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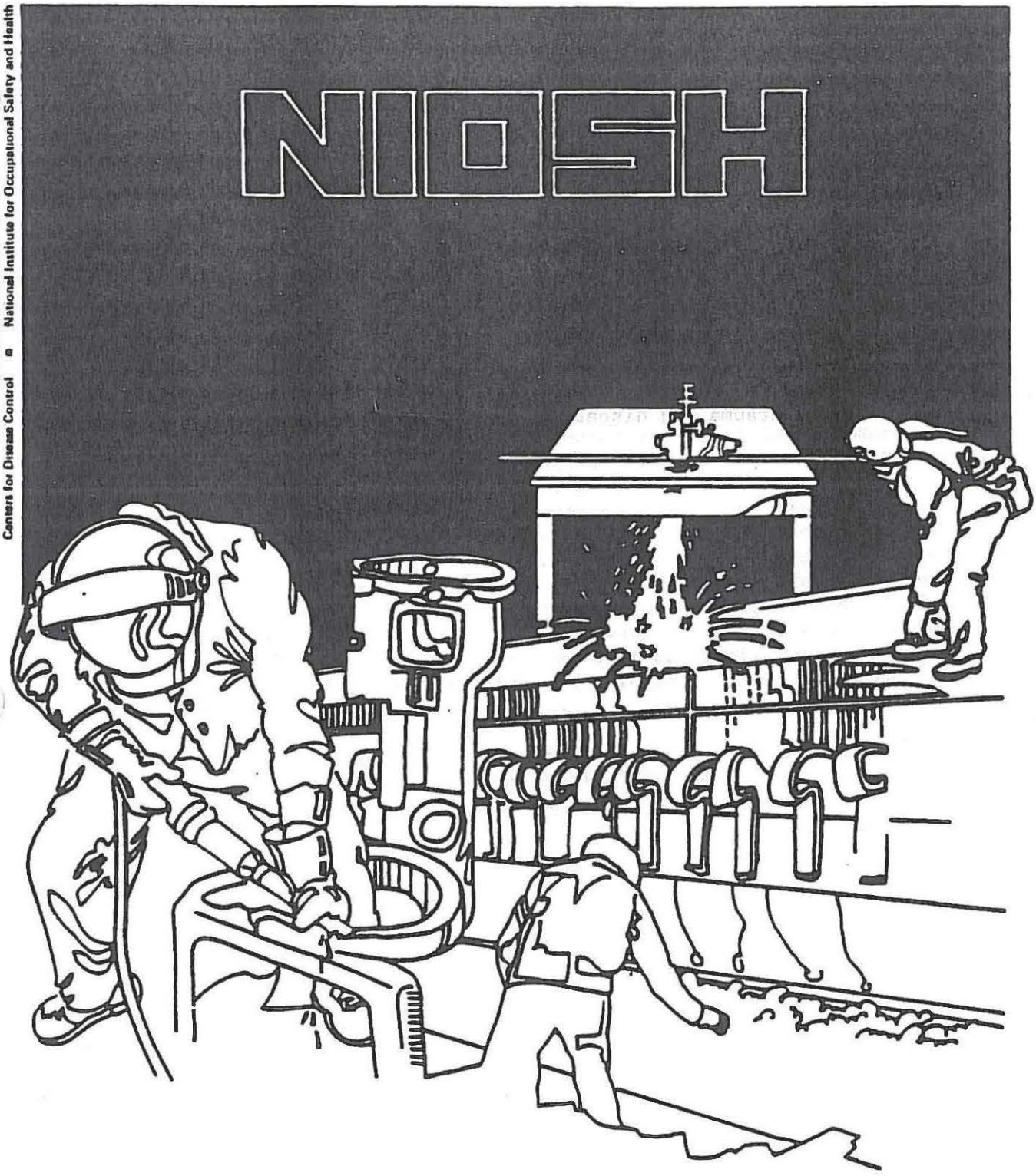

Health Hazard Evaluation Report

HETA 84-484-1754
DETROIT FIRE FIGHTERS
DETROIT, MICHIGAN

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.

On the basis of the data obtained during this investigation, it was concluded that most of the symptoms experienced by fire fighters developed after the fire and that the length of time spent at the fire plus the degree of exposure to heavy smoke, most likely contributed to the occurrence of their symptoms. Recommendations to establish a medical surveillance program for fire fighters, as well as a hazardous materials response team, are presented in Section VIII of this report.

