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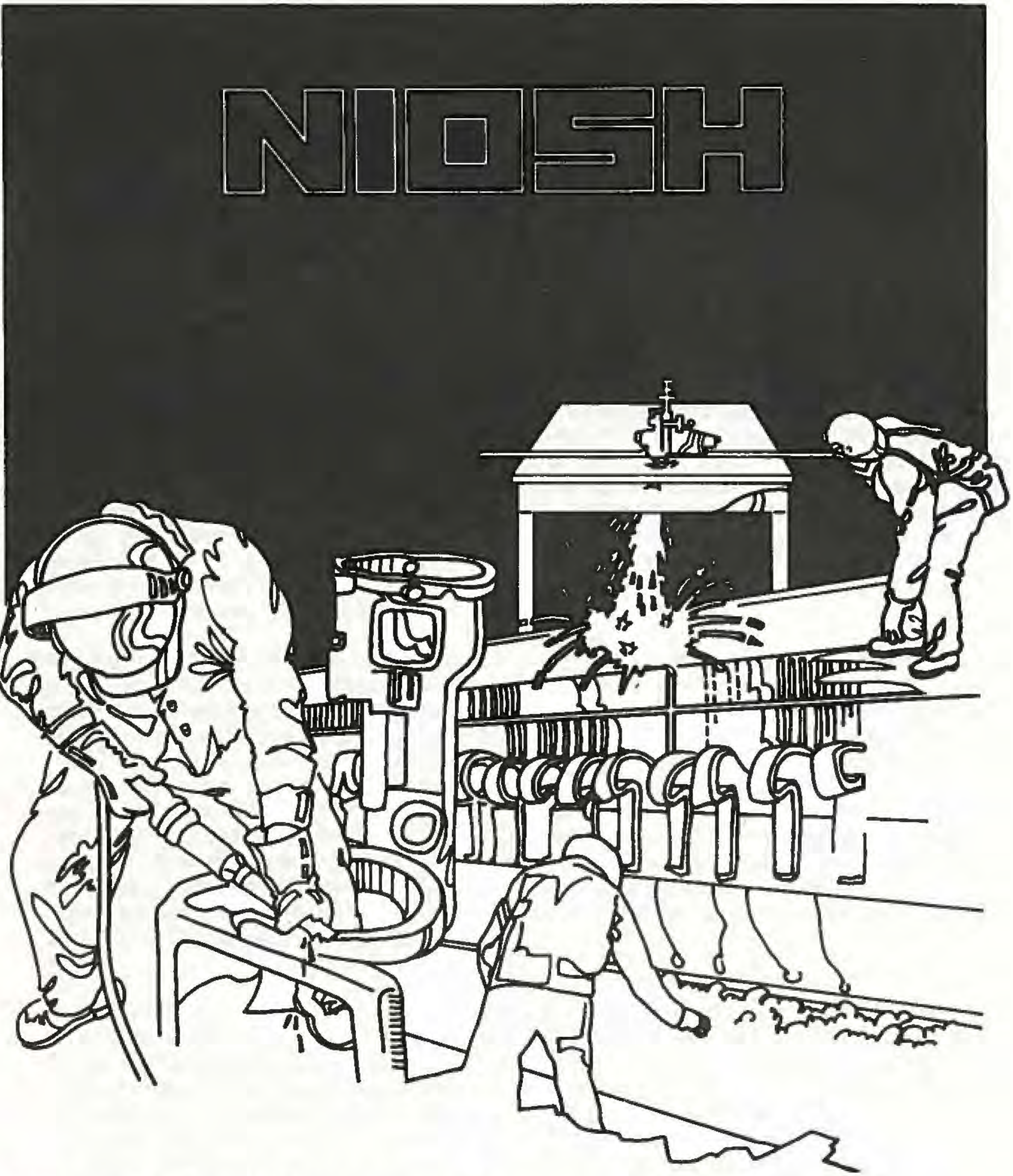

Health Hazard Evaluation Report

HETA 82-114-1097
FIRE DEPARTMENT
HOUSTON, TEXAS

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 82-114-1097
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FIRE DEPARTMENT
HOUSTON, TEXAS

NIOSH INVESTIGATOR:
E. JANNERFELDT, M.D.

