HETA 96–0020–2610
Martin Sprocket and Gear, Inc.
Fort Worth, Texas

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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. Mention of company names or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Calvin K. Cook of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Dino Mattorano, Hazard Evaluations and Technical Assistance Branch, DSHEFS. Desktop publishing by Ellen E. Blythe.

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Health Hazard Evaluation Report 96–0020–2610
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Fort Worth, Texas
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SUMMARY

The National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation (HHE) from a group of workers at Martin Sprocket and Gear, Inc. located in Fort Worth, Texas. The request reported workers' symptoms of chest pain, breathing difficulties, nausea, vomiting, and skin irritation believed to be caused by occupational exposure to metalworking fluids used in the production of power transmissions, tools, dies, and other devices for industrial applications.

During January 23–25, 1996, environmental monitoring was performed that included full–shift, personal breathing–zone (PBZ) air sampling for total particulates, iron oxide, endotoxins, and nitrosamines to assess potential exposures among machine operators. A safety review was also performed to identify general fire, safety, and health hazards and company Material Safety Data Sheets and injuries and illness records were reviewed. A symptoms questionnaire was distributed to machine operators to obtain background and baseline information about their health complaints.

An air sample collected on a worker while performing a metal grinding activity determined a time–weighed average (TWA) exposure concentration of 10 milligrams per cubic meter (mg/m^3) for total particulates, approaching the Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limit (PEL) of 15 mg/m^3 for total dust as an 8–hour TWA. The respirable particulate mass fraction was calculated as 2.6 mg/m^3, approaching both the American Conference of Governmental Industrial Hygienist's (ACGIH) Threshold Limit Value (TLV®) of 3 mg/m^3 and the OSHA–PEL of 5 mg/m^3 as an 8–hour TWA. Further analysis on the dust sample determined an iron oxide exposure concentration of 2.6 mg/m^3, below the NIOSH recommended exposure limit (REL) of 5 mg/m^3. Air samples for airborne metalworking fluids were none–detected. Endotoxin air sampling measured concentrations up to 4.9 endotoxin units per cubic meter (EU/m^3), well below a suggested exposure criterion of 90 EU/m^3. This exposure criterion was established based on a calculated zero pulmonary function effect level.

Since only trace levels of nitrosamines were detected in the bulk metal working fluids collected from machine reservoirs, full–shift PBZ samples for nitrosamines were not analyzed since they were very likely to reveal — at most — trace concentrations as well.

The very low response rate (15%) of workers who completed and returned questionnaires may not accurately represent the views of all 160 machine operators. Employees who did respond reported skin, eye, and respiratory problems.

With the exception of one metal grinding operation, NIOSH investigators did not measure any elevated airborne exposures to metal working fluids, total or respirable dust, or endotoxins. NIOSH investigators identified potential safety and fire hazards that could result in accidents if not corrected. Recommendations were provided to improve worker safety and health and fire prevention.

Keywords: SIC 3462 (Forgings, ferrous metals), skin irritation, dyspnea, grinding, milling, machine operators, iron oxide, metals, fire prevention, metalworking fluids, endotoxin, nitrosamines, total particulates.

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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) received a request to conduct a Health Hazard Evaluation (HHE) at the Martin Sprocket and Gear manufacturing plant located in Fort Worth, Texas. The request stated that machine operators in Departments #20 and #21 were experiencing symptoms of chest pain, breathing difficulties, nausea, vomiting, and skin irritation believed by employees to be associated with metalworking fluid exposures. On January 23, 1996, a site visit was made that began with an opening conference with management and employee representatives to discuss the nature of the request. On January 24–25, 1996, NIOSH investigators conducted industrial hygiene monitoring to measure worker exposures to total particulates, iron oxide, endotoxins, and nitrosamines.

BACKGROUND AND PROCESS DESCRIPTION

The Martin Sprocket and Gear, Fort Worth plant, employs about 15 workers over two shifts in Department #20; 150 workers in Department #21; and 10 workers in the Computer Numerically Controlled (CNC) Department. Machine operators perform heavy–duty milling, grinding, and machining of cast iron and alloy steel parts to produce tools, gears, power transmissions, sheaves, conveyors, and dies for industrial applications. Workers in Departments #20 and #21 used lathes, bandsaws, and other types of metalworking machinery for milling, boring, drilling, and abrasive grinding. Workers in the CNC Department operated specialized computer–controlled metalworking machinery. General mechanical ventilation was provided in each department and consisted of supply and exhaust fans located at ceiling level; no local exhaust ventilation was present at metalworking machinery. Machine operators generally wore protective gloves (made of chlorinated natural latex rubber), aprons, safety shoes, and eyewear. For specific operations, such as grinding, workers wore dust mask respirators approved by NIOSH and the Mine Safety and Health Administration (MSHA).