KEYWORDS: SIC 9224, Fire Fighters, Chemical Fires, Smoke Inhalation

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DETROIT FIRE FIGHTERS
DETROIT, MICHIGAN

NIOSH INVESTIGATORS:
Kern E. Anderson
James M. Melius, M.D.

I. SUMMARY

On August 17, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate respiratory complaints and skin irritation among fire fighters, following a five alarm chemical fire and explosion that occurred on August 6, 1984 at the Michlin Diazo Products Corporation warehouse, located in Hamtramck, Michigan (a Detroit suburb).

On October 15-18, 1984, NIOSH conducted a medical survey among fire fighters and other rescue personnel involved with the fire. The survey consisted of two components; baseline pulmonary function tests (PFT's) and self-administered medical questionnaires. The Michigan Department of Public Health collected environmental samples subsequent to the fire. Samples of air, leaves from nearby trees, weeds, wipe samples from the exteriors of nearby buildings and runoff water from the site, were analyzed for the presence of solvents and pesticides. With the exception of samples taken of runoff water, results of all the other samples analyzed were negative. Results of runoff water samples taken at the site indicated malathion and chlordane in low parts per million (ppm) ranges.

Questionnaire results indicated that respiratory and other symptoms were reported by a large proportion of fire fighters. Nose and throat irritation, lasting more than six hours after the fire, was reported by nearly half (46.7%) of the survey participants. Cough and shortness of breath were also reported by a large number of individuals (38.6% and 26.5% respectively). Several of these persons complained of cough and shortness of breath persisting at the time of the survey. Comparisons of the presence of these symptoms prior to, versus after the fire, revealed that most of the reported symptoms developed after the fire. Time spent at the fire and time spent in heavy smoke, were significantly associated with the occurrence of these and other symptoms. Fire fighters who spent more than six hours at the scene of the fire, were more than two times as likely to have developed persistent cough ($p < .05$ chi square). Age and cigarette smoking were not significantly associated with these symptoms.

The fire fighters generally demonstrated good pulmonary function, based on the PFT results. However 10.6% had abnormal findings. Due to the lack of baseline PFT data for these participants, the pulmonary function test results could not be used to evaluate acute respiratory problems, resulting from exposures at this fire.

II. INTRODUCTION

On August 6, 1984, fire fighters from three communities in the Detroit, Michigan metropolitan area responded to a five alarm chemical fire and explosion at the Michlin Diazo Products Corporation in Hamtramck, Michigan. On August 17, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from the International Association of Fire Fighters (IAFF) on behalf of the Detroit Fire Fighters Association, to evaluate respiratory complaints and skin irritation among fire fighters who were at the scene of the fire.

On August 23, 1984, NIOSH investigators met in Detroit with representatives from the Detroit and Hamtramck fire fighters, Michigan State Fire Marshal's Office, Michigan Department of Natural Resources, U.S. Environmental Protection Agency, and officials from the Detroit Fire Department to discuss the investigation. After gathering preliminary information about the fire, the NIOSH investigators visited the scene where the fire took place, to inspect the grounds and what remained of the demolished warehouse. On September 28, 1984, NIOSH investigators met with Detroit Fire Department officials along with representatives from the IAFF and the Detroit Fire Fighters to finalize arrangements for the Health Hazard Evaluation.

During October 15-18, 1984, NIOSH conducted the evaluation, offering medical questionnaires and baseline pulmonary function tests to fire fighters and other rescue personnel who were involved with the fire. The pulmonary function tests screened individuals for pulmonary abnormalities. The questionnaires solicited information to characterize exposures and subsequent symptoms experienced by individuals at the scene of the fire, as well as other pertinent epidemiologic data.

III. BACKGROUND

A. The Warehouse

Michlin Diazo Products Corporation owned, and was the principal tenant of, what was actually a group of several old warehouses in the southeastern corner of Hamtramck, Michigan (Detroit). In addition to Michlin Diazo, there were several other tenants which included; an antique furniture storage, refinishing and restoration business, a rare and classic car storage business (where over 100 classic and "mint" condition collectors cars were stored), a tool and die shop and storage facilities for two companies who supplied various chemical resin bases for paint and dye manufacturers.

The main warehouse structure was built in 1909 to house a plumbing and bathroom equipment manufacturing company. Late in the 1960's the site was occupied by an aluminum window and door manufacturer. Michlin Diazo acquired the site in approximately 1976. The company was involved in the blending and distribution of pesticides and was a supplier of chemical solutions used in the blue print industry. The primary inventory of chemicals at the time of the fire included aqua and anhydrous ammonia, phosphoric acid, methoxychlor, citric acid, methyl alcohol, malathion and varying, smaller amounts of a variety of other pesticides and chemicals.

