

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT
HE 79-19-740

RADFORD ARMY AMMUNITION PLANT
HERCULES INCORPORATED
RADFORD, VIRGINIA

September 1980

I. SUMMARY

In November 1978 the National Institute for Occupational Safety and Health (NIOSH) received a request from an authorized representative of employees at the Radford Army Ammunition Plant in Radford, Virginia to evaluate employees' exposures to various substances used in the plant. Employees' exposures were reportedly resulting in an increased incidence of heart disease, high blood pressure and respiratory disease.

The NIOSH evaluation of employee exposures was based on a review of the results of environmental samples collected by OSHA on February 6-23, 1979 and June 18, 1979. Environmental samples were collected for ethyl ether, n-butyl acetate, acetone, ethanol, nitroglycerin, coal dust, lead, coal tar pitch volatiles and dinitrotoluene.

Ethyl ether concentrations were found to range from 90-712 ppm. Five of the thirteen samples collected exceeded the permissible exposure level (PEL) of 400 ppm. Three samples taken for n-butyl acetate had concentrations ranging from 28-90 ppm (PEL - 200 ppm). Acetone levels on three samples ranged from 55 to 174 ppm (PEL - 250 ppm). Ethanol exposures ranged from 121 - 353 ppm (PEL - 1000 ppm). Nine samples collected for nitroglycerin showed concentration from non-detectable to 0.89 mg/M³ (PEL - 0.1 mg/M³). Coal dust concentrations were found to range from 0.17 to 0.78 mg/M³ (PEL - 2 mg/M³) and lead levels from non-detectable to 0.063 mg/M³ (PEL - 0.05 mg/M³). Two samples for coal tar pitch volatiles had concentrations of non-detectable and 0.1 mg/M³ respectively (PEL - 0.1 mg/M³). Four samples for dinitrotoluene showed levels from 0.3 to 0.9 mg/M³ (PEL - 1.5 mg/M³).

The medical interviews and record review revealed several cases of previously diagnosed asbestosis and heart disease.

Based on the environmental sample results, NIOSH determined that a potential health hazard exists as a result of employees' exposures to ethyl ether, nitroglycerin, lead and coal tar pitch volatiles. Recommendations to help alleviate these hazards are found on pages 9 & 10 of this report. A more complete evaluation of the occupational health hazards at Radford Army Ammunition Plant will be made available when the current NIOSH mortality study at that plant is complete.

Keyword: SIC 3483 (Ammunition)

II. INTRODUCTION

Under the Occupational Health Act of 1970*, NIOSH investigates the toxic effects of substances found in the workplace. On November 7, 1978, NIOSH received a request from Local 3-495, Oil Chemical and Atomic Workers International Union, AFL-CIO for a health hazard evaluation of all manufacturing, storage, laboratory and maintenance buildings and worksites at the Radford Army Ammunition Plant. The request alleged exposure to nitroglycerin, lead, isocyanates, asbestos and other chemical substances in the manufacturing of munitions, resulting in concern about the toxicity of these materials because of an increased incidence of heart disease, high blood pressure and respiratory disease.

III. BACKGROUND

A. Plant Process/Conditions of Use

The major mission of this installation is the manufacturing and maintenance of ammunition and explosive propellants. This includes the production, surveillance, renovation, demilitarization, storage and shipment of propellants, and the manufacture of nitric acid, nitrocellulose, and nitroglycerin.

Nitrocellulose Process

Processed wood or cellulose cotton are chopped into approximately 1/8 inch pieces. These materials go to a drier and then to a beater (Jordan Mill). This material then is transferred to the poacher house where it is neutralized with soda ash, back to a drier and then to the nitrating house where it is mixed with an acid. This material then passes to a wringer where the excess acid and water are removed.

Nitroglycerin

Nitroglycerin is manufactured from nitric-sulfuric acid and water. Plasticizers and triacetin are added. All moisture in excess of 3 percent of total weight is removed.