Metalworking machinery was generally equipped with an independent coolant distribution system that used Maxim Synthetic Blue®, a water–based metalworking fluid diluted with 98% water and formulated with a built–in biocide. A biocide was added to metalworking fluids only during onsite reclamation. The quality of metalworking fluids in machine reservoirs was monitored twice weekly using a refractometer.

In Department #20, two electrical discharge machines (EDMs) were present that contained dielectric fluid for making dies and forging tools. A Safety Kleen® degreaser tank was present for cleaning metal parts using a petroleum hydrocarbon solvent. A metal arc welding booth using helium gas was also present near the EDMs and the degreaser tank. In Department #21, finished sheaves and other products were painted at a spray paint booth equipped with a dedicated exhaust ventilation system.

EVALUATION METHODS

Industrial Hygiene Evaluation

An industrial hygiene evaluation was performed to determine worker exposures to airborne total particulates, iron oxide, endotoxins, and nitrosamines. A general safety evaluation was performed to identify potential safety and fire hazards of the plant's processes. Current Material Safety Data Sheets (MSDSs) and OSHA Log Summary of Occupational Illnesses and Injuries (Form 200) for the past three years were reviewed.

The following provides general sampling and analytical information for each air contaminant evaluated during the NIOSH HHE.

Total and Respirable Particulates: In accordance with NIOSH sampling and analytical method 0600[1] (with modifications), nine sample sets for total and respirable particulates were collected on pre–weighed polyvinyl chloride (PVC) filters using six–stage personal cascade impactors connected to highflow sampling pumps calibrated at a flowrate of 1.5 liters per minute (lpm). The diameter cut–point of respirable particulates was 3.5 micrometers (µm). Total dust levels were determined by summing the gravimetric results of each set of personal cascade impactors.

Iron Oxide: For the air samples that had detectable particulate levels, follow–up analyses were performed for 30 different metals, according to NIOSH sampling and analytical method 7300.[1]

Endotoxins: Seventeen air samples for endotoxins were collected on tared 5.0 µm pore size, 37–millimeter (mm) diameter polyvinyl chloride (PVC) filter cassettes, using highflow air sampling pumps calibrated at a flowrate of 1.5 lpm. In addition, 10 bulk samples were collected from machine reservoirs and unused lot containers. Endotoxin analyses were performed in duplicate on all samples by the quantitative chromogenic Limulus amebocyte lysate test (QCL–1000; Whittaker Bioproducts, Walkersville, Maryland). Results were reported in endotoxin units (EU) that were compared to the standard lipopolysaccharide–protein complexes, EC–5. For these analyses, 10 EUs are equivalent to one nanogram of endotoxin.

Nitrosamines: In accordance with NIOSH sampling and analytical method 2522, 20 air samples (19 PBZ, 1 area) were collected on Thermosorb/N® air samplers connected to high–flow air sampling pumps operating at a flow rate of 2 lpm.[1] Eight bulk samples were collected in glass vials from machine reservoirs and unused lot containers. All bulk samples were analyzed using gas chromatography (GC) with a capillary column. A high–resolution mass spectrometer (MS) operated in the selected ion–monitoring (SIM) mode was used to confirm the identity of any compound that eluted at the same retention time as the nitrosamine standards by monitoring its molecular ion. In this way, the chromatographic peak was confirmed as the nitrosamine compound of interest. The limit of detection (LOD) for this sample set was between 0.03 and 0.06 micrograms per gram (µg/gram) for each analyte.

Symptoms Questionnaires

Questionnaires were made available to all employees present during the NIOSH site visit to obtain background and baseline information about worker health complaints. For employees who were not present during the site visit, arrangements were made to grant them an opportunity to participate in the survey. The questionnaire asked if the employee had experienced symptoms associated with skin, eye, or respiratory ailments believed to be related to their work environment during the past year. The questionnaire also asked about the frequency of occurrence of symptoms reported, and the types of personal protective equipment (e.g., eye protection, gloves, respirators) used while working. The final section of the questionnaire allowed employees to present or discuss other concerns about their health and work environment. Questionnaires were later analyzed to determine the prevalence of reported symptoms.