Health and safety problems at the site had been reported months before the fire and explosion took place. At least one tenant had complained about unsafe conditions on the site and the constant, and at times, unbearable smell of ammonia. The warehouse had also been the site of three explosion incidents (anhydrous ammonia tanks) during the previous six months, which resulted in the company receiving warnings from the fire department and an OSHA citation.

B. The Fire

The fire began during the early morning hours on Monday August 6, 1984, when a child, apparently playing with matches, set-off the blaze. When the first of approximately 60 tanks of anhydrous ammonia exploded, the fire ripped through the old wooden warehouses, setting-off a series of "deafening" blasts and sending flames towering over 300 feet. Pieces of metal from the exploding tanks, along with bricks and other debris knocked out windshields on cars parked two blocks away and falling embers ignited the roofs of several homes and small businesses. The intense heat from the blaze along with the risk of the fire spreading to nearby homes, forced the evacuation of some 400 area residents. Debris from the explosions was reported to land as far away as five miles from the site.

Over 200 fire fighters fought the blaze, which raged for over four hours. Plumes of white, ammonia-laced smoke, along with heavy black smoke, could be seen for miles around. The smoke was so thick that air traffic controllers at the Detroit City Airport, located four miles away, could detect it on radar. The blaze was declared under control at approximately 11:30 a.m., although smoldering debris and small fires continued to erupt through Tuesday, August 7 th. The warehouse complex was completely destroyed.

Several fire fighters and other rescuers were treated at nearby hospitals for smoke inhalation, heat exhaustion and minor skin rashes and irritation. Major injuries to fire fighters or area residents were

not reported. The cause of the fire was later confirmed when a twelve-year old boy admitted setting the blaze. Damages were estimated to be in the millions of dollars.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

The Michigan Department of Public Health collected the following environmental samples subsequent to the fire;

- Air
- Leaves from several trees in the area
- Weeds
- Wipe samples from the exteriors of nearby buildings
- Runoff water from the site

These samples were analyzed for the presence of solvents and pesticides.

B. Medical

Fire fighters and other rescue personnel who were at the scene of the fire were eligible to participate in the survey. Personnel were notified through announcements issued jointly by the Detroit Fire Fighters Association and the Fire Commissioners Office.

Self-administered medical questionnaires were completed by survey participants in efforts to determine the nature and extent of ill-health effects they experienced as a result of exposures during the fire. Baseline pulmonary function tests (PFT's) were administered by NIOSH technicians to screen individuals for respiratory abnormalities. Ohio Medical Products dry rolling seal spirometers, connected to Spirotech dedicated computers, were used to administer PFT's. The Pulmonary Function Tests measured 1. Forced Vital Capacity (FVC) - the volume of air forced out of the lungs after breathing in as deeply as possible; 2. One second Forced Expiratory Volume ($FEV_{1.0}$) - the amount of air forcibly exhaled during the first second of expiration; 3. the ratio of $FEV_{1.0}$ to FVC; and 4. Forced Expiratory Flow (MMEF) - the average flow of air while exhaling. The PFT computer component recorded the flow-volume curves and analyzed them according to calculated predicted values, based upon the individual's age, height, sex and race. Results were calculated based upon the "best" test results from a minimum of three acceptable efforts, where the $FEV_{1.0}$ and the FVC from the two best curves differed by no more than 5%. $FEV_{1.0}$/FVC ratio was calculated based upon the best observed readings, regardless of which tracing they were selected from.

In interpreting the test results, pulmonary function is considered "normal" if the $FEV_{1.0}$ and the FVC are each 80% or more of the values predicted for an individual, and if the $FEV_{1.0}$/FVC ratio is 70% or more of the predicted value. The MMEF result is less predictable than the other two tests and is typically used to measure and compare changes in lung function over time. Predicted normal lung function values used in NIOSH Health Hazard Evaluations are derived from Knudson et al, 1976[1]

V. RESULTS

A. Environmental

Environmental sampling conducted by the Michigan Department of Public Health on air, leaves, weeds, soil, and extensive surfaces were negative for methylene chloride and other solvents as well as malathion and other pesticides.

Samples of runoff water taken at the site detected malathion and chlordane in low parts per million (ppm) ranges. Records obtained from the company, by the Michigan State Fire Marshal's office, revealed the types and quantities of chemicals stored at the warehouse at the time of the fire. The inventory of chemicals is presented in Table I below. Although chlordane was found in the samples of runoff water, the company denied that chlordane was stored on the site.