*Section 20(a) (6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 699(a) (6), authorizes the Secretary of Health, Education, and Welfare, following a written request by 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.

Solvent Process

Solvents, plastics and stabilizers are mixed with nitrocellulose. This material then goes to a preblocker, final press, cutting machine and then to a lathing and drilling operation. Water is used as a coolant during machine operations.

Solvent Recovery

The excess solvents are recovered by fractional distillation.

Solventless Propellants Process

Nitrated cellulose is mixed with nitroglycerin and other chemicals. This material is then converted into increments which are used in mortars.

TNT Process

This operation has not been done for the past three years, however, it basically consisted of nitrating toluene, purifying, finishing, and loading.

All operations at the present time are done on a batch process, however, conversions are being made to have a continuous process. Identical operations can be done in more than one building with anywhere from 2-5 employees.

The final products are Single phase - nitrocellulose, Double phase - nitrocellulose and nitroglycerin, Triple phase - nitrocellulose, nitroglycerin and nitroguanidine.

IV. EVALUATION DESIGN AND METHODS

On January 28, 1979 NIOSH and OSHA personnel met to discuss the agencies individual activities at the Radford Army Ammunition Plant. NIOSH representatives were informed that after repeatedly being denied entrance into the facility, a Memorandum of Understanding between the Secretary of Labor and the Secretary of the Army had been drawn up and that OSHA was scheduling extensive sampling at the plant in February, 1979. Rather than duplicating sampling efforts, the NIOSH industrial hygienist decided to conduct a walk-through survey of the plant, observe the OSHA sampling techniques and conduct a review of the OSHA environmental results. The necessity for any NIOSH environmental sampling would be decided once the OSHA study was complete.

On February 9-11, 1979, the NIOSH industrial hygienist made a visit to the Radford Army Ammunition Plant to observe OSHA environmental sampling procedures. OSHA conducted environmental sampling at the facility from February 6-23, 1979. Samples were collected for ethyl ether, n-butyl acetate, acetone, ethanol, nitroglycerin, coal dust, lead, coal tar pitch volatiles and dinitrotoluene. The sampling and analytical

procedures used are presented in Table 1. (Insufficient sample volumes were collected for nitroglycerin analyses during the February 6-23, 1979 inspection by OSHA. Sampling for nitroglycerin was repeated on June 18, 1979).

During the week of March 19-23, 1979 NIOSH representatives again visited the plant. A walk-through survey of the plant was conducted. The flow of materials was followed and areas were identified where OSHA had collected environmental samples. The presence and design of local exhaust ventilation and work procedures were noted.

B. Medical

A limited plant walk-through inspection was made on March 20, with both management and labor representatives. A visit was made to the Clinic where the NIOSH representatives met the Medical Director. It was ascertained from him that no recent excess of cardiovascular and/or respiratory disease among the work-force was apparent. This statement was confirmed by union representatives and employees.

The number of employees restricted, on health grounds, from work in specific areas has averaged 10% of the work-force. Any employee with a cardiovascular abnormality is restricted from working in the nitroglycerin area. Employees are also restricted from exposure to other toxic substances depending on their disability.

Pre-placement physical examinations are performed to ensure proper selection of the applicant for the work in which they will be involved. The pre-employment examination includes a personal and family history, audiometry, tonometry, vision test, chest X-ray, vital capacity with FEV-1, 2 and 3, urinalysis, CBC, blood chemistry profile if over 40 years of age, electrocardiogram with exercise (9 minutes treadmill stress test if exposed to nitroglycerin) and physical examination by plant physician.

Health evaluation examinations were also done on an annual basis, which includes the above tests. Treadmill stress tests are also performed on special supervisory personnel, fire-fighters and security guards. Although lagging with asbestos was discontinued four years ago, asbestos exposure still occurs, particularly to insulators. These employees have been issued air-supplied respirators for the past 4 years. All employees, both past and present, potentially exposed to asbestos have pulmonary function tests performed every 3 months, and chest X-rays every 6 months. Employees exposed to "cellulose cotton" also have these examinations at the same intervals of time although it has never been documented that this exposure leads to permanent lung damage.