I. SUMMARY

On January 16, 1982, a fire occurred in a warehouse belonging to the Polyscience Corporation in Houston, Texas. The warehouse contained several thousand pounds of polyvinyl chloride in the form of pellets. On January 25, 1982, the National Institute for Occupational Safety and Health was requested to document the prevalence and severity of health effects that had occurred in fire fighters exposed at the Polyscience fire and determine whether the fire had led to lasting adverse health effects. The request, which was submitted by the International Association of Fire Fighters, stated that firemen were experiencing skin disorders and other health effects and that these symptoms may have been caused by exposure to smoke and fumes during the fire. The concern over the exposure was increased by the documented carcinogenic properties of vinyl chloride.

In response to the request a medical survey was performed among Houston Fire Department fire fighters on February 1-3, 1982. A questionnaire concerning acute and persisting health effects associated with fighting the fire was completed by 75 % of the 125 fire fighters who attended the fire. Medical information regarding diagnoses for two hospitalized fire fighters associated with the fire was obtained.

The surveyed fire fighters reported a high prevalence of acute skin disorders and upper respiratory tract symptoms. Fifty-two percent reported skin disorders, the most common being redness and itching, and forty-four percent reported respiratory symptoms lasting more than three days after the fire. There was a positive correlation between time spent at fire and prevalence of acute skin disorders and respiratory symptoms. At the time of the interview, two weeks after the fire, none of the participants had skin symptoms, however, twenty-eight percent still had respiratory symptoms or were suffering from nausea. Although the persisting symptoms could be related to the Polyscience fire they undoubtedly also reflect the long-term health effects of the repeated periods of exposure to hazardous concentrations of smoke and fumes that fire fighters experience.

The results of this survey show that a large proportion of the fire fighters suffered acute effects due to exposure to smoke and fumes. The persisting respiratory symptoms, that some of the fire fighters were experiencing at the time of the survey, may also have been due to this exposure. However, these symptoms are more likely related to the accumulated effects of several years repeated exposure to high levels of smoke and fumes and to a certain extent perhaps attributable to the overall demanding nature of the job.

Recommendations are presented in Section VII of this Report.

KEY WORDS: SIC 9224, fire fighters, polyvinyl chloride

II. INTRODUCTION

On January 25, 1982, NIOSH was requested to document prevalence and severity of symptoms and to evaluate possible lasting adverse health effects among approximately 125 firemen involved in a large chemical fire in Houston, Texas, on January 16, 1982. The request, which was submitted by the International Association of Fire Fighters (IAFF), stated that firemen were experiencing skin disorders and other symptoms and that these may have been caused by exposure to smoke and fumes from burning polyvinyl chloride.

III. BACKGROUND

The Polyscience Corporation warehouse is a two-story building of approximately 28,000 square feet, the area involved in the fire was about 11,000 square feet. At the time of the fire several thousand pounds of polyvinyl chloride in the form of pellets were stored in the building. No significant amounts of other plastics or chemicals were present in the building. The fire lasted about 4 hours, the building was seriously damaged and several retaining walls collapsed. The extensive amounts of PVC caused the conflagration to be extremely intense and hot and presumably produced toxic air contaminants, such as hydrogen chloride, and carbon monoxide. Approximately 125 fire fighters were involved in putting out the blaze. All the PVC was thermally decomposed and high concentrations of smoke and fumes spread through-out the area surrounding the site. No environmental sampling was performed during the fire or during the subsequent clean-up and overhaul.

Due to the extent and duration of the fire and the number of firemen involved, air packs or other adequate respiratory protection devices were probably not used to the extent warranted by the high concentrations of smoke and fumes.

IV. EVALUATION DESIGN AND METHODS

On February 1-3 1982, a NIOSH medical epidemiologist visited Houston in response to the request. The investigation was initiated using a self-administered questionnaire to determine the prevalence and character of the health effects and symptoms firemen had experienced during the first few days after the fire and what health effects they were still suffering. Information was also sought regarding the two fire fighters who had been hospitalized after the fire.

The questionnaires were analyzed to detect possible correlation between prevalence and character of health effects and estimates of exposure, such as time spent at the fire.