EVALUATION CRITERIA

General

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 preexisting medical condition, and/or 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 thus potentially increase 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 the following: (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, OSHA permissible exposure limits (PELs).[4] In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA–PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever is the most protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report reflect the 1971 values.

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 period.

Oil Mists and Particulates, Not Otherwise Classified

The evaluation criteria for oil mists are primarily based on studies conducted with a petroleum based, white mineral oil with no additives.[5,6] Mineral oils, as well as other lubricating or cutting oils, can contain a complex mixture of aromatic, naphthenic, and straight– or branched–chain paraffinic hydrocarbons. The composition of a given oil depends upon the way in which the oil was processed, and the degree to which it was processed. Many mineral oils in use today vary in composition, and can contain various additives and impurities.

Mineral oil mist is of low toxicity.[7] Inhalation of mineral oil mist in high concentrations may cause pulmonary effects, although this has rarely been reported. A single case of lipoid pneumonitis suspected to have been caused by exposure to very high concentrations of oil mist was reported in 1950; this occurred in a cash register serviceman whose heavy exposure occurred over 17 years of employment.[8] Early epidemiological studies linked cancers of the skin and scrotum with exposure to mineral oils.[9] These effects have been attributed to contaminants such as polycyclic aromatic hydrocarbons (PAHs) and/or additives with carcinogenic properties present in the oil. The International Agency for Research on Cancer (IARC) determined that there is sufficient evidence for carcinogenicity to humans, based on epidemiologic studies of uncharacterized mineral oils containing additives and impurities; there is inadequate evidence for carcinogenicity to humans for highly refined oils.[10] Prolonged exposure to mineral oil mist may also cause dermatitis. Persons with pre–existing skin disorders may be more susceptible to these effects.

Environmental evaluation criteria for mineral oil mist have been established by ACGIH and OSHA at 5 milligrams per cubic meter (mg/m^3) of air as an 8–hour TWA. This concentration was selected to minimize respiratory irritation and pulmonary effects. The NIOSH REL for oil mist is also 5 mg/m^3, with a STEL of 10 mg/m^3. However, since the role of additives and oil fume from partial heat–decomposition have yet to be completely evaluated experimentally, NIOSH suggests that these criteria may not be applicable to all forms of oil mists.[5]

Water–soluble metalworking fluids cannot be analyzed using the oil mist sampling method. Thus, a total mass measurement is made, knowing that the water soluble oil portion of the sample collected must be less than the total mass. This measurement is the same one that is used for particulates not otherwise regulated (PNOR), a generic criterion established for airborne particulates that do not have an established occupational health exposure criterion. Currently, there is no generic occupational exposure standard or guideline for metalworking fluids. Formerly referred to as nuisance dust, the preferred terminology for the non–specific particulate OSHA PEL is now *"particulates, not otherwise regulated,"* or *"not otherwise classified (NOC)"* for the ACGIH TLV. The OSHA PEL for total particulate, NOR, is 15 mg/m^3 and 5 mg/m^3 for the respirable fraction, determined as 8–hour averages. The ACGIH recommended TLV for exposure to a particulate, NOC, is 10 mg/m^3 (total dust, 8–hour TWA) and 3 mg/m^3. These are generic criteria for airborne dusts which do not produce significant organic disease or toxic effect when exposures are kept under reasonable control.[11] These criteria are not appropriate for aerosols that have a biologic effect and may not be appropriate for evaluating metalworking fluids. NIOSH does not agree with the OSHA PEL for total particulates NOC because the Institute concludes that adverse health effects could occur at the established OSHA PELs. Although NIOSH has not officially adopted a REL for total or respirable particulates NOC, the Institute has recently proposed a generic REL of 0.5 mg/m^3 for metalworking fluids.[12]

Iron Oxide Particulates

Inhalation of iron oxide dust is known to cause a benign pneumoconiosis (siderosis). Iron oxide alone does not cause fibrosis in the lungs of animals, and it is likely that the same applies to humans.[13] Iron oxide exposures for periods of 6 to 10 years usually are required before recognizable changes occur in the lungs by X–ray; the retained dust produces X–ray shadows that may be indistinguishable from fibrotic pneumoconiosis.[13,14] Although toxicology information suggests that iron oxide alone is not carcinogenic to humans and animals, an increased incidence of lung cancer has been observed in hematite mining workers exposed to iron oxide; however, cancer cases are presumably caused by the inhalation of iron oxide plus certain other substances (i.e., radon gas).[15] Workers such as welders are typically exposed to a complicated mixture of metal particulates and fume of metallic oxides (including iron), and are subject to mixed–dust pneumoconiosis; this should not be mistaken with benign pneumoconiosis caused by iron oxide.[3] The OSHA–PEL for iron oxide is 10 mg/m^3 as an 8–hour TWA. The NIOSH–REL and the ACGIH–TLV for iron oxide are both 5 mg/m^3 as an 8–hour TWA.

