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I. SUMMARY

On March 1, 1994, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation from employees of DIAMET Corporation in Columbus, Indiana. The request concerned the occurrence of dermatitis and respiratory symptoms suspected to be associated with the application of a rust-preventative oil to finished metal parts. On August 8-9, 1994, NIOSH investigators conducted a site visit that included an opening conference with employee and management representatives, a walk-through survey of the manufacturing area, confidential employee interviews, and a review of company records. The NIOSH investigators also performed environmental sampling to determine employee exposures to airborne oil mist and petroleum distillates (naphtha), evaluated the effectiveness of current engineering controls, and photographed the affected skin surface of one employee previously diagnosed with dermatitis.

NIOSH investigators made themselves available to all employees involved in the application of the rust-preventative oil. As a result, informal confidential interviews were conducted on a voluntary basis with 15 employees during the site visit. Several of these employees attributed eye, skin, and upper respiratory irritation with exposure to the rust-preventative oil, and reported that these symptoms subsided when they were away from work. Environmental sampling was conducted to assess the airborne concentrations for the constituents of the rust-preventative oil. Twenty-two air samples were collected, 11 samples each for oil mist and naphthas. Paired personal breathing zone (PBZ) and area samples for both analytes were collected from four employees and four areas, for comparison purposes. Two additional PBZ samples for each of the analytes were collected from four other employees. Two consecutive, partial shift area samples had to be collected for both analytes from one of the areas to prevent sample overloading.

The oil mist concentrations for the PBZ samples ranged from below the minimum quantifiable concentration of 0.10 milligrams per cubic meter of air (mg/m^3) to 0.29 mg/m^3, while the concentrations for the area samples from the spray applications ranged from 0.21 to 5.4 mg/m^3. The naphtha concentrations for the PBZ samples ranged from 5.9 to 33 mg/m^3, while the concentrations for the area samples ranged from 6.8 to 380 mg/m^3. Both the oil mist and naphtha concentrations were greatest on two of the partial shift samples collected at the manual spray station. Samples obtained from the automatic spray tables and a manual spray station indicated that the use of the automatic spray tables reduced the potential for exposure, and that employees applying the rust-preventative oil with manual spray bottles may periodically encounter oil mist and naphtha concentrations above the respective NIOSH recommended exposure limits (RELs). However, the calculated time-weighted average (TWA) concentrations for all the PBZ and area samples were below the NIOSH RELs of 5 and 350 mg/m^3 for oil mist and naphthas, respectively. Even though the recently implemented engineering controls (i.e., process enclosure) effectively reduced the potential for airborne exposure to the rust-preventative oil, the evaluation of the automatic spray tables installed by DIAMET revealed design deficiencies such as the inappropriate application of local exhaust ventilation (i.e., a slotted hood outside of the enclosure) that limited the effectiveness of the system.

The review of photographs taken of one employee's affected skin surface and medical records from the dermatologist's evaluation of this employee indicated findings consistent with nonspecific dermatitis in which job-related oil exposure played an exacerbating role. Review of employee health records for ten DIAMET employees revealed diagnoses that included hand dermatitis (five employees), hand and face dermatitis (two), respiratory irritation (two), and nasal irritation (one). In all cases, the rust-preventative oil was listed as a possible cause of the health problem.

Results of the environmental sampling indicated that the greatest potential for airborne exposure to the rust-preventative oil occurs during manual spray applications. Although the TWA concentrations for the PBZ and area samples did not exceed the relevant evaluation criteria for oil mist and naphthas, partial shift samples collected during the manual spray application indicated that employees performing this task may be periodically exposed to airborne concentrations above these criteria. Results also indicated that the automatic spray tables dramatically reduce the potential for airborne exposure to the rust-preventative oil. However, an evaluation of these tables revealed design deficiencies that could be modified to improve their effectiveness. Review of medical and employee health records revealed that from June 1993 to June 1994, ten employees presented dermatitis and respiratory tract irritation that was considered by an occupational health clinic's personnel to be related to the rust-preventative oil. Recommendations to reduce exposures are presented in Section VIII of this report.

KEYWORDS: SIC 3714 (Motor vehicle parts and accessories), oil mist, petroleum naphtha, petroleum distillates, dermatitis, respiratory irritation, rust-preventative, personal protective equipment, engineering controls.

