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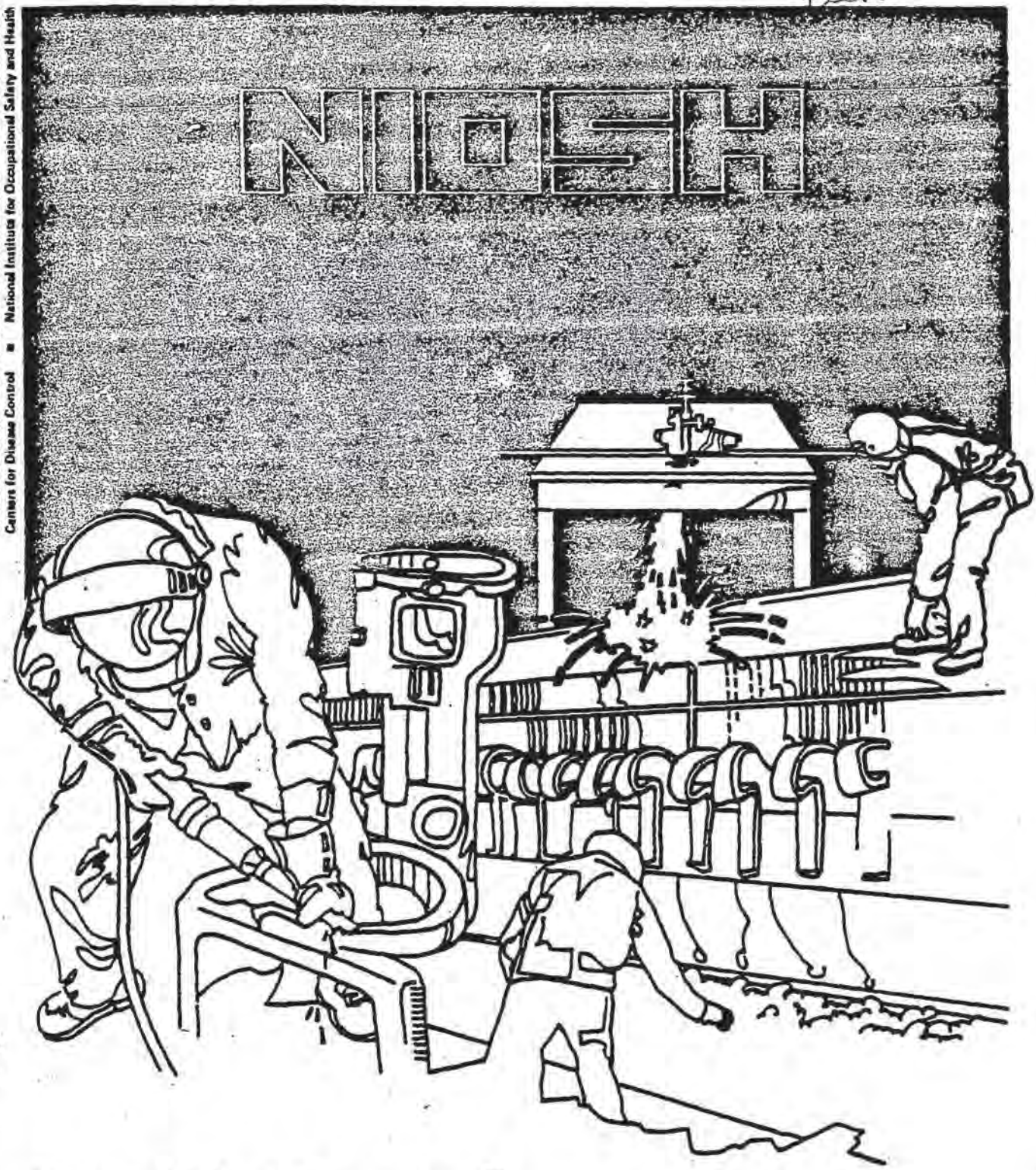

Health Hazard Evaluation Report

HETA 83-186-1628
RAYTHEON MISSILE SYSTEMS DIVISION
BRISTOL, TENNESSEE

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.

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RAYTHEON MISSILE SYSTEMS DIVISION
BRISTOL, TENNESSEE

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I. SUMMARY

In March 1983, the National Institute for Occupational Safety and Health (NIOSH) received a request to investigate a reported outbreak of dermatitis among machinists assigned to the Machine Department's Airframe Workcenter at the Raytheon Company, Missile Systems Division, Bristol, Tennessee. The requesters suspected the dermatitis was caused by worker contact with machine cutting fluids and a solvent identified as "varsol." On July 13-15, 1983, NIOSH investigators visited the plant to observe work practices, collect samples of various cutting fluids for chemical analysis, collect air samples for determination of oil mist and solvent vapor exposures, and to conduct an epidemiologic study to determine the extent of work-related dermatitis prevalent in the Machine Department.