Endotoxins

An endotoxin is a lipopolysaccharide compound from the outer cell wall of gram–negative bacteria, which occur abundantly in organic dusts.[16] It has been shown that the biological properties of endotoxin vary depending upon the bacterial species from which they are derived, as well as upon the state of the growth cycle of the bacteria.[17] Endotoxins have a wide range of biological activities involving inflammatory, hemodynamic, and immunological responses. Of most importance to occupational exposures are the activities of endotoxin in the lung.[18] The primary target cell for endotoxin–induced damage by inhalation is the pulmonary macrophage. Human macrophages in particular have been shown to be extremely sensitive to the effects of endotoxin in vitro.[19] Endotoxin, either soluble or associated with particulate matter, will activate the macrophage, causing the cell to produce a host of mediators.[18]

Clinically, little is known about the response to inhaled endotoxins. Exposure of previously unexposed persons to airborne endotoxin can result in acute fever, dyspnea, coughing, and small reductions in forced expiratory volume in one second (FEV_1), although some investigators have not been able to demonstrate acute changes in FEV_1.[12] The effects of repeated exposure to aerosols of endotoxins in humans are not known. Some animal studies have demonstrated a chronic inflammatory response characterized by goblet cell hyperplasia and increased mucous production. This suggests that repeated exposure may cause a syndrome similar, if not identical, to chronic bronchitis.[18]

Occupational exposure criteria have not been established for bacterial endotoxin by either OSHA, NIOSH, or ACGIH. However, Jacobs has reported that a sufficient toxicological data base is believed to exist for establishing an occupational limit for endotoxin based on acute changes in pulmonary function.[18] Eight–hour TWA concentrations have been suggested to avoid an over–shift decline in FEV_1 at 1000 – 2000 EU/m^3, chest tightness at 3,000 – 5,000 EU/m^3, fever at 5,000 – 10,000 and toxic pneumonitis at 5,000 – 10,000 EU/m^3.[17,20]

The exposure system for the study from which this recommendation was made consisted of a commercial carding machine in a cardroom, an exposure room, and connecting duct work. Airborne dust concentrations were determined in the exposure room using four vertical elutriators.[20] The vertical elutriator has traditionally been the instrument of choice for cotton dust sampling because it will not collect cotton fly lint fibers and dust particles with an aerodynamic mass medial diameter larger than 15 µm.[21]

Nitrosamines

Nitrosamines are potent animal carcinogens. Nitrosodimethylamine (NDMA) has been shown to be the most potent carcinogen in the nitrosamine family. In animals, the target organs are the liver and kidney. Although nitrosamines are suspected to be human carcinogens, their carcinogenic potential in humans has not been proven.[7]

There are currently no airborne standards for nitrosamines, except NDMA. OSHA and ACGIH recommend that NDMA be regarded as a potential occupational carcinogen and that exposure to it be controlled to the lowest feasible level. NIOSH further recommends that occupational exposure to *all* nitrosamines be reduced to the lowest possible level.

RESULTS

Industrial Hygiene Evaluation

Air Sampling Results

One PBZ air sample that was collected on a worker who was grinding metal parts revealed a TWA exposure concentration of 10 mg/m^3 for total particulates, a result which equals the ACGIH–TLV. This result, however, was below the OSHA PEL for total particulates of 15 mg/m^3. The mass of the particulates from the sample which was respirable was calculated to be 2.6 mg/m^3 as a TWA. This respirable concentration is below both the ACGIH–TLV of 3 mg/m^3 and the OSHA PEL of 5mg/m^3 (both are criteria for respirable particulates). Finally, an elemental analysis of the particulate revealed that iron was the predominant metal present. The concentration of iron (expressed as iron oxide) was 2.6 mg/m^3, an amount below the applicable NIOSH, ACGIH, and OSHA occupational exposure criteria. Particle size distribution for total and respirable particulates were log–normal.