Interviews with representatives of the union and with the health and safety representative of the Fire Department provided further information concerning immediate and lasting health effects that were reported among the fire fighters.

V. EVALUATION CRITERIA

GENERAL

According to statistics obtained from local Fire Department management and published annually by the IAFF, fire fighting is the most hazardous profession in the United States. As a cause of occupational mortality and morbidity it out-ranks other high-risk professions such as mining and construction. A considerable proportion of these effects are due to the high incidence of trauma, including severe burns and acute smoke inhalation, which is a common cause of injury and death among fire fighters.

Apart from acute effects, there is an increasing recognition of the fact that repeated incidents of exposure to high levels of smoke and fumes, such as fire fighters may experience, can cause chronic disease and other lasting health problems. These effects occur mainly in the respiratory system, and can result in debilitating conditions, such as chronic bronchitis and/or emphysema[5]. Even in fire fighters with no signs of overt pulmonary disease it is common to find decreased pulmonary function as measured by spirometry.

The respiratory effects, both acute and chronic, are mainly caused by irritating gases, for example oxides of nitrogen. Although these gases are also produced by thermal decomposition of common organic substances, it is possible that the increased use of synthetic building materials has led to higher levels of previously uncommon, highly irritating gases, such as formaldehyde, phenol, and hydrogen chloride.

In addition to respiratory irritants, fire fighters may also be exposed to toxic substances, which can cause hematologic, neurologic and liver function disturbances. These toxins can be produced by pyrolysis, but can also have been present prior to the fire, for example in chemical waste dumps and pesticide warehouses. In the latter situation the fire may cause destruction of containers with subsequent toxic contamination of the environment in which the fire fighters work.

Fire fighters are often exposed to high levels of noise and it is possible that this may result in hearing loss although this remains to be documented.

The fire fighter profession is characterized by periods of intense work interspersed with periods of relative inactivity. This in combination with the significant risk of bodily injury and accidents probably leads to high levels of stress and other untoward psychological effects among fire fighters. Due to the considerable prevalence of obvious physical health problems, these psychological effects tend to be overlooked.

SPECIFIC

Toxins

Conflagrations involving plastics, both as building materials and as stored materials, cause the release of thermal decomposition products in addition to commonly occurring products of pyrolysis, such as carbon monoxide. The chemical nature of the gases and fumes released depend upon the composition of the burning plastics and also the temperature of the fire. Complete combustion, which usually requires temperatures of at least 1400°C, commonly results in less toxic end products than those released by combustion at lower temperatures.

The following section will describe the more prevalent of the hazardous products caused by thermal decomposition of plastics and other chemicals.

Carbon Monoxide[2]

An important cause of death in association with fires is the inhalation of carbon monoxide (CO), a colorless, odorless gas that results from the incomplete combustion of various carbonaceous compounds.

The toxic effects of CO are due to its high affinity for the oxygen transporting elements of the blood. Since this affinity is higher than for oxygen, CO replaces oxygen and thereby blocks the transportation system for oxygen in the body.

Inhalation of high concentrations of CO 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.

Polyvinyl Chloride[2,3]

The decomposition products of polyvinyl chloride (PVC) are largely a function of the temperature at which pyrolysis occurs. Gaseous hydrogen chloride is released at a temperature of 250°C and above 350°C carbonaceous degradation occurs. Hydrogen, methane, ethylene, ethane, benzene, and toluene are produced from PVC at temperatures ranging between 350 - 850°C.

When laboratory animals were exposed to decomposition products of 1-2 grams of PVC at 550°C, 50 % of the animals died within 2 hours. The cause of death was, apart from carbon monoxide intoxication, pulmonary edema and interstitial pulmonary hemorrhage.

Vinyl chloride monomer, the parent compound of PVC, is a potent carcinogen and has also been shown to cause other serious health effects. Although it is possible that the monomer may be released by thermal decomposition of PVC, it is unlikely that such release could lead to hazardous concentrations of vinyl chloride since this compound is flammable and would consequently be pyrolyzed instantaneously.

Nitrogen Oxides[2]

Various nitrogen oxides (N_xO_y) are released by thermal decomposition. At sufficient concentrations they cause eye and mucous membrane irritation and if dissolved in water produce nitric acid, 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.