II. INTRODUCTION

On March 1, 1994, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request for a health hazard evaluation (HHE) from employees of DIAMET Corporation in Columbus, Indiana. The request detailed concerns about the occurrence of dermatitis and respiratory symptoms suspected to be associated with the application of a rust-preventative oil to finished metal parts. On August 8-9, 1994, NIOSH investigators conducted a site visit that included an opening conference with employee and management representatives, a walk-through survey of the manufacturing area, confidential employee interviews, and a review of company records. The NIOSH investigators also performed environmental sampling to measure employee exposures to airborne oil mist and petroleum distillates (naphtha) and evaluated the effectiveness of current engineering controls, such as the use automatic spray tables to apply the rust-preventative oil.

III. BACKGROUND

DIAMET Corporation opened its Columbus, Indiana, plant in 1988 and currently employs approximately 210 workers. DIAMET manufactures sintered, metal machinery components using a powder metallurgy process. This process allows the manufacture of complexly shaped components and oil-impregnated sleeve bearings using various alloys of nickel, copper, iron, graphite, and carbide. These components are used in automobiles, office equipment, and electrical appliance applications.

Fine metallic powders are mixed to form different alloys according to customer specifications. Using a compacting press, the powders are formed into specific shapes in dies under high pressures. The materials are then sintered by heating them for 1 to 3 hours at approximately 2000 degrees Fahrenheit (°F) in a nitrogen-atmosphere furnace. The actual temperatures vary depending on the type of alloy being heated. The sintering process produces a hard component that is then sized under high pressure using other compacting presses. Depending on the customer specifications, some of the components are also treated with a steam process to further harden the part and to create controlled surface oxidation, which helps to prevent future oxidation. The components are then machined to specifications using surface grinders which produce precise tolerance levels and smooth finished surfaces. Final finishing to remove any metal burrs is completed using steel brushing, vibration, and tumbling. After the final finishing, the parts are washed with Freon®, dried, and undergo automatic gauging to comply with the quality control/quality assurance program. The parts are then manually inspected by material handlers and treated with the rust-preventative oil before packing. Packers also apply the rust-preventative oil to the parts as needed. Employees generally work 12-hour shifts, and approximately 24 material handlers and packers are involved with the application of the rust-preventative oil during a work week.

At the time of this investigation, the rust-preventative oil was applied using either an automatic spray table or a manual spray bottle. DIAMET was continuing to implement engineering controls, such as the automatic spray table, to both improve application of the rust-preventative oil and prevent employee exposure. The rust-preventative oil was originally applied using a dip tank. This procedure was not satisfactory because excess oil prevented the observation of flaws. The dipping procedure was then replaced with manual spraying. This procedure satisfied customers, but the procedure did not provide consistent coverage and increased employee complaints. To correct the problem, DIAMET began investigating application with the automatic spray tables. The spray tables were purchased and received in late 1993, but were not installed until May 1994 because modifications were needed. DIAMET was currently planning further improvements to the automatic spray tables, as well as the installation of additional units.

At the time of the NIOSH investigation, the automatic spray tables consisted of a grilled rotating base and spray nozzles, all of which were enclosed. Operators manually placed parts onto the rotating base outside the enclosure. As the grilled base rotated, parts passed into the enclosure and were introduced to the oil mist from the spray nozzles. After the oiled parts passed through the enclosure, operators removed the parts and placed them into the appropriate containers. In an attempt to reduce concentrations of observed escaping oil mists (from the enclosure) and potential exposures, DIAMET designed a local exhaust ventilation system at the enclosure entry and exit points. The local exhaust ventilation system consisted of polyvinyl chloride (PVC) piping connected to a small centrifugal fan. The escaping oil mist was captured through a 1 foot long (½ inch width) slot in pipes that ran parallel to both the entry and exit. Air from each of these local exhaust ventilation systems was ducted back into the plant through individual vertical PVC pipes, approximately 12 feet in height.

IV. METHODS

During the opening conference, the scope of the request, the planned environmental sampling, the components of the medical evaluation, and the engineering controls being implemented by DIAMET were discussed. Company records required for NIOSH review were also identified. Copies of these records, which included employee health and medical records and the results of previous environmental sampling, were requested and reviewed.