Air sampling for airborne metalworking fluids was none–detected. Endotoxin air sampling results revealed concentrations up to 4.86 EU/m^3, well below Castellan's exposure criteria of 90 EU/m^3, which was established based on a calculated zero pulmonary function effect level.

Nitrosamine analysis, first performed on bulk metalworking fluid samples, detected only trace concentrations in five of eight samples (no nitrosamines were detected in the remaining samples). Therefore, analyses of air samples for nitrosamines were not performed since it was unlikely that nitrosamines would be present.

Other Observations

In Department 20, two EDMs were located only 5 feet and 16 feet from the welding booth, and the Safety Kleen® degreaser tank was located only 15 feet away. According to the National Safety Council, there is the possibility of the ignition of discharge gases from the EDMs.[22] According to a "Health Hazard Warning" placard on the degreaser tank, it contains a combustible petroleum solvent. In accordance with OSHA general requirements (29CFR Part E, 1910.252) for fire prevention and protection, welding processes and other spark or flame producing processes shall not be within 35 feet of combustible materials.[23] In addition, an emergency eyewash station or shower was not present in the general vicinity of chemical processes (e.g., EDMs) to assist workers in the event of accidental chemical splashes to the face and eyes.

Review of OSHA Form 200 Log of Injuries and Illness from 1993 to 1996 discovered only one documented case of skin rash; no respiratory reports were recorded.

Symptoms Questionnaire

Since only 24 of the approximately 160 machine operators returned questionnaires to NIOSH investigators (an approximate response rate of 15%), the questionnaire response may not accurately represent the views of all machine operators. Some respondents reported adverse skin conditions believed to be caused by dermal exposure to metalworking fluids. Reported skin disorders were signs of redness, dryness, cracking, rash, itching, blistering, and pimples located on face, hands (palms and back), forearms, upper arms, and groin area. Some respondents reported experiencing at least one symptom of chest tightness, shortness of breath, wheezing, cough with phlegm, and eyes, nose, throat, and/or sinus irritation. A few respondents reported experiencing both skin and respiratory related symptoms. The final section of the questionnaire allowed employees to discuss other concerns about their health and work environment. The issues presented were general concerns about the potential hazards of the metalworking fluids, and that the soap provided in the restroom is thought to be a cause of dry skin.

DISCUSSION AND CONCLUSIONS

Worker exposure to mineral oil mist is common when using oil–based metalworking fluids. However, since water–based metalworking fluids were used at Martin Sprocket and Gear, air sampling for mineral oil mists were not performed during this survey. Previous NIOSH investigations have discovered little or no exposure to mineral oil mist when using water–based metalworking fluids.[24,25]

Based on the carcinogenic properties of nitrosamine compounds that were often present in metalworking fluids, the EPA banned the use of these compounds in metalworking fluids. Many metalworking fluids, however, contain amine compounds (e.g., diethanolamine) that react during the machining of metal parts to produce nitrosamines.

Endotoxins have generally been quantified in machining operations where water–based metalworking fluids are used. Because health effects from exposure to endotoxins have been documented in human case studies, air sampling was performed to evaluate worker exposure to endotoxin.

An air sample collected during the abrasive metal grinding operation measured 10 mg/m^3 for total particulates as a full–shift TWA. Of this, further analysis for metals revealed 2.6 mg/m^3 of iron oxide dust, below the NIOSH–REL of 5 mg/m^3. The remaining constituents were believed to be abrasive material (unidentified), trace amounts of other metals, and other unknown particulates. The grinding operation is done infrequently, but when performed the process occurs for about 4 to 8 hours.

Although questionnaires were made available to all machine operators in each department, only 24 were returned. Because this is a low response rate, the inferences drawn from questionnaire analysis may not accurately represent the collective views of the machine operators.

In conclusion, NIOSH air sampling results indicated no elevated exposures to metalworking fluids that explains workers' health complaints. However, one worker's full–shift exposure to respirable dust and inhalable iron oxide dust approximated the ACGIH TLV of 3 mg/m^3 and approach the ACGIH TLV of 5 mg/m^3, respectively. NIOSH investigators also noted potential safety and fire hazards.

RECOMMENDATIONS

1. To reduce potential fire hazards in Department #20, the EDMs and the Safety Kleen® degreaser tank should be separated by a minimum of 35 feet from the welding booth and other sources of sparks or flames. In accordance with OSHA regulations, the ensuing equipment layout should be such that no combustible source(s) is within 35 feet of an ignition source.[23] Additional welding shields or curtains should be considered at the welding booth to better isolate sparks created during welding.