Personal breathing zone air samples for cutting oil mist were collected from machinists operating semi-automatic machines which used a non-soluble cutting oil (Chevron Metalworking Fluid 502 or British Petroleum Sevora 53A). These same operators were also monitored to determine their personal exposures to "varsol" (later identified as mineral spirits) vapors. One lathe operator using a water soluble oil emulsion (Trim® Sol) was monitored for exposure to Trim® Sol mist and mineral spirits. Bulk samples of two types of used and unused cutting oils were analyzed for trace metals. A sample of Trim® Sol was analyzed to determine its organic composition. Questionnaires were administered to workers exposed to various types of cutting oils and metalworking fluids, and to a comparison group of non-exposed workers. Each worker reporting skin problems was given a dermatologic examination by a NIOSH Physician.

Results of the environmental sampling showed workers were not exposed to airborne oil mists or Trim® Sol Mist. Mineral spirits vapor exposures were detected but the levels ranged from about 3 to 22 mg/M^3, well below the NIOSH recommended limit of 350 mg/M^3. Trace metals known to cause skin irritation or sensitization (arsenic and zinc) were detected in bulk samples of both used and unused cutting oils. No chromium or nickel was detected in the oil samples. Chloromethyl phenol (chlorocresol), a compound related to a class of known skin irritants, was found in the Trim® Sol concentrate.

The questionnaire results suggest the prevalence of skin rash was much greater among employees exposed to cutting fluids (36%) than among the unexposed comparison group (12%). From the descriptions and examinations, the skin rashes appeared to be more simple irritant dermatitis than eczema or folliculitis.

Based on the environmental and medical findings, it was determined that a health hazard did exist for workers in the Machine Department from the combined effects of direct skin contact with cutting oils and fluids, biocides, solvents, and metal shavings. No specific agent was identified as the cause of the skin rash problems. Exposures to airborne oil mists or organic vapors were not found hazardous under the evaluated working conditions. General control measures to reduce exposure are contained in the body of this report.

KEYWORDS: SIC 3761 (Guided missiles and space vehicles and parts) dermatitis, cutting oils, Trim® Sol, mineral spirits, varsol

II. INTRODUCTION

On March 11, 1983, NIOSH received a confidential request from three employees who worked in the Machine Department at the Raytheon Missile Systems Division in Bristol, Tennessee. The requesters reported that 3 to 5 workers in this department had recently experienced skin rashes and noted their concern for other adverse health effects from inhalation of solvent vapors. Petroleum based cutting oils and mineral spirits, referred to as "varsol," were suspected by the requesters as the cause of the reported skin rashes. The requesters reported that one worker had been sensitized to varsol as determined from skin patch testing performed by the worker's personal physician. A Raytheon Company representative confirmed that three workers in the Machine Department had experienced problems, but only case one was still active. This worker, although transferred to another job, continued to experience skin problems with other chemicals used in the new work assignment.

On July 13-15, 1983, three NIOSH investigators, a physician, an industrial hygienist, and an epidemiologist conducted an environmental and epidemiological investigation at the Raytheon Machine Department. The study was designed to characterize reported health problems and to evaluate potential exposures for machinists working with petroleum based cutting oils, water soluble metalworking fluids, and solvents. Preliminary findings and recommendations were discussed during a closing conference following the survey, and summarized in a letter to the Raytheon Company Safety Director on August 8, 1983. Copies of this report were provided to the employee requesters. Air monitoring results were provided by telephone on August 22, 1983. The Safety Director's response to the NIOSH preliminary recommendations was received by NIOSH on April 19, 1984.

III. BACKGROUND

The Raytheon Missile Systems Division has operated the Bristol, TN plant since 1953. Originally operated by the Sperry Corp., the plant was taken over by Raytheon in 1956. The building and most of the production machinery is owned by the United States Navy. When NIOSH visited the plant, Raytheon was building the Navy's Sparrow 7M Missile. The plant operated three shifts per day with a work force of about 1076 people.

Upon arrival at the plant, NIOSH investigators found the three most recent dermatitis cases had occurred in the Machine Department's "Airframe Workcenter." According to the company nurse, only 11 cases of skin rash had been reported throughout the plant during the previous 12 months.

About 30 machinists worked in Airframe, with around 50% assigned to the first shift. The Machine Department had 11 other workcenters including Lathe, Drill, and Mills. About 197 employees worked in the Machine Department.

Most of the machining work done in Airframe was the fabricating of the aluminum and stainless steel missile housing components. Much of the work was performed on 6 Milwaukee-matic® machines. These machines were computer controlled. Each movement of the cutting arm was directed by a punched paper tape. The machine operator was only required to mount and dismount the piece being machined. Machining time varied from just under one hour to about 3.5 hours, depending on the size of the piece and the number of functions (boring, drilling, milling, tapping, etc.) the machine was programed to perform.

The petroleum based cutting oils used in the Machine Department were: Chevron Metalworking Fluid 501, 502, 503, 504, and 505; and British Petroleum Sevora 53A. Extreme pressure additives included sulfur (1-2%), chlorine (1-3%), and borate (0-1%) compounds. No biocides were used in these cutting oils.

The metalworking fluid used mostly for machining aluminum was Trim® Sol, a soluble oil emulsion manufactured by the Master Chemical Corporation. Trim® Sol was purchased as a concentrate and mixed with water to solutions of 2-6% depending on the type of machining work performed.