Phenol[2]

Phenolic resins are relatively inert but are decomposed by heat to yield products including phenol and formaldehyde. Phenol (C_6H_5OH) has a marked corrosive effect on all tissues and if not removed promptly may cause severe burns. The systemic effects are serious and include shock, cyanosis and kidney damage.

Formaldehyde[2,3]

The plastics melamine-formaldehyde and urea-formaldehyde begin to decompose after 30 minutes at 350°C with the release of formaldehyde vapors. Formaldehyde (HCHO) is a colorless, pungent gas which causes severe mucous membrane and eye irritation.

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. Formaldehyde has been shown to be carcinogenic in laboratory animals.

Hydrogen Chloride[2]

Hydrogen chloride (HCL) is a gas, the aqueous solution of which is known as hydrochloric acid. It can be released through pyrolysis of polyvinylchloride (PVC), a very common type of plastic. Both the acid and the gas are in high concentrations extremely corrosive to eyes, skin, and mucous membranes, and can cause burns, ulcerations and dermatitis. The irritant effect of the vapors on the respiratory system may produce laryngitis, glottal edema, bronchitis, pulmonary edema, and death.

Hydrogen Cyanide[2,3]

Inhalation of large doses of hydrogen cyanide (HCN), a gas caused by thermal decomposition of acrylonitrile, 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 mainly mild upper respiratory tract and eye irritation.

Acrolein[2]

Thermal decomposition of propylene produces acrolein ($H_2C{=}CHCHO$), a compound with pronounced mucous membrane irritating properties. Skin burns and dermatitis result from prolonged exposure. Due to its pungent, offensive odor and intense irritation of eyes and upper respiratory tract, severe effects from acute exposure are rare, as the vapors are not tolerated even in minimal concentrations. Acute exposure may, however, cause bronchial inflammation, resulting in bronchitis and pulmonary edema.

Polymer-Fume-Fever[3]

Polytetrafluoroethylene (PTFE, Teflon[R]) presents a special thermal decomposition hazard, called Polymer-Fume-Fever (PFF). As with Metal-Fume-Fever the presenting clinical symptoms characteristically develop a few hours after exposure to PTFE pyrolysis fumes. The initial symptoms consist of chest-discomfort and dry cough. Subsequently occurring systemic symptoms include increased body temperature, increased pulse rate, sweating, and chills. Recovery takes place fairly rapidly and is usually complete within two days. The specific agent responsible for PFF and the mechanism involved are unknown.

Stress

Epidemiologic studies of occupational groups with high levels of stress have indicated that severe stress is associated with increased risk of cardiovascular disease, especially in occupational groups suffering a combination of high job demands and low decision latitude or presence of environmental constraints[3,4]. While high levels of job demand are undoubtedly characteristic of the fire fighter profession, it has not been determined to what extent they also are subjected to low levels of decision latitudes or environmental constraints.

Fire fighters are often the first to have contact with survivors of fires and other disasters and may thus be required to perform with considerable emotional stability also when exposed to serious physical hazards. This adds to the already considerable stress experienced by these rescue workers since they must not only deal with the psychological consequences of the risks that they themselves are exposed to but must also be prepared to offer emotional support to survivors.

VI. EVALUATION RESULTS AND DISCUSSION

Approximately 125 fire fighters were involved with the fire, all were provided with questionnaire forms of which 94 were returned. All respondents were male, their ages ranged from 21 to 57 years with a median of 30. The number of years worked as fire fighters ranged from 1 to 26 with a median of 6 years. The time spent at the scene of the fire ranged from 1 - 18 hours with a median of 4 hours. Current cigarette smoking was reported by 32 % of the respondents. Smokers had a higher median age than non-smokers and had also worked longer as fire fighters. In regard to exposure measures, such as hours spent at the fire and respirator usage, smokers and non-smokers were similar.

Only 3 % of the respondents reported using a respirator all the time that they were exposed to smoke and fumes and 68 % reported not using respirators at all while at the scene of the fire.

Two firemen sought medical care during and after the fire for respiratory problems caused by smoke inhalation. They were both released after a few hours. There were no indications that their respiratory problems were related to inhalation of specific toxic fumes.