2. Although only trace nitrosamine concentrations were detected in metalworking fluids at machine workstations, this issue should still be discussed with employees. While nitrosamines were not detected on air samples collected, trace levels were present in bulk metalworking fluids. Thus, dermal exposure may pose a health hazard to workers.

3. An emergency eyewash station or shower should be located in the general vicinity of chemical processes (e.g., EDMs, degreasing) where there is potential for workers to experience chemical splashes to the face or eyes. The American National Standards Institute (ANSI) recommends that emergency eyewash and shower equipment be located so that it requires workers no more than 10 seconds to reach and should be within a travel distance no more than 100 feet from the hazard.[26]

4. Ventilation control measures should be implemented in the welding area to control welding fume emissions. Movable direct exhaust ventilation hoods (see Appendix A) should be used for welding processes to effectively control emissions at the welding source before reaching a worker's breathing zone.

5. The preferable means of reducing worker exposure to metal dust is with the use of local exhaust ventilation. If feasible, a hand grinding bench or an extractor head for small radial grinders should be considered (see Appendix B and C). Respiratory protection should only be used as an interim control measure or as an additional means of reducing worker exposure, when engineering controls are not feasible.

6. Although not confirmed by laboratory analysis, machine hydraulic fluid appeared to have leaked into the metalworking fluid reservoir of a lathe located in Department #20. Hydraulic fluid is a much less refined oil than metalworking fluids and can contain polyaromatic hydrocarbons (PAHs). Because PAHs are carcinogenic in humans, actions should be taken to remedy the hydraulic fluid leak to ensure workers are protected against potential PAH exposure. Inspection for hydraulic fluid leaks should be part of the company's machine maintenance program.

7. Machine operators were provided with gloves made of chlorinated natural latex rubber for dermal protection against the metalworking fluid and its constituents (i.e., diethanolamine). Unfortunately, natural latex rubber does not offer resistance to permeation by metalworking fluids and constituents. This may result in skin contact and promote occupational dermatitis.[27] Instead, workers should be provided with protective gloves made of nitrile rubber, which are effective against permeation by metalworking fluids and its constituents. Also, adequate sleeve length is necessary to protect forearms from exposure to metalworking fluids. Minimizing dermal exposure to metalworking fluids can be accomplished by instructing workers to wear

proper protective clothing (i.e., gloves, aprons) and to practice good personal hygiene by thoroughly washing hands, forearms, and other contact areas during breaks and at the end of each work–shift. Extreme caution should be taken when selecting and wearing protective clothing and jewelry that may get caught in moving machinery that can result in serious injury.

8. As discussed during the closing conference, splash guards on three metalworking machines in Department #21 should be improved to effectively prevent metalworking fluids from splashing on workers. This can be accomplished by modifying existing splash guards or installing additional ones.

9. To improve hazard communication, copies of MSDSs could be displayed at electrical discharge machines, degreaser tanks, and other chemical processes. The presence of MSDSs could also aid in the event of emergency response.

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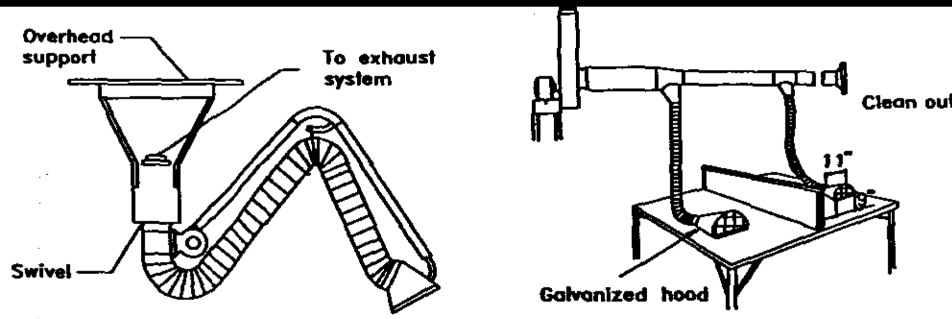
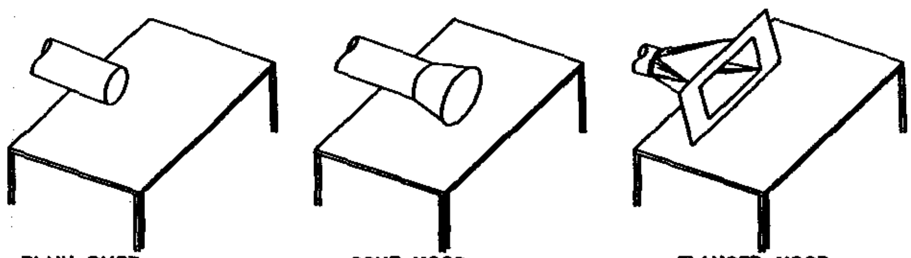
Appendix A
Selected Local Exhaust Ventilation Designs