Blood lead determinations are carried out on lead-burners quarterly and those exposed to this chemical in production areas semi-annually. This test is performed more frequently if indicated. The employee is

transferred from lead exposure if his blood-lead exceeds 60 ug/100 g blood.

Special tests are performed on all employees exposed to potentially toxic substances in their employment. The frequency and scope of these checks are established by the Medical Director based on the type and degree of exposure. If an employee has any cardiac or respiratory disability, he is evaluated with respect to the wearing of a respirator.

Employees returning to work after periods of absence in excess of three days, due to injury or illness are examined to ensure that the employee's condition is such that he will not be a hazard to himself or others.

The occupational health clinic is equipped to very high standards, and is staffed by the Medical Director, one part-time physician, a head nurse and seven staff nurses, two clinical technicians and two X-ray technicians. The dispensary operates three shifts seven days a week; one nurse is present at the clinic on the 4 p.m. - 12 shift, and the midnight to 8 a.m. shift, and on all shifts on weekends. A physician is available for emergencies.

Annual medical records have been maintained on all employees since the plant went into operation in 1941, until the present, amounting to approximately 30,000. These records are stored in individual folders, but recently, microfilming has been introduced.

Examples of the medical records of the annual examination were studied, and discussed with the Medical Director.

The NIOSH physician was present, for employee consultation, over the next three days, for the last two hours of the midnight to 8 a.m. shift, the whole of the day shift, and for the first two hours of the 4 p.m. to midnight shift.

Twenty-six employees (25 men and 1 woman) sought consultation on health matters which they believed to be work-related. All but one employee worked on the day shift.

Four of the men completed the form authorizing the release of medical information to NIOSH from their private physicians. These doctors were contacted by letter, and all replied.

C. Epidemiology

The NIOSH epidemiologist reviewed a representative number of medical and personal records to determine their completeness and content. The records were found to be satisfactory for future study.

V. EVALUATION CRITERIA

The environmental evaluation criteria used for this study are presented in Table 2. Listed in Table 2, for each substance, are the recommended environmental limit, the source of the recommended limit, the principal or primary health effects underlying each recommended limit, and the current federal standard.

VI. RESULTS AND DISCUSSION

A. Environmental

1. Ethyl Ether

Thirteen long term (4-8 hrs.) and two short term samples (6-8 minutes) were collected in a) Building 3514, Cutting House (Powder Tray and Cutting Machine Operator) and b) Building 2508, B Line Mix House (Puller and Charger Operator) for ethyl ether. The time weighted averages (TWA) for the long term samples ranged from 90 to 712 ppm of ethyl ether. Five of these samples exceeded OSHA standards in the following areas: Powder Tray, Cutting House, Mix House and Single Base. Two short term samples (6-8 minutes) collected in Building 3509, G Line Propellant Mix House ranged from 1488 to 1721 ppm and exceeded the ACGIH Short Term Exposure Limit (STEL) of 500 ppm.

2. N-Butyl Acetate

Three personal air samples were collected for n-butyl acetate in Building 4924-5. Exposures ranged from 28-99 ppm (TWA). These levels were below the TLV and OSHA standards of 150 ppm.

3. Acetone

Three personal air samples were collected for acetone in Building 4924-5. Exposures ranged from 55-174 ppm (TWA). These levels were below the TLV, OSHA and NIOSH standards.

4. Ethanol

Five personal air samples were collected in Buildings 2500 and 7103-2 for ethanol exposures ranged from 121 to 353 ppm (TWA). These levels were below the TLV and OSHA standards.