A solvent cleaner known to Raytheon employees as "varsol" later identified as "Rule 66 Mineral Spirits," was supplied by Ashland Chemicals. This solvent was highly refined to reduce its aromatic hydrocarbon content to less than 8%, but according to the supplier, it typically contained less than 3% aromatics. Machinists on the Milwaukee-matic machines used mineral spirits to clean petroleum based cutting oil and metal filings from the finished piece. When machine operations were completed, the piece was removed and dipped in an open topped can, half filled with mineral spirits. The solvent was brushed or poured over the piece and the piece was allowed to drip dry. Compressed air was frequently used to blow off metal filings and excess solvent from the finished piece.

Several of the workers told the NIOSH investigators that some operators had contaminated the cutting oil by cleaning the finished piece with solvent before removing it from the Milwaukee-matic. This work practice was not observed during the NIOSH survey. The company had eliminated the need to use mineral spirits in this manner by installing a small hose which delivered a stream of cutting oil over the finished piece to flush off the metal shavings.

Only the centerless grinder and two smaller machines were equipped with local exhaust ventilation systems. Plastic splash guards were used on most of the machines to control oil sprays, and cutting oils contained an antimisting agent to control oil mist generation.

General appearance of the shop was excellent. The shop was extremely well lighted and fully air-conditioned. The building had a 16-zone air-conditioning system and each zone supplied 96,000 cubic feet of air per minute, which according to Raytheon's building engineer, contained a minimum of 10% outdoor makeup air, resulting in about 13 air changes per hour. The dust filter system included a dust-stop pre-filter and an 85% efficient bag filter. Temperature was controlled by reheating the cooled air with electric duct heaters.

Trim® Sol and petroleum cutting oils were changed in machines when process specifications called for a different metal working fluid. At the time of the NIOSH visit, Trim® Sol and cutting oils were not recycled. Trim® Sol was replaced when machine operators noted a foul odor from the fluid. The petroleum based cutting oils were changed only after the buildup of dirt and metal filings prevented proper flow through the machine. Raytheon had previously changed cutting oils on a pre-set schedule, but manpower shortages in recent years had prevented adherence to the schedule. A manual sump pump system was used to change the fluids and oils. The used oils and fluids were temporarily stored in special tanks until picked up by a hazardous waste disposal contractor.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

The industrial hygiene investigation conducted in the Machine Department on July 14, 1983, included:

(1) monitoring the personal exposures of 4 Milwaukee-matic operators to airborne oil mist and mineral spirits vapors,

(2) monitoring the personal exposure of a lathe operator to Trim® Sol mist and mineral spirits vapors,

(3) area monitoring (near the cutting tool) for sulfur dioxide as a thermal decomposition product from sulfur containing cutting oils,

(4) Trace elements analysis of unused samples of Chevron 502 and B.P. Sevora 53A and used samples of each oil taken from operating Milwaukee-matic machines, and

(5) Qualitative organic analysis of Trim® Sol concentrate.

Airborne oil mists and Trim® Sol mist were sampled on 37mm 5-micron PVC filters mounted in 3-piece plastic cassettes connected to pre-calibrated battery operated air sampling pumps which pulled air through the filter collector at one liter per minute (Lpm). Sampling equipment was worn by the operator with

the filter cassette attached to the machine operator's shirt collar. The samples were quantitatively analyzed by infrared spectroscopy according to NIOSH Method No. P&CAM 283.[1] Results for the samples and blank filters were calculated from calibration curves prepared from appropriate bulk samples of the cutting oils and Trim® Sol concentrate.

Personal exposures to organic vapors from the mineral spirits used by the 4 Milwaukee-matic machine operators and one lathe operator were collected using organic vapor adsorbing charcoal tubes. Calibrated air sampling pumps pulled a measured volume of air through the tubes at about 100 cubic centimeters (cc) of air per minute. The NIOSH laboratory analyzed the charcoal tubes by gas chromatography according to NIOSH Method No. P&CAM 127[2], modified by using hexane to quantitate the mineral spirits content.

Two machining operations on hardened steel with sulfur containing cutting oils were monitored for sulfur dioxide using long term direct reading detector tubes. Calibrated battery powered air sampling pumps pulled a measured volume of air through the tubes at approximately 20 cc of air per minute. Detector tube inlets were placed as close to the cutting tool as possible. The two operations sampled were believed to have the greatest potential for cutting oil breakdown.

To identify compounds associated with skin problems, unused and in-use samples of petroleum cutting oils (Chevron 502 and BP Sevora 53A) were analyzed for residual trace metals. Each sample was weighed then ashed with nitric and perchloric acids. The residues were dissolved in a dilute solution of these acids, and the sample solutions were analyzed for trace elements content by inductively coupled plasma/atomic emission spectroscopy (ICP/AES).

To better define its chemical composition, a bulk sample of unused concentrated Trim® Sol emulsion was qualitatively analyzed by mixing the concentrate in either carbon disulfide or acetone. Because preliminary GC analysis indicated both solutions had similar composition, only the carbon disulfide solution was analyzed by gas chromatography/mass spectrometry (GC/MS).