A. Environmental Evaluation

On August 9, 1994, the NIOSH investigators performed environmental sampling to determine employee exposures to airborne oil mist and petroleum distillates (naphtha). The environmental sampling was conducted to measure the airborne concentrations of the constituents of the rust-preventative oil. According to the Material Safety Data Sheet (MSDS), the rust-preventative oil is composed of petroleum distillates (naphtha), petroleum lubricating oil base stock, and sulfonic acid as petroleum barium salts. Personal breathing zone (PBZ) and area air samples were collected for the major components, oil mist and naphthas, using two different NIOSH analytical methods.[1] The PBZ samples were collected from eight material handlers and packers, who were involved in the application of the rust-preventative oil. The employees rotated between job tasks and different production lines throughout their shifts, so they would rotate between application stations that employed either manual spraying or the automatic spray tables. Therefore, general area samples were collected from locations near two of the automatic spray tables and one of the manual spray stations to determine the relative potential exposures from the different types of application. A background general area sample was also collected from a location away from the spray applications.

Separate samples for both oil mist and naphthas were collected from each area and four of the eight employees. Only one sample for either oil mist or naphthas was collected from the other four employees. Two of these employees worked a rotation schedule, while the other two were packers who remained at a location adjacent to each other throughout their shifts. Bulk samples of the rust-preventative oil were also collected for use during sample analysis.

The samples for oil mist were collected using 37 millimeter (mm), mixed cellulose ester membrane (MCE) filters with an 8 micron (µm) pore size. These filters were attached via Tygon® tubing to Gilian®, Model No. HFS 513A, hi-flow personal sampling pumps calibrated at a flow rate of 2.0 liters per minute

(Lpm). These filters were then analyzed for oil mist by infrared spectrophotometry following NIOSH Method 5026.[1] Each filter was transferred with tweezers into a scintillation vial and extracted with 10.0 milliliters (mL) of Freon 113®. The resultant solutions were analyzed at an absorbance modeled against standards prepared from the liquid oil bulk samples obtained from DIAMET to determine oil mist concentrations.

The air samples for naphtha were collected using standard 150 milligram (mg) activated charcoal tubes. These sorbent tubes were attached via Tygon® tubing to Gilian®, Model No. LFS 113 DC, low-flow personal sampling pumps calibrated at a flow rate of 200 mL per minute (mL/min). These sorbent tubes were then analyzed by gas chromatography according to NIOSH Method 1550.[1] The samples were desorbed for 30 minutes in 1.0 mL of carbon disulfide. Aliquots of the resulting solution were analyzed with a Hewlett-Packard, Model 5890 II, gas chromatograph equipped with a flame ionization detector (GC/FID). Standards prepared from the bulk samples of the rust-preventative oil were used to determine the naphtha concentrations.

B. Engineering Evaluation

The engineering evaluation consisted of a review of the current oil mist control applications; specifically, the local exhaust ventilation systems employed on the automatic spray tables. The rationale, design, and operating parameters of these systems were determined through discussions with management and the engineering staff. The efficacy of these individual local exhaust systems was also assessed through direct observation and the use of chemical smoke to determine surrounding air flow patterns.

C. Medical Evaluation

During August 8-9, 1994, the NIOSH investigators made themselves available to all employees involved in the application of the rust-preventative oil. As a result, informal confidential interviews were conducted on a voluntary basis with 15 employees during the site visit. The investigators also photographed the affected skin of one employee previously diagnosed with dermatitis. These photographs and the employee health and medical records were later reviewed by a NIOSH dermatologist.

V. 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 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: 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] 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 are the more protective criteria. 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.