Skin disorders, developing during and immediately after the fire, were reported by 54 % of the participants. Erythema and pruritus were the most common symptoms, and were frequently located on exposed body surfaces, such as the face and neck. The skin disorders lasted an average of 2 days with a maximum of 14 days. Nose and throat irritation, lasting for at least 3 days following the fire, was reported by 32 % of the respondents and cough during the same time period by 27 %. Other symptoms and health effects were less common. The results are summarized in Table 1. The prevalence of fire fighters with multiple symptoms three days after the fire is shown in Table 2.

At the time of the interview, two weeks after the fire, cough was the most common symptom, reported by 19 %, whereas 21 % reported "other health effects". The "other health effects" covered a wide range and there was no indication of commonly occurring symptoms that could have been related to exposure to the fire. The symptoms reported at the time of the interview are summarized in Table 1.

While there is definitely an association between exposure to the fire and acute symptoms during the days following the fire it is more difficult to determine whether this association persists for symptoms reported at the time of the interview, two weeks after the fire. This is mainly due to the lack of a non-exposed but in other respects comparable reference group.

In order to study the correlation between extent of exposure and response, the total study population was separated into groups with high and low exposure. The only measures of exposure available in the analysis were hours spent at the fire, the assumption being that persons that spent a long time at the fire had higher exposure than others. However, this measure of exposure may be confounded if severely exposed persons left the scene of the fire after short time, due to development of symptoms. Conclusions regarding the data must be made bearing this in mind.

In this analysis fire fighters who had spent 4 or more hours at the fire had significantly higher prevalence of skin disorders (70 %) than those who had spent 1 - 3 hours at the fire (25 %). The group with the longer exposure also had significantly higher prevalence of individuals with multiple acute respiratory complaints (54 %) when compared to the group with shorter exposure times (6 %). These results indicate that the risk of developing acute health effects was positively correlated with time spent at fire, however, this correlation does not exist for symptoms present at the time of the interview, two weeks after the fire.

Cigarette smokers reported higher prevalence of respiratory complaints both during the three days immediately after the fire and at the time of the interview. The was no difference in prevalence of skin disorders between smokers and non-smokers. As previously stated there was no association between time spent at the fire and smoking status that could explain the difference in prevalence of respiratory symptoms. These results are summarized in Table 3.

In conclusion, there was a high prevalence of acute respiratory and dermatologic symptoms in the surveyed population and a strong correlation between presence of symptoms and time spent at the fire. However, data show no apparent association between the health effects reported at the time of the interview and duration of exposure to the fire. These persisting health problems are probably also related to the repeated exposures that fire fighters suffer and may also reflect the high degree of stress experienced by professionals in this particular occupation.

Other NIOSH Health Hazard Evaluations of fire fighters exposed to chemical fires[6] and fires with a large number of victims[7] have shown both persisting physical symptoms as well as residual psychological effects. In a study of close to 400 fire fighters involved in a chemical blaze in Elizabeth, New Jersey, the results showed a high prevalence of various respiratory tract symptoms. NIOSH is currently performing a follow-up survey of this group in order to determine association between exposure to smoke and impaired pulmonary function. A survey of the fire fighters involved in the MGM Grand Hotel fire in Las Vegas, Nevada, showed a high prevalence of persisting psychological effects and indicated that such effects may be contributed to the stress experienced by fire fighters.

Until quite recently the health effects, both acute and chronic, suffered by fire fighters were considered to be an inherent and unavoidable part of their profession. However, during the last few years it has been understood that many of these health effects, physical as well as psychological, are preventable and thus unacceptable. In the final section of this report are presented recommendations that, properly implemented, will lead to a modification, reduction or elimination of the occupational riskfactors that fire fighters are exposed to.

VII. RECOMMENDATIONS

1. Based on the results of this investigation there does not appear to be a need for further medical evaluation and follow-up of the group of fire fighters involved in the Polyscience fire; however, individuals with persisting symptoms should obviously be offered medical care and follow-up. In order to reduce risk factors and prevent health effects periodic physical examinations, as a general practice for fire fighters and as a surveillance method to detect developing ill health, should be provided. These examinations may include pulmonary function testing, chest x-rays, and cardiovascular evaluation, including stress electrocardiograms when appropriate, in addition to hematologic and liver function screening and audiograms. Such a health maintenance program should not only encompass the early detection of toxic effects of chemical and physical agents but should also facilitate the detection of signs and symptoms of ill health due to other causes.