B. Medical

To determine the extent of skin problems in the Machine Department, the NIOSH investigators administered questionnaires and examined two groups of employees:

(1) from Department 7761 (Machine), 94 workers who had exposure to various types of cutting oils and metalworking fluids, and

(2) from Department 7744 (Shipping, Receiving, and Incoming Inspection and Testing), an unexposed comparison group of 26 workers.

Employees having exposure to any other chemicals known to cause skin problems were excluded from the comparison group. The questionnaire was designed to collect information on work histories, work exposures, medical histories, and health problems.

The evaluation of each participant who reported a skin problem included an examination of exposed areas of the skin: the hands, forearms, legs, and neck.

A case of potentially work-related dermatitis was defined as past or present skin rash on exposed parts of the body lasting three or more days during the person's employment at Raytheon; and excluded physician-diagnosed specific dermatoses such as psoriasis, fungal infections, and poison oak or poison ivy rash. This broad definition was used for both the exposed and non-exposed comparison group.

V. EVALUATION CRITERIA

A. Cutting Oils

The three major types of metal working (or cutting) fluids are: straight (insoluble) cutting oils, soluble oils (oil-in-water) emulsions, and synthetic or semi-synthetic cutting fluids.[3]

Straight cutting oils are mineral oils, sometimes blended with vegetable or animal oils, and may contain sulfur, chlorine, phosphorus, or other additives to enhance performance under conditions of high heat and pressure. Biocides are sometimes added to prevent rancidity. Dependent on the intended use, the concentrate is diluted with water at a rate of 1:5 - 1:50 and has a pH of 8.0 - 9.5.

Emulsified oils are complex mixtures of mineral oils, emulsifiers, corrosion inhibitors, extreme pressure additives, antifoaming agents, dyes, and water conditioners. The emulsifiers may include petroleum sulphonates, soaps, or non-ionic surfactants. Typical biocides (if used) include thiocarbamates, phenols, adamantane salts, isothiazolinones, nitromorpholine, tris-(hydroxymethyl) nitromethane, triazines, or pyridinethiol-oxide.

Synthetic oils contain little or no oils. The concentrate is diluted at a rate of between 1:10 and 1:200, depending on the intended use with a pH of 8-10. Common components include corrosion inhibitors (alkanolamines, carboxylic acids, mercaptobenzothiazoles, borate esters), surfactants, blending agents (glycols), biocides, water conditioners, antifoaming agents, and dyes.

B. Skin Diseases Associated With Cutting Oils

1. Straight Cutting Oils

Skin exposure to straight oils has long been known to cause oil acne or folliculitis and, when prolonged, hyperpigmentation, keratoses, and cancer of the scrotum and other exposed skin.[4] The folliculitis results from plugging of the hair follicles and usually develops in workers soon after their first exposure. Eczematous dermatitis occasionally occurs and is usually of irritant cause. However, sensitization to extreme pressure additives, biocides, and trace metal contaminants such as nickel or chromium may occasionally produce rare cases of allergic contact dermatitis.

There have been several reports of skin cancer in workers exposed to cutting oils. The latent period before development of skin cancer may be 20-25 years. In addition, skin cancers have been produced on the skin of mice following repeated applications of cutting oils containing polycyclic aromatic hydrocarbons.[5]

2. Soluble Oils

With emulsified oils, oil acne usually does not occur, and keratoses and skin cancer are much rarer. However, eczematous dermatitis is common. The reason for the irritant nature of soluble oils is not entirely known, but may be owing to the combination of its wetness, alkalinity and surfactant content.[4] Soluble oils tend to defat the skin, producing a dermatitis in its early stages similar to that caused by prolonged contact with soaps and detergents.[5] Allergic dermatitis may develop as a result of sensitization to biocides and corrosion inhibitors. A common mistake in the maintenance of an emulsion-type cutting fluid is the addition of biocide above that necessary to prevent bacterial growth. Excess biocide can be irritating and the likelihood of sensitization is increased. Allergic contact dermatitis from the following additives has recently been reported.[3]

- ethylenediamine
- butylphenol (antioxidant)
- chlorocresol (biocide)
- tris-nitrol and triazine (antimicrobials)
- hydrazine (stabilizer)
- balsam of Peru (fragrance)
- Proxel CRL (benzisothiazolin-3-one)

Patch testing of patients with soluble oil dermatitis is frequently negative. When sensitization occurs, constituents must be tested separately to determine the causative agent.[4]

3. Synthetic and Semi-synthetic Oils

Nitrosamines have been found in synthetic and semi-synthetic oils as either additives or contaminants, formed from sodium nitrite and triethanolamine that are used in many synthetic cutting oil formulations. Although their potency varies, many nitrosamines are known carcinogens. There has been recent speculation about the possible association between nitrosamine content in cutting fluids and skin cancer, but further studies are needed to settle this question.[6]

C. Suspected Sources of Dermatitis in Machine Department

Petroleum based cutting oils and an oil-in-water emulsion fluid (Trim® Sol) are used throughout the Machine Department at Raytheon. The various biocides used in some of these fluids are possible skin and mucous membrane irritants.[7] Cutting oils have long been reported as a cause of eczema and oil acne, or folliculitis.[8,9] Adding to the problem, metal shavings from the metal working operations, can cause mechanical irritation to the skin. Nickel salts formed during the machining of nickel alloys, like stainless steel, could also cause skin sensitization.[3] Organic solvents, sometimes used to clean oil from the skin, can have a defatting action which results in dry, cracked skin, making the skin more susceptible to the effects of cutting fluids.

