NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2004-0239-3014
MK Ballistic Systems
Hollister, California

September 2006

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (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 (OSHA) 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 employers 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.

HETAB also provides, upon request, technical and consultative assistance 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. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Steven Lee, Yvonne Boudreau, and Christine West of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Austin Sumner of the California Department of Health. Analytical support was provided by DataChem Analytical Services. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

Copies of this report have been sent to employee and management representatives at MK Ballistic Systems and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. The report may be viewed and printed from the following Internet address: http://www.cdc.gov/niosh/hhe. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Highlights of the NIOSH Health Hazard Evaluation

This NIOSH Health Hazard Evaluation (HHE) was requested by management at MK Ballistic Systems in Hollister, California. In August 2004, we investigated management concerns about the possibility that exposure to silver iodide could be a cause of thyroid disease in workers.

What NIOSH Did

- We visited MK Ballistic Systems to evaluate exposure to silver iodide.
- We collected air samples for flare materials, including silver iodide, aluminum, magnesium, and strontium.
- We interviewed employees and reviewed their medical records and medical histories.

What NIOSH Found

- Exposure to flare materials was below all workplace exposure limits.
- Employees had thyroid conditions not likely related to working at this facility.
- The worker who mixed the highly combustible flare materials used good work practices and protective equipment to prevent injuries from accidental fires and explosions.

What MK Ballistic Managers Can Do

- Continue to ensure that employees who handle highly combustible materials are thoroughly trained and supervised in using good work practices and protective equipment.
- Provide workers with gloves that are effective in preventing skin contact with flare materials.
- Ensure that employees with possible work-related health problems are evaluated by a physician, preferably one familiar with occupational conditions.

What MK Ballistic Employees Can Do

- Always use the most careful work practices and protective equipment (e.g. blast shields, fire suits, and conductive plastic bags) when handling highly combustible materials.
- Wear gloves to prevent skin contact with flare materials.
- Report any health problems that you think might be work-related to your employer.

What To Do For More Information:

We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2004-0239-3014

Health Hazard Evaluation Report 2004-0239-3014
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SUMMARY

In May 2004, the owner of MK Ballistic Systems, Hollister, California, requested that NIOSH evaluate potential exposure to silver iodide during the manufacturing of cloud-seeding flares to determine if this exposure could be a cause of thyroid disease in two employees.

Since 1991, the company has employed nine workers to manufacture flares; however, production was stopped in July 2003, due to concerns about exposure to silver iodide. During the NIOSH visit in August 2004, 28 flares were produced by two employees to enable NIOSH investigators to evaluate exposure to flare components. The flare composition is a pyrotechnic mixture of metal powders and oxidizers containing silver iodide, strontium nitrate, potassium perchlorate, aluminum powder, and magnesium powder. One worker ("blender") combines these powders with a polyester resin, and the other worker ("presser") packs the mixture into paper tubes to finish producing the flare.

The blender had a personal breathing-zone airborne concentration of 0.38 mg/m^3 of silver iodide, and the presser was exposed to 0.01 mg/m^3. No occupational exposure limits have been developed for silver iodide. Silver iodide is a non-soluble compound; therefore, the more protective evaluation criteria for silver metal, soluble silver compounds, and iodine are not applicable. Exposures to aluminum, magnesium, and strontium in both workers were well below their evaluation criteria.

Three of the nine employees were interviewed. Review of their medical records revealed no association between their diagnosed medical conditions and their exposures at MK Ballistics Systems. While there was concern that exposure to silver iodide might precipitate thyroid disorders, our evaluation did not find high exposures. In addition, there is no evidence in the medical literature that exposure to iodide compounds is related to the development of the specific thyroid disorders found in the workers.

NIOSH investigators concluded that there were no health hazards from exposure to flare components among employees at MK Ballistics Systems. The thyroid disorders confirmed in two employees are not uncommon and could not be associated with occupational exposures at this facility.

Keywords: NAICS 2819, (Industrial Inorganic Chemicals) silver iodide, aluminum, magnesium, strontium cloud,-seeding flares, Hashimoto's thyroiditis, thyroid nodules.