5. Nitroglycerin

Thirty personal air samples were collected for nitroglycerin during the period February 6-23, 1979. These samples were collected from the Powder Truck Driver and Buildings 9310-2, Buildings 3509, 3514, 4912-24, 3630, 3637, 7103-2. The samples collected during this period were all non-detected due to an insufficient volume of air sampled. The sampling was repeated on June 18, 1979.

Nine personal and general air samples were collected in the Nitration, Neutralizing House, and Even Speed operations. Concentrations of nitroglycerin ranged from non-detected to 0.89 mg/M³.

Although atmospheric exposures did not exceed OSHA standard, the environmental samples collected at the Even Speed operation exceeded both the TLV and NIOSH recommended standard. Exposure to the Even Speed operators ranged from 0.60 to 0.89 mg/M³.

6. Three personal samples for coal dust were collected in the Dry House (Building 3110) and in Powerhouse #1. Concentrations ranged from 0.17 to 0.78 mg/M³ (PEL - 2 mg/M³). The samples contained no detectable levels of quartz.

7. Coal Tar Pitch

Two samples were collected for coal tar pitch in Powerhouse #1. The two samples had concentrations of non-detectable and 0.1 mg/M³ (PEL - 0.1 mg/M³). The samples were also analyzed for benz(a)pyrene, a suspect carcinogen. No benz(a)pyrene was detected.

8. Lead

Seven personal air and wipe samples were collected for atmospheric lead content in Building 1731, 4718, 2060, and Lunch Room 720. Concentrations ranged from non-detected to 0.063 milligram per cubic meter of air (TWA). The exposure to lead in Building 2060 exceeded OSHA standard.

9. Dinitrotoluene

Four atmospheric samples were collected for dinitrotoluene at the weighing and grinding operations. Analysis of these samples showed that concentrations ranged from 0.3 to 0.9 mg/M³. These values are below the recommended standard for 1.5 mg/M³.

During the walk-through and also as noted in United States Army Environmental Hygiene Agency Survey Report No. 35-0007-38, September 12-21, 1977, the ventilation systems in various buildings were either of poor design or lacking in proper maintenance. In some areas there was a down-draft exhaust which did not appear to sufficiently capture the solvent vapors. In other areas, 180° or acute 90° bends were noted. At a weighing station a hood type exhaust was present which would be conducive in drawing contaminants past the breathing zone of the employee.

Deficiencies in local exhaust ventilation systems were noted in the following areas:

BUILDING 4914
4912-3
4924-5
3513
3514
3508
1733
A3524

B. Medical

It was ascertained from union representatives, individual employees, and management, that there had been no recent increase in the reporting of cardiovascular and/or pulmonary disease.

Of the twenty-six employees who sought consultation, three of them had been diagnosed as suffering from asbestosis. One of them showed marked progression although he had been restricted from asbestos exposure for more than ten years. The other two men were diagnosed on annual chest X-rays, and pulmonary function testing, last year, and showed minimal changes. Two of the men had been moderate-to-heavy cigarette smokers in the past. These men, with another three employees with pleural plaques but no discernible lung involvement are restricted from further asbestos exposure.

For the past four years, all employees potentially exposed to asbestos from pipes previously lagged with this substance have worn air-supplied respirators.

Of the seven employees with symptoms and/or signs of cardiovascular disease, the two workers who had suffered myocardial infarction had no work history of nitroglycerin exposure. Of the three workers complaining of angina, two had developed this symptom while currently exposed to nitroglycerin and one more than one year after cessation of exposure. The hypertensive worker had no history of nitroglycerin exposure, while arteriosclerotic heart disease was diagnosed in one employee while he was currently exposed to this chemical. All are restricted from further exposure to nitroglycerin.

Of the six employees complaining of cardiovascular disease (two with a history of myocardial infarction, two with angina, one with a diagnosis of arteriosclerotic heart disease, and one with hypertension); four employees gave histories of nitroglycerin exposure.