TABLE I

INVENTORY OF CHEMICALS STORED AT MICHLIN DIAZO PRODUCTS CORP.
HAMTRAMCK, MICHIGAN
AUGUST 1984

CHEMICAL	QUANTITY
Aqua Ammonia	10,000 gal
Anhydrous Ammonia	3,000-5,000 lbs
Citric Acid	2,000-3,000 lbs
Stannous Chloride	50 gal
Phosphoric Acid 35% liquid - 75%	1,000 gal
Carbon Dioxide	500 lbs
Dyes (red, green, blue)	Small Amounts
Defoamer	5 gal
Surfactant/Sycol	300-400 gal
Diazinon	1 gal
Methoxychlor (20 drums - 25% liquid)	2,000 lbs
White Oil (used with Methoxychlor)	100 gal
Malathion	200 gal
Ethyl Alcohol	1 gal
Methyl Alcohol	200 gal
Paint Thinner	1 qt
Dipona	1 gal
Mineral Spirits	50 gal

B. Medical

Approximately 200 fire fighters and other rescue personnel involved with the Michlin Diazo fire were eligible to participate in the survey. Subsequent members of the study population were self-selected.

The study participants included 136 fire fighters, 7 medical response workers, 1 policeman, and 1 other worker. For the purposes of the data presented in this report, only the data on male fire fighters will be used (eliminating the data on the 9 non-fire fighters and on one female fire fighter). This final group thus includes 135 fire fighters. Some participants did not answer certain questions on the questionnaire; thus, for some data analyses or presentations, less than 135 respondents will be included.

Demographic information on the fire fighters is presented in Table II. Most of the participating fire fighters were from Detroit, and represented a wide range of ages and seniority averaging over fifteen years in the fire service. These participants spent an average of nearly six hours at the fire scene (range 1.25 to 26 hours) with more time being spent by Hamtramck fire fighters (average 13 hours) compared to the other fire departments (average 4.2 hours).

A number of ways of characterizing exposure at the fire scene were evaluated including time spent at the fire, job at the fire scene, respirator use, and time spent with limited visibility due to smoke while not wearing a respirator ("During the time you were not using a respirator how long were you exposed to such high levels of smoke or fumes that you could not easily see a person or large object 10 feet away?"). Nearly all of the fire fighters did not wear a respirator for any appreciable time during the fire. Only six reported wearing a respirator for more than ten minutes. Therefore, time spent at fire and time spent with reduced visibility were used to distinguish degrees of smoke exposure for the fire fighters.

Respiratory and other symptoms were reported by a large proportion of the participants (Table III). Nearly half reported nose and throat irritation lasting more than six hours after the fire. Cough and shortness of breath were also reported by a large number of participants. A considerable number of participants reported that these symptoms were persisting at the time of the survey. Persistent cough, shortness of breath, and nose and throat irritation were reported by 17%, 15%, and 14% of the participants respectively. Time spent at the fire scene and time spent in heavy smoke were significantly associated with the occurrence of these symptoms, particularly the respiratory symptoms (see Table III). Age of the participant and cigarette smoking were not significantly associated with these symptoms.

These symptoms were also compared with the presence of these symptoms prior to the time of the fire. Fifteen fire fighters (17.2%) reported the development of a morning cough since the fire. Fire fighters who spent more than six hours at the fire scene were more than twice as likely to have developed a persistent cough ($p < .05$ Chi square). The development of persistent shortness of breath (which was not apparent prior to the fire) showed a similar relationship with time spent at the fire and with time spent in dense smoke. These findings support the conclusion that most of the reported symptoms developed after the fire in fire fighters without these symptoms prior to the fire and that degree of exposure at the fire contributed to the occurrence of these symptoms.

The pulmonary function testing was not conducted to evaluate acute problems resulting from exposure at this fire. The lack of baseline testing data precludes their use for this purpose. While most fire fighters showed good pulmonary function test results, 14 (10.6%) had abnormal test results. These included 10 with evidence of obstructive lung disease, 3 with restrictive lung disease, and one with a mixed restrictive/obstructive pattern.