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INTRODUCTION

In May 2004, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from the owner of MK Ballistic Systems, Hollister, California. The owner wanted to know whether exposure to silver iodide during the production of cloud-seeding flares could be a possible cause of two cases of thyroid disease among employees.

In August 2004, NIOSH investigators conducted an environmental and medical evaluation of workers manufacturing cloud-seeding flares. Exposure to silver iodide, aluminum, magnesium, and strontium was assessed, and employee interviews were conducted.

BACKGROUND

MK Ballistic Systems employs workers to manufacture "less lethal impact munitions," such as bean-bags and rubber projectiles, for law enforcement. They also have occasionally filled contracts to manufacture cloud-seeding flares. Since the opening of the facility in 1991, they have employed nine employees: five blenders and four pressers. The company stopped manufacturing flares in July 2003, due to concerns about possible exposure to silver iodide. In order to measure workers' exposure to flare chemicals during the NIOSH site visit, one blender and one presser produced two batches of 14 flares to recreate the process that had been used in the past.

When blended, the flare composition is a pyrotechnic mixture of metal powders and oxidizers that presents a potential fire hazard. The flares are produced in a 22 foot x 8 foot trailer that is separated from the other work buildings. It has a door at each end to provide natural dilution ventilation.

The blender starts by weighing about 3200 grams of strontium nitrate and removing lumps with a 20 mesh screen. The same is done with 360 grams of potassium perchlorate and 430 grams of silver iodide. These powders are placed in a conductive plastic bag and manually tumbled and kneaded until the mixture appears uniform. Then, 270 grams of aluminum powder and 500 grams of magnesium powder are mixed in a conductive plastic bag. The blender dons an aluminized fire suit and pours the mixed metal powders into the bag with the oxidizers and silver iodide and thoroughly blends the materials. The mixture is carefully poured into a stainless steel pan positioned behind a Plexiglas® blast shield. Then, 280 grams of a polyester resin, containing styrene, is mixed with 4 milliliters of a hardening catalyst (methyl ethyl ketone peroxide) and this mixture is added to the mixed powders and blended by the operator, who wears latex gloves.

The presser takes small cupfuls of the flare mixture and pours them into paper phenolic tubes. An aluminum rod and hammer are used to make sure that each tube is thoroughly packed.

METHODS

Environmental

On August 24, 2004, the NIOSH investigators conducted an evaluation of worker exposure to airborne silver iodide, strontium, magnesium, and aluminum. Personal breathing zone (PBZ) air samples were collected on mixed cellulose ester filters at a flow rate of 2.5 liters per minute and analyzed for metals by inductively coupled plasma emission spectroscopy, according to NIOSH Manual of Analytical Methods (NMAM) 7303[1] Exposure to silver iodide was calculated by multiplying the silver concentration by the

molecular weight of silver iodide divided by the molecular weight of silver. PBZ air samples were collected from each of the two workers while they produced two batches of flares.

Medical

Since the opening of the facility in 1991, MK Ballistics Systems has employed nine employees: five blenders and four pressers. Prior to the NIOSH site visit, the president of the company invited current and former employees to participate in private interviews with NIOSH personnel. Three employees volunteered and were privately interviewed by NIOSH medical officers. Medical records, provided by one of the interviewed employees, were reviewed.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects, even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects, even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and this potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[4] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever is the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or likely to cause death or serious physical harm. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits, such as PELs. Even in the absence of a specific OSHA PEL, an employer is still required by OSHA to protect their employees from hazards.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Silver Iodide

No occupational exposure limits have been developed for silver iodide. Silver iodide is a non-soluble compound not likely to produce toxic effects from either silver or iodine. Therefore, silver iodide is categorized by OSHA as a particulate not otherwise regulated (PNOR). The OSHA PEL for PNORs is 15

mg/m^3. This is a generic criterion for airborne dusts that do not produce significant organic disease or toxic effects when exposures are kept under reasonable control. ACGIH classifies these substances as "particles (insoluble or poorly soluble) not otherwise specified (PNOS)." ACGIH believes that some PNOSs may produce adverse health effects and recommends that full-shift TWA exposure should be kept below 3 mg/m^3 of respirable particles, and 10 mg/m^3 of inhalable particles until a TLV can be set for the particular substance.[3] An extensive review of the medical literature revealed no evidence that exposure to silver iodide is associated with thyroid abnormalities.