The cutting fluids and solvents most commonly used by the Raytheon Machine Department included:

(1) Chevron Metalworking Fluids 501, 502, 503, 504, and 505 and British Petroleum Sevora 53A:
Extreme Pressure Additives
- sulfur 0-2% (by weight)
- chlorine 1-3% (by weight)
- boron .18% (by weight in 505 only)

Trim® Sol Metalworking fluid (oil-in-water emulsion)
- 94-98% water
- 2-6% Trim® Sol oil-emulsion concentrate
A mixture of: petroleum oil, non-ionic surfactants, chlorinated paraffin wax, petroleum sulfonate, odorants (biocides) silicone defoamer, dye and water.

Organic Solvent - Ashland Chemicals Rule 66 Mineral Spirits

D. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff use environmental evaluation criteria for assessment of many 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. However, not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, 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 evaluation 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 potentially increase the general exposure. Lastly, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1. NIOSH criteria documents and recommendations, 2. the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's),[10] and 3. the U.S. Department of Labor (OSHA) Occupational Safety and Health Standards.[11] Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based solely on concerns relating to the prevention of occupational disease. When considering the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that employers are legally required to meet only those levels specified by an OSHA standard.

For those compounds with established occupational exposure limits, the various criteria proposed by OSHA, ACGIH, and NIOSH for airborne concentrations of the chemical substances measured in this evaluation are discussed below. 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 high short-term exposures.

For the purposes of this evaluation, NIOSH has selected the most stringent exposure limits as our environmental criteria. The major health effects anticipated for workers exposed above these criteria or suspected adverse health effects from direct contact with the chemicals evaluated in this investigation are summarized in the following section.

1. Oil Mists

Although occupational exposures to oil mist generated during machining operations have been frequently documented, reported cases of respiratory system disorders (lipid pneumonia) have been rare. Workers exposed to oil mists do however experience discomfort, especially when the airborne concentration exceeds 5 mg/M^3 and the mist becomes visible. There is no relationship established for inhalation of oil mist and lung cancer.[3] The ACGIH's recommended TLV for mineral oil mist is $5mg/M^3$ as an 8-hour TWA. This concentration is also the permissible exposure limit enforced by OSHA. This standard was established to prevent the airborne level of oil mist from reaching a nuisance level, and is applicable to straight mineral oil mists.

2. Mineral Spirits

Mineral spirits are clear, colorless liquids with a pleasant sweetish odor. They are commonly used as a general-purpose industrial solvent and as a thinner in paints and varnishes. Prolonged or repeated contact with the skin can cause moderate skin irritation or dermatitis. Ingestion of mineral spirits can cause gastrointestinal irritation, nausea, vomiting, and diarrhea. If swallowed, aspiration into the lungs causes chemical pneumonitis which can be fatal. Airborne concentrations of mineral spirits above 2,500 mg/M^3 have been shown to cause nausea and vertigo in humans.[12] Inhalation of mineral spirits vapors can irritate the upper respiratory tract and will depress the central nervous system resulting in dizziness, weakness, fatigue, nausea, headache, and under conditions of severe exposure, unconsciousness and possible asphyxiation. The 10-hour TWA exposure limit recommended by NIOSH is 350 mg/M^3 with a ceiling limit of 500 mg/M^3. These limits were established to prevent the symptoms of central nervous system depression, upper respiratory irritation, and chronic responses based on the projected toxicities of the major aliphatic (70-90%) and aromatic (10-30%) components of mineral spirits.[13]

VI. RESULTS AND DISCUSSION

A. Environmental Results

1. Oil Mist

Air sample results indicated airborne oil mist exposures and Trim® Sol mist exposure were non-detectable for the five workers monitored. The NIOSH sampling and analytical method was capable of detecting cutting oil mist above 0.1 mg/M^3 and Trim® Sol fluid mist above 0.2 mg/M^3. The machining operations sampled and limits of detection for each sample are presented in Table 1.

2. Mineral Spirits Vapors

Personal exposures to mineral spirits vapors did not exceed the recommended environmental criteria of 350 mg/M^3. The results for each of the five samples collected are presented in Table 2. The concentrations detected ranged from 3 to 22 mg/M^3. Because the Milwaukee-matic machine operators used mineral spirits only when removing finished pieces (about every 3.5 hour), their duration of exposure was limited. The lathe operator did not use mineral spirits, which accounts for the lower concentration detected at that location.

