

The annual medical history should include an updated job description that enumerates the chemicals to which he/she has been exposed. The examination should be conducted with these in mind. Health effects should be noted in the interim examination, e.g. reproductive history.

2. Medical History

A complete medical history should focus pulmonary and cardiovascular systems but other organ systems should also be

assessed as risk factors for cardiac and pulmonary diseases (e.g., cigarette smoking, family history).

3. Physical Examination

A baseline physical examination should be performed that emphasizes the cardiovascular system, pulmonary system, respiratory system, eyes, teeth and hearing. Detailed neurological and skin examinations are also indicated since the skin and central and peripheral nervous systems may be especially affected by certain toxins.

4. Routine blood/urine tests

These tests may be useful for detecting individuals with specific problems such as diabetes or elevated lipid levels.

a) Complete blood count, including hematocrit, hemoglobin differential, white count, red blood cell indices, platelet count and reticulocyte count and liver function tests. Other blood tests may be indicated depending on the toxicity of the substance and the organs that are affected by a specific exposure. (See Special Test Example below.) These tests are important for hazardous materials response workers who are more likely to be exposed to hazardous chemicals. Baseline testing (e.g. liver function tests) are useful in evaluating these fire fighters after a significant chemical exposure.

b) Urine testing including pH, protein, acetone, glucose, blood, microscopic examination.

5. Immunizations: these should include Hepatitis B and tetanus.

6. Pulmonary Function Testing - Pulmonary function testing is also very important due to hazards from smoke and any irritant chemical inhalation. Base-line testing is particularly important in order to track changes in pulmonary function over time. Such changes may only be apparent when current results are compared to results from prior tests. As a minimum, it should consist of simple lung ventilation, forced volume in one second (FEV_1), forced vital capacity (FVC) and FEV_1/FVC %. This should be performed annually.

7. Chest X-ray - Although not advisable for routine periodic screening, baseline chest x-rays (a standard 14 x 17 PA exposure) can be helpful for later follow-up, should pulmonary injury occur. The lateral view is not necessary for screening purposes subsequent periodic chest x-rays should only be performed when clinically indicated and not as a routine measure.

8. EKG - An electrocardiogram should be included in the baseline examination. It ordinarily should be the standard 12-lead resting type. A stress test should also be included - a graded exercise test (see #7).

9. Cardiac Testing - While a baseline electrocardiogram can be helpful, cardiac stress testing for asymptomatic individuals is probably not advisable at the current time. Positive testing in asymptomatic individuals may not be indicative of heart disease and can lead to further unnecessary testing.

10. Audiometry - Audiometric testing is also important because of the growing evidence that fire fighters may suffer significant noise-induced hearing loss from exposure to noise from sirens, etc. This should be performed annually.

11. Visual acuity exam - vision should be corrected to at least 20/40 distant vision in one eye and colors should be distinguished appropriately.

B. Periodic Monitoring

The medical examination and other tests (except for the x-rays) should be repeated periodically. A yearly examination is probably a good approach, particularly for older individuals. This should include as a minimum, an interim medical and occupational history review, a screening physical examination (including teeth and eyes), basic blood and urine laboratory tests. The monitoring examination should be supplemented by procedures and special tests only as warranted by exposure to specific significant hazards. For hazardous materials response workers, examinations should occur at least every year and more often if indicated after significant exposures at several incidents.

Appendix 3
Special Tests - Examples

A routine annual monitoring examination as outlined above is satisfactory for most workers. However, additional special tests may be indicated for those who have been exposed to chemical or physical agents, in accordance with OSHA or other applicable standards.

Substance	Special Test
Acrylonitrile	Chest x-ray, fecal occult blood proctosigmoidoscopy
Inorganic arsenic	Chest x-ray, sputum cytology
Asbestos	Chest x-ray, pulmonary function testing
Benzene	Reticulocyte count
Inorganic lead	Blood lead, peripheral Blood smear morphology Blood zinc protoporphyrin
Organophosphate pesticides	Blood Cholinesterase

Many of the substances that fire fighters have been exposed to in the course of their duty such as reproductive, central nervous system and other toxicities from over exposure have been reported in animal testing and in some not yet definitive human studies. Thus, the laboratory battery outlined below contains some tests which should be performed one time in order to obtain baseline values. These tests should be repeated only if the fire fighter develops a medical problem involving that particular organ system.

Other supplemental procedures and special tests should only be warranted by exposure to specific significant hazards and stresses. These could include:

a) Nerve Conduction Velocities

This evaluation should be performed bilaterally and must be interpreted by someone expert in neurotoxicity since changes secondary to cigarette smoking, ethanol, aging and various disease states must be factored into the evaluation.

b) Cortical Function Evaluation, including brainstem evoked potentials, visual evoked potentials and neuropsychologic test battery.
-Thyroid Function - T3-T4 (RU).

Appendix 4

Breathing Apparatus

This basic summary is to be used as a guide to develop a respiratory protection program. The components of this program should include:

Hazard assessment;
Hazard Control; Establishment of
written operating procedures for the
selection and use of respirators;
instruction and training;
Facepiece fit testing;
cleaning; sanitizing,
inspecting, replacement, repair
and maintenance of respirators;
medical surveillance and
program surveillance and evaluation
are also major elements that are
part of a good respirator program.

Rhode Island Regulations covering the use of SCBA's for all fire services in the state.

1. As of January, 1986, all SCBA purchased after that date must be OSHA/MSHA approved.

2. All fire departments must provide training and instruction on the use of SCBAs.

3. Each department must adopt a SCBA cleaning and sanitizing program.

4. SCBA must be inspected after a fire, and at least once during each shift.

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