Another six employees complained of shortness of breath on exertion. One was obese, with the diagnosis of chronic bronchitis, and one was an asthmatic. A brief Medical Research Council (MRC) respiratory

questionnaire was administered to the remaining four with negative results. These four men had had pulmonary function tests performed, with chest X-rays, for some years, with no abnormal results. They were apprehensive about developing asbestosis, as were three other symptomless employees who attended the clinic for informational purpose. One of these employees expressed anxiety about the possibility of developing byssinosis after exposure to cellulose cotton. He was informed that, in light of current knowledge, no such association exists.

The remaining eight employees had symptoms and/or signs of non-work-related diseases.

Of the four private physicians who were contacted by letter, three replied that their patients had not sought consultation on any work-related disease. The fourth doctor had under his care one of the two workers diagnosed last year as suffering from asbestosis, and stated that there had been no significant changes in pulmonary function, or chest X-rays since then. The NIOSH physician has written to these four employees.

A more complete evaluation of occupational medical problems will be determined by the current NIOSH mortality study at that plant.

VII. RECOMMENDATIONS

1. An education program should be established for all employees. The program should delineate symptoms, handling procedures, proper protective equipment and personal hygiene. The program should be repeated periodically.

2. The employer should provide a daily change of clean work clothing intended to minimize access of dust to the skin of employees in areas where nitroglycerin or ethylene glycol dinitrate are present. Work clothing shall be changed immediately when soiled with liquid nitroglycerin.

Rubber or plastic gloves with a cotton lining, or plain cotton gloves should be provided for employees who may have skin contact with nitroglycerin. The gloves should be changed at least daily.

3. Employees should be allowed sufficient time to remove contaminated clothing and wash prior to eating or leaving work.

4. The respirator program should be reviewed. Section 1910.134 of OSHA, Respiratory Protection, outlines the minimal acceptable program.

5. General work practices should be improved. For example: In Building A3524 when the employee has to transfer the material from large drums into bags, it is necessary for him to reach down into the

drum to remove the material for weighing. Unnecessary exposure would be eliminated by either purchasing material in smaller lots or tilting the drum to remove the material.

6. An evaluation of all exhaust systems should be made by an experienced industrial ventilation engineer to ascertain that the systems are operating at maximum efficiency and the design conformed with established industrial ventilation principles. The design of some systems showed more concern with the explosability factor than employee exposure.

7. A periodic maintenance program should be established for all local exhaust systems.

8. Insulation with asbestos was discontinued about 3 years ago. At the present time exposure occurs during pipe removal. A standard operating procedure should be established for all employees who handle asbestos. These procedures should encompass those recommendations contained in NIOSH Revised Criteria for a Recommended Standard . . . Occupational Exposure to Asbestos⁹.

9. Employees who are occupationally exposed to NG shall be counseled so that each is aware that headache, dizziness, palpitations, and nausea are symptoms of overexposure, that these symptoms usually become worse when alcohol is used, and that some of these symptoms may disappear with continued exposure as tolerance develops. Employees shall be warned that symptoms, such as headache, palpitations, and chest pain, can occur particularly on weekends, on holidays, or at the beginning of the work week, as a result of interruption of exposure to NG. They shall be advised to consult a physician promptly if they experience such symptoms. All nitroglycerin workers should have the comprehensive physical examination giving particular attention to the heart and circulatory systems, the central and peripheral nervous systems, and the skin performed semi-annually, and more often if indicated by the responsible physician.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENTS

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IX. REFERENCES

1. OSHA Safety and Health Standard, (29 CFR 1910), U.S. Department of Labor, 1978.
2. NIOSH Criteria for a Recommended Standard . . . Occupational Exposure to Nitroglycerin and Ethylene Glycol Nitrate, Publication No, 78-167, June 1978.
3. American Conference of Governmental Industrial Hygienist, Threshold Limit Values for Chemical Substances in Workroom Environments for 1979.
4. NIOSH Manual of Sampling Data Sheets, 1977 Edition, U.S. DHEW, PHS, CDC, NIOSH (77-159).
5. NIOSH Criteria for a Recommended Standard . . . Occupational Exposure to Coal Tar Products, No. 78-107, September 1977.
6. Occupational Diseases: A Guide to their Recognition, U.S. DHEW, PHS, CDC, NIOSH, Publication No. 77-181, Revised June 1977.
7. Industrial Hygiene Toxicology, Frank A. Patty, July 1967.
8. NIOSH Criteria for a Recommended Standard . . . Occupational Exposure to Inorganic Lead. Publication No. 78-158, Revised Criteria 1978.
9. NIOSH Revised Recommended Asbestos Standard, December 1976.

X. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this report are available from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability can be obtained from the NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

- A.) COR Staff, Commander, Radford Army Ammunition
- B.) General Manager, Hercules Incorporated Army Ammunition
- C.) DRSAR-SF, Rock Island Arsenal
- D.) President, Local 3-495, OCAW
- E.) OCAW International Union
- F.) U.S. Department of Labor - Region III
- G.) NIOSH - Region III

For the purpose of informing the approximately 1700 "affected employees," the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

TABLE 1
AIR SAMPLING AND ANALYSIS METHODOLOGY

<u>SUBSTANCE</u>	<u>COLLECTION DEVICE</u>	<u>ANALYSIS</u>	<u>REFERENCES</u>
Ethyl Ether	Charcoal Tube	Gas Chromatography	NIOSH S 80
n-Butyl Acetate	Charcoal Tube	Gas Chromatography	NIOSH S 47
Acetone	Charcoal Tube	Gas Chromatography	NIOSH P&CAM 127
Ethanol	Charcoal Tube	Gas Chromatography	NIOSH S 56
Nitroglycerin	Sorption on Tenax - GC	Gas Chromatography	NIOSH P&CAM 203
Coal Dust	AA Filter	Gravimetric	
Lead	AA Filter	Atomic Absorption	NIOSH P&CAM 173
Coal Tar Pitch	Glass Fiber Filter Silver Membrane Filter	Benzene Extraction	NIOSH P&CAM 217
Dinitrotoluene	AA Filter Ethylene Glycol Impinger	High Pressure Liquid Chromatography (HPLC)	NIOSH S 215

10/11

TABLE 2

ENVIRONMENTAL EVALUATION CRITERIA

<u>SUBSTANCE</u>	<u>RECOMMENDED ENVIRONMENTAL LIMIT</u>	<u>SOURCE</u>	<u>PRIMARY HEALTH EFFECTS</u>	<u>OSHA STANDARD</u>
Ethyl Ether	400 ppm	OSHA	Mucous membrane irritation, narcosis	400 ppm
n-Butyl Acetate	150 ppm	OSHA	Mucous membrane irritation, narcosis, dermatitis	150 ppm
Acetone	250 ppm	NIOSH	Mucous membrane irritation, narcosis, dermatitis	1000 ppm
Ethanol	1000 ppm	OSHA	Mucous membrane irritation, dermatitis	1000 ppm
Nitroglycerin	0.1 mg/M ³ (20 minute ceiling)	NIOSH	Headaches, heart effects	2 mg/M ³
Coal Dust	2 mg/M ³	TLV	Pneumoconiosis	2.4 mg/M ³
Lead	0.05 mg/M ³	OSHA	Abdominal discomfort, anemia, weakness of wrist and ankle muscles, kidney damage	0.05 mg/M ³
Coal Tar Pitch	0.1 mg/M ³	NIOSH	skin and lung cancer	0.2 mg/M ³
Dinitrotoluene	1.5 mg/M ³	OSHA	anoxia, anemia, liver damage	1.5 mg/M ³

All air contaminants are time weighted average (TWA) exposures for a normal work day of a 40 hour workweek unless designated ceiling. A ceiling limit is one which should not be exceeded at anytime.