2. A physical fitness program, with special regard to the reduction or modification of personal as well as job-related riskfactors should be designed and made available to emergency personnel.

3. Fire fighters and other personnel who attend fires should be appraised before hand of the special types of fires and exposures that could occur in their district so that, if possible, appropriate precautions may be taken.

4. Protective equipment, in good working order and properly maintained, should be available in sufficient quantities.

5. Fire fighters should be made aware of the high levels of stress that they are exposed. They should be offered counseling in order to identify and reduce particular stressors and in order to induce behavioral changes leading to increased ability to cope with high levels of stress.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENT

Evaluation Conducted and Report Prepared By:	Eric Jannerfeldt, M.D. Medical Officer Medical Section HETAB, NIOSH Cincinnati, Ohio
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies NIOSH Cincinnati, Ohio

Acknowledgement

Statistical Analysis:	Support Services Branch Division of Surveillance Hazard Evaluations and Field Studies Cincinnati, Ohio

IX. DISTRIBUTION AND AVAILABILITY

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For the purpose of informing the employees, the employer will promptly "post" this report for a period of thirty (30) calender days in prominent places near where the employees work.

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TABLE 1

PREVALENCE OF SYMPTOMS AND HEALTH PROBLEMS
REPORTED ON QUESTIONNAIRE

HOUSTON FIRE DEPARTMENT
HOUSTON, TEXAS

JANUARY 1982

	PREVALENCE	
	FOR AT LEAST THREE DAYS AFTER FIRE	AT TIME OF INTERVIEW*
SHORTNESS OF BREATH	25 %	14 %
COUGH	30 %	19 %
WHEEZING	12 %	4 %
NOSE AND/OR THROAT IRRITATION	32 %	10 %
SKIN DISORDER	54 %	0 %
NUMBNESS OR TINGLING	10 %	2 %
DIZZINESS OR NAUSEA	12 %	4 %
OTHER HEALTH PROBLEMS	-	21 %

* - TWO WEEKS AFTER FIRE

TABLE 2

PREVALENCE OF FIRE FIGHTERS WITH MULTIPLE SYMPTOMS REPORTED ON QUESTIONNAIRE

HOUSTON FIRE DEPARTMENT
HOUSTON, TEXAS

JANUARY 1982

	PREVALENCE*
NO RESPIRATORY SYMPTOMS	55 %
ONE OR TWO RESPIRATORY SYMPTOMS	33 %
THREE OR MORE RESPIRATORY SYMPTOMS	12 %
NO DERMATOLOGIC SYMPTOMS	48 %
ONE OR TWO DERMATOLOGIC SYMPTOMS	47 %
THREE OR MORE DERMATOLOGIC SYMPTOMS	5 %

* - THREE DAYS AFTER FIRE

TABLE 3

PREVALENCE OF SYMPTOMS AND HEALTH PROBLEMS AMONG SMOKERS AND NON-SMOKERS REPORTED ON QUESTIONNAIRE

HOUSTON FIRE DEPARTMENT
HOUSTON, TEXAS

JANUARY 1982

	PREVALENCE			
	FOR AT LEAST THREE DAYS AFTER FIRE		AT TIME OF INTERVIEW*	
	SMOKERS	NON-SMOKERS	SMOKERS	NON-SMOKERS
SHORTNESS OF BREATH	38 %	20 %	19 %	12 %
COUGH	48 %	22 %	27 %	15 %
WHEEZING	21 %	8 %	0 %	5 %
NOSE AND/OR THROAT IRRITATION	48 %	23 %	15 %	8 %
SKIN DISORDER	59 %	52 %	0 %	0 %
NUMBNESS OR TINGLING	6 %	11 %	3 %	2 %
DIZZINESS OR NAUSEA	13 %	11 %	6 %	3 %
OTHER HEALTH PROBLEMS	-	-	25 %	20 %

* - TWO WEEKS AFTER FIRE

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