Source:
Industrial Ventilation Manual, 20th Edition
American Conference of Governmental Industrial Hygienists[15]



FLEXIBLE EXHAUST CONNECTIONS



PLAIN DUCT | CONE HOOD | FLANGED HOOD

RATE OF EXHAUST

X,	Plain duct, cfm	Flange or cone, cfm
Up to 6	335	250
6-9	755	560
9-12	1335	1000

Face velocity = 1500 fpm
Minimum duct velocity = 3000 fpm
Plain duct entry loss = 0.93 VP_d
Flange or cone entry loss = 0.25 VP_d

Notes:

1. Locate work as close as possible to hood.
2. Hoods perform best when located to the side of the work.
3. Ventilation rates may be inadequate for toxic materials.
4. Velocities above 100-200 fpm may disturb shield gas.

GENERAL VENTILATION, where local exhaust cannot be used :

Rod, diam.	cfm/welder
5/32	1000
3/16	1500
1/4	3500
3/8	4500

OR

A. For open areas where welding fume can rise away from the breathing zone:
cfm required = 800 x lb/hour rod used

B. For enclosed areas or positions where fume does not readily escape breathing zone:
cfm required = 1600 x lb/hour rod used

For toxic materials, higher air flows are necessary and operator should use respiratory protection equipment.

Other types of hoods:
Bench, see VS-90-01
Booth, for design see VS-90-30
Q = 100 cfm/ft² of face opening

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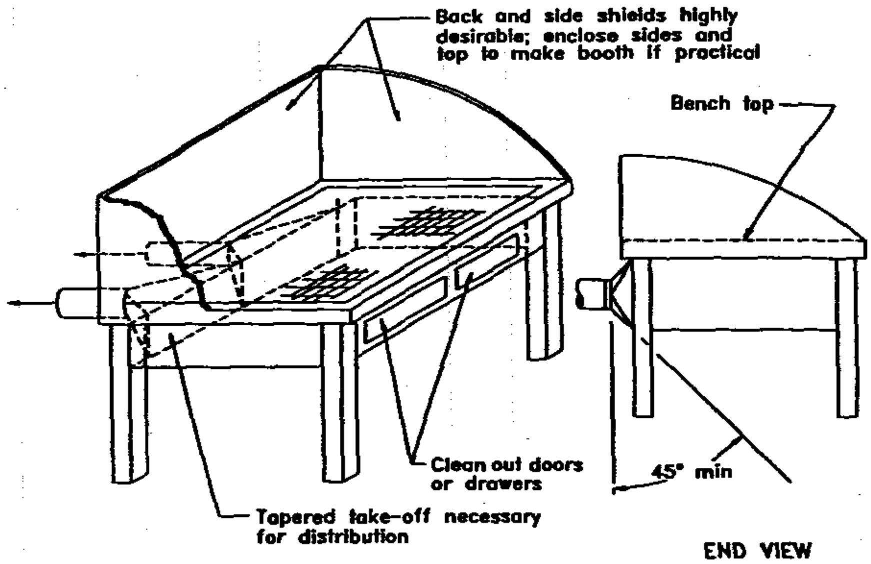
WELDING VENTILATION MOVABLE EXHAUST HOODS

DATE 1-91 FIGURE VS-90-02

Appendix B
Selected Local Exhaust Ventilation Designs

Source:
Industrial Ventilation Manual, 20th Edition
American Conference of Governmental Industrial Hygienists[15]