Other Metals

The 8-hour OSHA PEL-TWA for aluminum is 15 mg/m^3, and the full-shift NIOSH REL-TWA and ACGIH TLV-TWA are both 10 mg/m^3. Magnesium and strontium are classified as PNOR and PNOS. The most protective eight-hour TWA exposure limits for magnesium, aluminum, and strontium are listed in Table 1 on page 4.

Abnormalities of the Thyroid Gland

Hypothyroidism

Hypothyroidism refers to a condition in which the amount of thyroid hormone in the body is below normal. This is the most common form of thyroid dysfunction. Large population studies have shown that as many as one woman in 10 over the age of 65 has evidence of hypothyroidism. The most common cause of hypothyroidism is Hashimoto's thyroiditis.[5] It is named after the Japanese physician, Hakaru Hashimoto, who first described it in 1912. Classified as an autoimmune disorder, Hashimoto's thyroiditis causes an autoimmune reaction in which a person's own immune system produces antibodies that attack one's own thyroid gland. This destruction causes hypothyroidism and results in the complete absence of thyroid cells. This can be treated with the administration of thyroid hormone in a prescription drug form. The cause of Hashimoto's thyroiditis is unknown. Autoimmune hypothyroidism, which includes Hashimoto's thyroiditis, occurs in up to four out of 1000 (0.4%) women and one out of 1000 (0.1%) men. About 5% of women experience thyroiditis after pregnancy, and up to 20% of these women develop permanent hypothyroidism 5 to 10 years after delivery. Focal thyroiditis, which involves limited areas of the thyroid gland, has been found in up to 40% of autopsy cases. Risk factors for autoimmune hypothyroidism, such as Hashimoto's thyroiditis, include genetic factors and a diet high in iodine.

Hyperthyroidism

Hyperthyroidism is a condition in which there is too much thyroid hormone.[6] The most common underlying cause of hyperthyroidism is Graves' disease, a condition named for an Irish doctor who first described the condition. Graves' disease occurs in up to two out of 100 (2%) women and approximately two out of 1000 (0.2%) men. Graves' disease is classified as an autoimmune disease, a condition caused by the patient's own immune system damaging the patient's thyroid gland. Graves' disease is most common in people age 30-50 and tends to run in families. Evidence for genetic risk factors for Graves' disease include an increased risk for thyroid disease among siblings and an association with or genetic links to other autoimmune diseases, such as pernicious anemia, Addison's disease, and diabetes mellitus. Possible environmental risk factors include iodine intake, exposure to certain drugs, smoking habits, stressful life events, and a number of infectious agents.[6]

Goiter

A goiter is an enlargement of the thyroid gland. There are different kinds of goiters. A simple goiter usually occurs when the thyroid gland is not able to produce enough thyroid hormone to meet the body's needs. The thyroid gland makes up for this lack by enlarging, which usually overcomes mild deficiencies of thyroid hormone. The modern use of iodized table salt in the U.S. prevents this deficiency. Risk factors

for the development of a goiter include female gender, age over 40 years, inadequate dietary intake of iodine, residence in an endemic area, and a family history of goiter.[6]

Thyroid nodules

Thyroid nodules are quite common; up to 50% of the population will have nodules in their thyroid.[6] They are detected by palpation (touch) in approximately 5% of adults. Most nodules are unrecognized because those smaller than one centimeter in diameter and those deeply embedded in the gland are not likely to be detected by palpation. Fortunately, about 90% to 95% of thyroid nodules are benign (not cancerous).[7,8] Although the cause of most thyroid nodules is unknown, some risk factors for developing nodules include a lack of iodine in the diet, older age, female gender and having had irradiation therapy on the head or neck as a child.[6] Exposure to iodine compounds has not been associated with thyroid nodules.