TABLE II

DEMOGRAPHIC AND JOB INFORMATION ON PARTICIPATING MALE FIRE FIGHTERS

	Number	Percentage
RACE:		
White	108	81.2
Black	25	18.8
AGE:		
20-29	17	12.6
30-39	62	58.5
40-49	34	25.2
50 or older	22	16.3
FIRE DEPARTMENT:		
Detroit	103	76.3
Hamtramck	26	19.3
Highland Park	6	4.4
YEARS FIRE FIGHTING:		
0-9	31	23.3
10-19	67	50.4
20-29	20	15.0
30 or more	15	11.3

TABLE III

SYMPTOMS REPORTED BY PARTICIPATING FIRE FIGHTERS

SYMPTOM	NUMBER	PERCENTAGE
For more than six hours after fire:		
Wheezing	19	16.5[a]
Cough	44	38.6[a,b]
Shortness of breath	30	26.5[a,b]
Nose and throat irritation	56	46.7[a,b]
Skin rash	18	14.9
Numbness or tingling	11	9.1
Dizziness or nausea	18	14.9[a]
Since the fire:		
Other Symptoms	26	22.0
Sought medical attention	9	7.6
Continuing at the time of survey:		
Wheezing	7	6.4[b]
Coughing	17	14.9[a,b]
Shortness of breath	15	13.3[a,b]
Nose and throat irritation	14	11.5
Skin rash	6	5.0
Numbness or tingling	4	3.7
Dizziness or nausea	3	2.6

[a]Statistically significant increase for fire fighters who spent more than 6 hours at the fire

[b]Statistically significant increase for fire fighters who spent 0.5 hours or more in dense smoke without a respirator.

VI. DISCUSSION

The high incidence of respiratory and other symptoms among these fire fighters is similar to that found in other NIOSH studies of fire fighters after large fires involving chemicals.[2,3] Although the relationship of these symptoms to longer term health effects is unclear, the occurrence of symptoms does point out the need for better protection for fire fighters responding to these types of incidents.

VII. RECOMMENDATIONS

1. Because fire fighters are exposed to many hazardous materials during routine fire fighting and hazardous materials incidents, a program of routine medical surveillance should be established. The basic elements of this program should include;

   a. Examination - The baseline examination should begin with a complete medical history and physical examination. Primary focus should be on the pulmonary and cardiovascular systems, but other organ systems should also be assessed as should risk factors for cardiac and pulmonary diseases (e.g., cigarette smoking, family history, etc.)

   b. Pulmonary Function - Pulmonary function testing is also very important due to hazards from smoke and and 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.

   c. Chest X-ray - Although not advisable for routine periodic screening, baseline chest x-rays can be helpful for later follow-up, should pulmonary injury occur.

   d. 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.

   e. Blood and Urine Testing - Routine blood and urine testing (CBC, urinalysis, liver function tests, etc.) may be useful for detecting individuals with specific problems such as diabetes or elevated lipid levels. Such testing is more important for hazardous materials response workers who are more likely to be exposed to hazardous chemicals. Baseline testing (e.g. liver function tests) may be useful in evaluating these fire fighters after a significant chemical exposure.

f. 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.

g. Special Tests - For individuals with abnormalities on the other tests outlined above, or as indicated by their medical history, further testing may be necessary. In addition , hazardous materials response workers may require some special testing. For example, if they often respond to incidents involving pesticides, baseline cholinesterase levels may be useful for comparison with later tests should they be exposed to a pesticide spill.

h. Periodic Testing - 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. For hazardous materials response workers, examinations should occur at least every year and more often if indicated after significant exposures at several incidents.

2. Fire fighters often face serious exposures when responding to hazardous materials incidents because they lack appropriate protective equipment. In order to prevent fire fighters from receiving undue exposures during these types of incidents, a hazardous materials response team should be established. The basic minimum elements for establishing such a response team must include;

a. Comprehensive training for all team members and routine practice drills.

b. State-of-the-art personal protective equipment

c. Protocols for addressing decontamination issues.

d. Industrial hygiene/environmental sampling capability.

e. coordination with other agencies involved in emergency/disaster response.

VIII. REFERENCES

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:

Kern E. Anderson
Public Health Advisor/Epidemiologist
Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies

James M. Melius, M.D., Dr. P.H.
Director
Division of Surveillance, Hazard Evaluations and Field Studies

Field Assistance:

Richard Ehrenberg, M.D.
Hazard Evaluations and Technical Assistance Branch

Marion Coleman
Health Technician
Support Services Branch

James Collins
Health Technician
Support Services Branch

Originating Office:

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies

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1. International Association of Fire Fighters Union (Rich Duffy)
2. Detroit Fire Fighters, Detroit, Michigan
3. Hamtramck Fire Fighters, Hamtramck Michigan
4. OSHA, Cincinnati Region
5. NIOSH Cincinnati Region

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