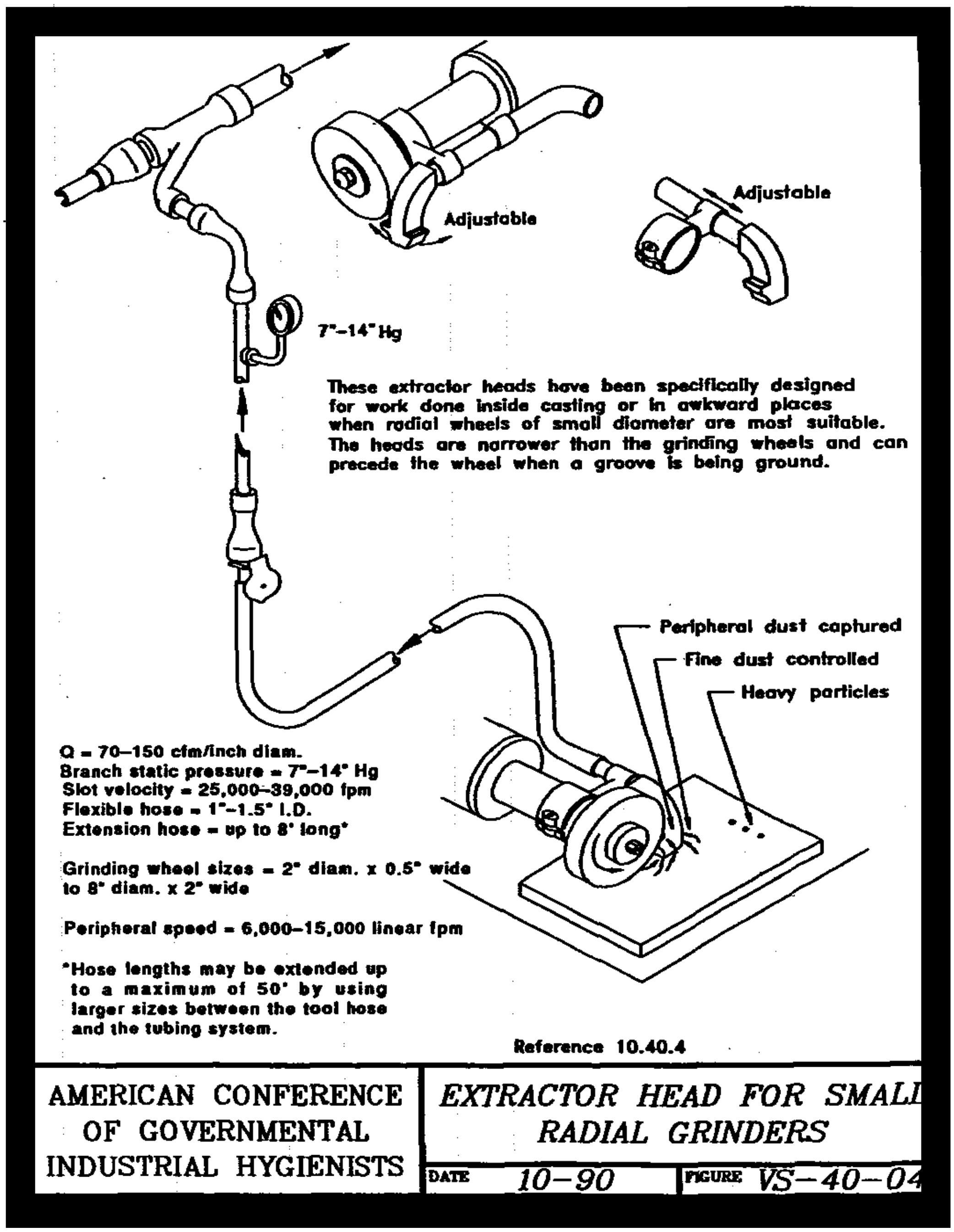
$Q = 150\text{–}250\ cfm/ft^2$ of bench area
Minimum duct velocity = 3500 fpm
$h_e = 0.25\ VP_d$
If slots are used for distribution:
$h_e = 1.78\ VP_s + 0.25\ VP_d$

Notes:
1. If grinding in a booth, use 100 fpm face velocity.
2. For downdraft grilles in floor: $Q = 100\ cfm/ft^2$ of working area.
3. Provide equal distribution.
4. Provide for clean out

AMERICAN CONFERENCE OF GOVERNMENTAL INDUSTRIAL HYGIENISTS	*HAND GRINDING BENCH*	
	DATE *02–91*	FIGURE *VS–80–18*

Appendix C
Selected Local Exhaust Ventilation Designs

Source:
Industrial Ventilation Manual, 20th Edition
American Conference of Governmental Industrial Hygienists[25]



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