3. Analysis of Metalworking Fluids

The analysis for trace elements in the two used and two unused samples of petroleum cutting oils revealed the following results:

TRACE ELEMENT - micrograms/gram of oil (ppm)
(limit of detection = 2.5 ppm)

(* = elements associated with symptoms of dermatitis)[14]

(1)

Chevron 502 (unused)		Chevron 502 (used)	
* arsenic	24.0	* arsenic	16.8
- calcium	5.4	- calcium	12.5
* zinc	13.0	* zinc	35.5
		* aluminum	3.4
		* copper	3.5
		- iron	11.9
		- magnesium	2.8
		- sodium	20.5
		* phosphorus	46.8

(2)

BP Sevora 53A (unused)		BP Sevora 53A (used)	
* arsenic	23.8	* arsenic	24.5
- calcium	116.0	- calcium	18.6
* phosphorus	85.4	* phosphorus	72.9
* zinc	50.5	* zinc	19.5
- sodium	9.9	- barium	3.1
		* copper	2.9
		- iron	105.0

(3) Elements looked for, but not detected:
(detection limit = less than 2.5 ppm)

silver, beryllium*, cadmium, chromium*, lanthanum, lithium, manganese, molybdenum, nickel*, lead, platinum*, antimony*, selenium*, strontium, tellurium, titanium, thallium, vanadium, yttrium, and zirconium.

The GC/MS qualitative analysis of the Trim® Sol concentrate detected the following organic compounds:

- chloromethyl phenol isomer (chlorocresol),
- various glycols (diethylene glycol) and glycol ethers,
- and a series of unresolved aliphatic hydrocarbons typical of machine cutting oils.

4. Thermal breakdown products from Cutting Oils

Direct reading monitors placed near two high temperature machining operations on the Milwaukee-matics detected no sulfur dioxide vapor emissions. Sulfur dioxide had been identified as a possible thermal breakdown product of the sulfur containing cutting oils.

B. Medical Results

Exposed vs. non-exposed, and case vs. non-case groups were similar in race and age (Table 3). Compared to the exposed group, there was a significantly greater proportion of females in the unexposed group ($p = 0.004$). Seven of 26 (33%) of the unexposed group reported a history of asthma, hay fever, eczema, or other allergies, as did 33 of 94 (35%) of the exposed group.

As displayed in Figure 1, two of 16 (13%) machine operators in the exposed group reported having a skin rash, as did eight of 26 (31%) mill operators, nine of 18 (50%) drill operators, nine of 24 (38%) lathe operators, and two of seven (29%) inspectors. Thirty-four (36%) of the 94 exposed employees, but only three (12%) of the 26 unexposed reported having had skin rash fitting the case definition ($p < 0.057$).

Eighteen of 31 (58%) exposed workers with skin rash cases thought that either varsol or Trim® Sol were responsible for their reported skin rashes. The other 42% did not specify a particular type of cutting fluid as being worse than another. Of the three cases of skin rashes reported by workers in the unexposed group, one was a tester and the other two were inspectors.

Nineteen of the 31 (61%) cases in the exposed workers primarily involved the hands, and 12 (39%) the arms. Nineteen characterized their rashes as being red and itchy, five as blisters or papules, and three as dry, scaly skin. Duration of the skin rashes ranged from three days to 40 years, with a median of eight months. About half of the skin rashes first occurred since 1980. Descriptions of the three unexposed skin rashes were different from those in the exposed group. One was reported as dry hands, one as dry hands and legs, and one as acne on the chest.

Six of the cases from the exposed group had positive examination findings on the skin on the day of the NIOSH survey. Two had pimples on the neck, one had red papulas on the forearms, one had red fingers, one had papulas on the wrist, and one had dry, scaly arms.

Two of the three workers from the unexposed group reporting rashes had positive skin examination findings. One had acne on the face and chest, and one had dry skin on the legs and thighs.

C. Discussion

Based on the results of the questionnaire, it appears that Milwaukee-matic machine operators have less skin problems than millers, drillers, lathe operators, or inspectors; although the difference between machine operators (two of 16) and all others (31 of 75) was not statistically significant ($p = 0.10$). This apparent difference may exist because Milwaukee-matic operators have less direct skin contact with cutting oils.

Finding traces of arsenic in both used and unused samples of cutting oils from two different suppliers (British Petroleum and Chevron) was not expected. Upon learning of the NIOSH finding, the Chevron Environmental Health Center conducted their own atomic absorption and ion chromatography analysis of samples of new and used Chevron 502 cutting oils obtained from a plant in Virginia. Samples of various components and additives were also analyzed. Chevron found no detectable arsenic in the cutting oil samples (detection limit 0.1 ppm) but their analysis of an additive package, known as TLA 297 supplied by the Texaco Chemical Company, detected 8 ppm arsenic which Chevron identified as organic arsenic. Chevron estimated the adding of TLA 297, containing 8 ppm arsenic, would contaminate Chevron 502 cutting oil with about 280 ppb arsenic, a concentration Chevron considered toxicologically insignificant. Chevron's findings confirmed the presence of arsenic in the cutting oils and identified Texaco TLA 297 as the most likely source. It was suggested by Chevron representatives that TLA 297 may also have been used by British Petroleum for their cutting oils, but this was never confirmed.