RESULTS

Environmental

The blender had PBZ airborne concentrations of 0.45 mg/m^3 of silver iodide while mixing the first batch of flares and 0.33 mg/m^3 while mixing the second batch (Table 1). The mean exposure to silver iodide during both batches was 0.38 mg/m^3. The blender wore an Avon Model S-10 military-style gas mask designed for protection against exposure to potential airborne warfare agents, including nuclear, biological, and chemical substances. The presser was exposed to a mean airborne silver iodide concentration of 0.01 mg/m^3 while pressing both batches of flares. Exposure to airborne concentrations of aluminum, magnesium, and strontium among both workers were well below the evaluation criteria.

Table 1: Airborne Concentrations of Flare Components (mg/m^3)

Job	Sample Time	Aluminum	Magnesium	Strontium	Silver Iodide
Blender	0825 - 1025	0.22	0.37	1.2	0.45
Presser	1025 - 1125	ND*	0.01	0.006	0.007
Blender	1230 - 1345	0.37	0.79	1.7	0.33
Presser	1345 - 1440	ND	0.01	0.013	0.013
Evaluation Criteria		10 (NIOSH)	15 (OSHA)	10 (ACGIH)	10 (ACGIH)

* = Below the sampling and analytical limit of detection (< 0.005 mg/m^3)

Medical

NIOSH medical officers interviewed three (33%) of the nine current or former employees; two reported having thyroid problems. One reported having thyroid problems diagnosed prior to beginning work at the facility and the other developed thyroid abnormalities while working there. One employee reported having a hair analysis which reportedly showed significant exposure to silver compounds. One employee provided medical records.

DISCUSSION & CONCLUSIONS

Good work practices while mixing the flare components resulted in the generation of very little visible airborne dust during the NIOSH visit. Exposures to flare components were found to be well below any concentrations known to cause adverse health effects.

Employee interviews and medical record review revealed no information suggesting an association between diagnosed medical conditions and exposures at MK Ballistics Systems. There was employee concern that exposure to silver iodide might precipitate thyroid disorders, but our evaluation did not find high exposures. In addition, there is no evidence in the medical literature that exposure to iodide compounds is related to the development of the specific thyroid disorders found in the interviewed workers.

Hair samples should not be considered representative biological samples, and results of hair sample analyses should not be considered indicative of any specific disease or pathology.[9] While hair samples may be used for certain forensic investigations, the current scientific literature does not support the use of hair analysis as a definitive method for biological exposure assessment in the occupational setting.[10]

RECOMMENDATIONS

1. The results of this investigation show that respirators are not required when working with flare components. OSHA regulations allow the voluntary use of disposable filtering facepiece respirators as long as employees are provided with a copy of OSHA 1910.134 Appendix D – Information for Employees Using Respirators When Not Required under the Standard. The voluntary use of all other types of respirators also requires a written respiratory protection program that addresses the medical fitness of the employee and the proper maintenance of the respirator.

2. Both the blending and pressing workers should avoid skin contact with the flare component mixture by wearing gloves resistant to styrene permeation. Gloves composed of 4-H Silver Shield® and TyChem 9400® are more resistant to styrene than latex.[11]

3. If the production of flares is resumed, safe work practices and protective equipment (e.g., blast shields, fire suits, and conductive plastic bags) should continue to be properly used when handling pyrotechnic mixtures. This is particularly important to stress when training and supervising new employees to mix flare components.

4. Employees should continue to obtain medical care from a health care professional to address thyroid and other medical concerns. All workers should be encouraged to report potentially work-related health problems. Because the work-relatedness of certain health concerns may be difficult to prove, each person with possible work-related health problems needs to be fully evaluated by a physician, preferably one familiar with occupational conditions.

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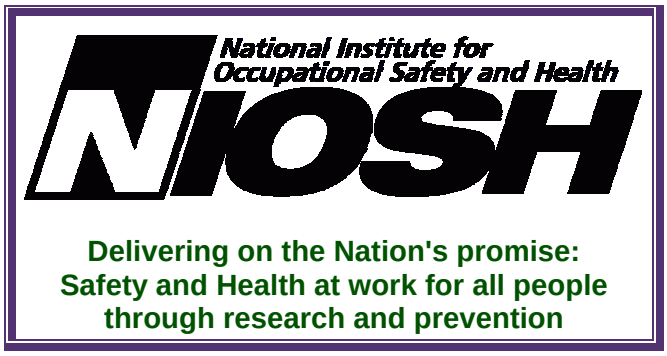

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