The NIOSH findings suggest that arsenic levels may have been much higher in TLA 297 than the Chevron results indicated. NIOSH found 17-24 ppm arsenic in the Raytheon cutting oil samples. Chevron reported to NIOSH that they had been assured by Texaco that arsenic was not an intentional component of TLA 297. Chevron reported that Texaco would investigate the problem, with the objective of eliminating arsenic contamination from TLA 297.

The results of the NIOSH study uncovered no evidence to suggest that arsenic-contaminated cutting oils were responsible for the outbreak of dermatitis among the Milwaukee-matic machine operators. Of the employees reporting problems with skin rash, 58% believed their rash was caused by contact with mineral spirits (varsol) or Trim® Sol. The biocide found in Trim® Sol, chlorocresol, comes from a class of chemicals known to cause skin irritation. However, when considering that Trim® Sol concentrate is used at Raytheon in solutions of only 2-6%, the amount of chlorocresol in direct contact with the skin should not be enough

to cause skin rash. Only by patch testing with the various cutting fluids or specific components of these fluids could one hope to determine which metalworking fluid or solvent was the cause of an irritant or allergic dermatitis in an affected worker.

VII. CONCLUSIONS

The cumulative prevalence of skin rash was much greater among employees exposed to cutting fluids than among the unexposed comparison group. From descriptions and examinations, the skin rashes appeared to be more simple irritant dermatitis than eczema or folliculitis. The excess of skin rashes is probably caused from the combined effects of exposures to cutting oils and fluids, biocide additives, solvents, and metal shavings.

VIII. RECOMMENDATIONS

Since primary exposure occurs by direct contact with the cutting fluids, and not from airborne mist or vapor, NIOSH makes the following recommendations for avoiding repeated and prolonged contact with these cutting fluids and their additives.

A. Recommendations for Employees

1. At work, oily work cloths should not be used to wipe oil off the skin, as metal particles present may cause skin abrasions, which can lead to infection. Organic solvents should not be used to wash oil off the skin. Waterless skin cleaner and disposable paper towels should be used for this purpose.

   Immediate first-aid treatment should be provided for any injury, and any open wounds should be kept covered and away from any contact with cutting fluids and other chemicals.

3. After work, the skin should be thoroughly washed with soap and water and a conditioning cream used to counter defatting of the skin. Periodic self-examination of the skin is recommended; and any unexplained or changed rash, sore, wart, or mole should receive medical attention.

4. Care should be taken to prevent clothes from being contaminated with splashed cutting fluids by using impervious aprons or protective coveralls, and, when feasible, protective gloves. Work clothes should be changed daily.

B. Recommendations for Employers

1. Adequate and well-maintained washing facilities with a plentiful supply of disposable paper towels should be provided.

2. Since most Machine Department employees' hands and arms are in frequent direct contact with cutting oils and water soluble metalworking fluids, waterless skin cleaner dispensers and paper towels should be readily available in all workcenters where metalworking fluids are used.

3. Light, impervious aprons should be provided for workers, and when appropriate, gloves should also be provided for use where they do not pose a safety hazard. The company should be responsible for the laundering of work clothes.

4. Employees should be informed of the possible skin problems that may occur from frequent contact with cutting fluids, and should be encouraged to follow the recommendations in this report.

5. Workers with dermatitis should be referred for medical advice. Temporary removal from exposure to cutting oil may be required for workers with severe dermatitis problems.

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XI. DISTRIBUTION AND AVAILABILITY

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After ninety (90) days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati, Ohio address.

Copies of this report have been sent to:

1. Raytheon Missile System Division
2. Representatives for Employees (confidential)
3. NIOSH Region IV
4. OSHA, Region IV
5. Designated State Agencies

For the purpose of informing the approximately 200 "affected employees", the employer will promptly "post" this report for a period of thirty (30) calendar days in a prominent place(s) near where the affected employees work.

TABLE 1
OIL MIST SAMPLING RESULTS

MACHINE DEPARTMENT
RAYTHEON MISSILE SYSTEMS DIVISION
BRISTOL, TENNESSEE
HETA 83-186

July 14, 1983

Location Machining Task-Oil Used	Sampling Time Start-Stop	minutes	Flow Rate Lpm	Sample Vol liters	Detection limit*
Air Frame Workcenter					mg/M^3
Milwaukee-Matic Machining:					
Pedestal-Chev 502	0906-1548	402	1.00	402	0.10
Midsection-Sevora 53A	0833-1535	422	1.00	422	0.08
Control Housing-Chev 502	0853-1544	411	1.00	411	0.10
Lower Housing-Chev 502	0944-1549	365	1.00	365	0.11
Lathe Workcenter					
Midsection Shell-Trim@ sol	0922-1515	353	0.90	318	0.19
Environmental Criteria =					5.0

NOTE* No oil mist was detected in any of the samples taken. Airborne oil mist concentration was therefore less than the limits indicated.

TABLE 2
MINERAL SPIRITS VAPORS

MACHINE DEPARTMENT
RAYTHEON MISSILE SYSTEMS DIVISION
BRISTOL, TENNESSEE
HETA 83-186

July 14, 1983

Location	Sampling Time Start-Stop minutes	Sample Vol liters	Concentration mg/M^3
Airframe Workcenter			
Milwaukee-matic Machining:			
Pedestal	0906 - 1548 402	27.40	21.90
Midsection	0833 - 1535 422	44.40	13.51
Control Housing	0853 - 1544 411	45.06	11.10
Lower Housing	0944 - 1549 365	44.76	13.41
Lathe Workcenter			
Midsection Shell	0922 - 1515 353	34.90	2.87
Environmental Criteria =			350.0

TABLE 3
EMPLOYEE DEMOGRAPHICS

RAYTHEON MISSILE SYSTEMS DIVISION
BRISTOL, TENNESSEE
HETA 83-186

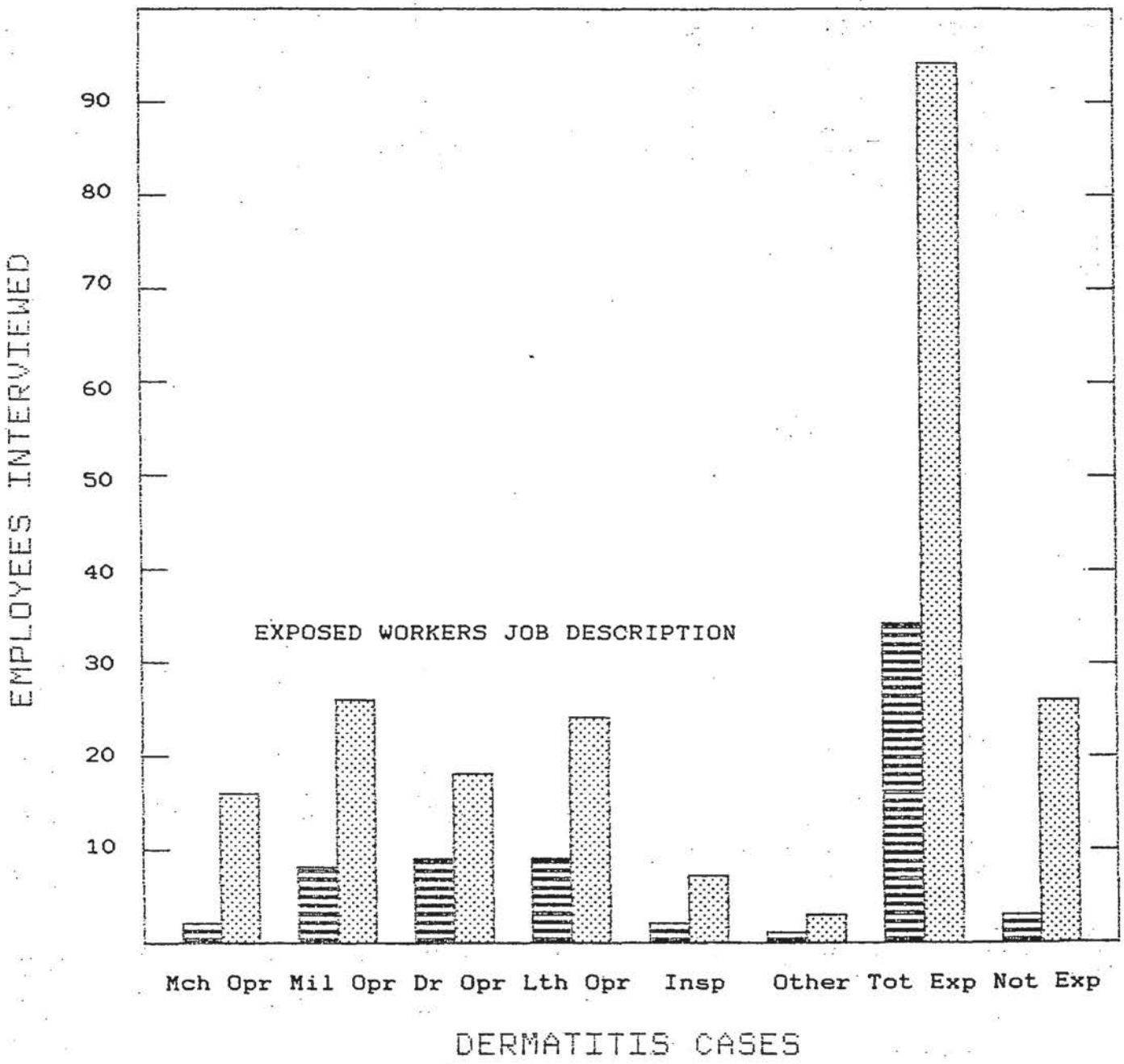
July 13-15, 1983

	Exposed	Non-exposed	Cases	Non-cases
Race				
White	93	26	34	86
Black	1	0	0	0
Sex				
Male	89	19	31	77
Female	5	7	3	9
Age (years)				
Range	25-64	27-58	29-66	25-63
Median	51	51	52	50
Mean (± s.d.)	49 ± 9	49 ± 9	51 ± 9.6	49 ± 9

FIGURE 1
DERMATITIS PREVALENCE

MACHINE DEPARTMENT
RAYTHEON MISSILE SYSTEMS DIVISION
BRISTOL, TENNESSEE
HETA 83-186

July 13-15, 1983



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