A. Oil Mists

The evaluation criteria for oil mists are based primarily 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 an irritant dermatitis or a folliculitis (an irritation of hair follicles). 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. These criteria were established 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. The role of additives and oil fume from partial heat-decomposition has yet to be completely evaluated experimentally, and therefore, NIOSH suggests that these criteria may not be applicable to all forms of oil mists.[5] In addition, the ACGIH Notice of Intended Changes has proposed a TLV of 0.2 mg/m^3 and a confirmed human carcinogen designation for mists of mildly refined mineral oils containing polynuclear aromatic hydrocarbons.[3]

B. Petroleum distillates (Naphtha)

Petroleum distillates (naphtha), also referred to as refined petroleum solvents, is a general term used to describe a class of complex hydrocarbon solvent mixtures.[11] Petroleum naphtha is composed mainly of aliphatic hydrocarbons (as distinguished from coal tar naphtha, which is mixture composed primarily of aromatic hydrocarbons).[12,13] Petroleum distillates are further characterized by the boiling range of the mixture; typically, the larger hydrocarbon chain length equates to a higher distillation fraction.[11] Specific names for some typical petroleum distillate mixtures are presented below, in order of increasing temperature of boiling ranges: petroleum ether, rubber solvent, varnish makers' and painters' (VM & P) naphtha, mineral spirits, Stoddard solvent, and kerosene.[11] Boiling ranges of these mixtures overlap, therefore, some of these mixtures contain the same hydrocarbons but in different proportions.

Effects from exposure to refined petroleum solvents are primarily acute, unless significant amounts of substances that have chronic toxicity are present, such as benzene or glycol ethers. Epidemiologic studies have shown that exposure to similarly refined petroleum solvents (i.e., mineral spirits, Stoddard solvent) can cause dry throat, burning or tearing of the eyes, mild headaches, dizziness, central nervous system (CNS) depression, respiratory irritation, and dermatitis.[11]

Petroleum naphtha appears to have weak skin cancer causing potential in laboratory mice.[14] The IARC has determined that there is only limited evidence implicating petroleum naphtha as a carcinogen in animals and insufficient evidence associating exposure to petroleum naphtha and the development of cancer in humans.[15] However, depending upon the manufacturing process, petroleum naphtha may sometimes contain varying amounts of aromatic hydrocarbons such as benzene.

Many petroleum naphtha mixtures used throughout industry contain *n*-hexane or other simple alkanes. Prolonged and repeated exposure to *n*-hexane may damage peripheral nerve tissue and result in muscular weakness and loss of sensation in the extremities.[11] Studies indicate that some solvents, such as methyl ethyl ketone (MEK), may potentiate peripheral neuropathy caused by *n*-hexane.[16]

Since naphthas are mixtures of aliphatic hydrocarbons, the evaluation criteria are based upon the mixture composition in relation to the most commonly available products - petroleum ether, rubber solvent, VM& P naphtha, mineral spirits, and Stoddard solvents. The NIOSH REL for all of the petroleum distillate mixtures is 350 mg/m^3 as a full shift TWA exposure, for up to 10 hours per day, providing a

40-hour work week is not exceeded. In addition, a ceiling concentration limit (for a 15 minute duration) of 1800 mg/m^3 is recommended by NIOSH. The OSHA PEL for petroleum distillates (naphtha) is 2000 mg/m^3 TWA, while the PEL for Stoddard solvents is 2900 mg/m^3. The ACGIH has also established a TLV-TWA (for eight hours) of 1590 mg/m^3 for rubber solvent (naphtha), 1370 mg/m^3 for VM & P naphtha, and 525 mg/m^3 for Stoddard solvents.

VI. RESULTS AND DISCUSSION

A. Work Practices and Personal Protective Equipment

The workers involved with the rust-preventative oil application were provided personal protective equipment which included safety glasses and gloves. In addition to the gloves, barrier creams were used by some employees. Two types of protective gloves were provided which included nitrile gloves and nitrile-laminated polycotton gloves with ventilated backs. During the investigation, it was observed that some of the these gloves needed to be replaced because they had small tears. Several employees reported that it was sometimes difficult to obtain replacement gloves because they had to request them through a team leader. In contrast, other employees indicated that they could obtain new gloves as needed. However, none of the employees indicated that they had received training regarding the use of protective gloves.

B. Environmental

The results of the exposure monitoring performed for oil mist and naphthas during the application of the rust-preventative oil are presented in Table I. Twenty-two samples were collected; 11 samples each for both oil mist and naphthas. Of the 11 samples collected for each analyte, six were PBZ and five were area samples. Paired PBZ samples for both analytes were collected from four individuals applying the rust-preventative oil, while one sample for either oil mist or naphthas was collected from four additional employees. Two of these employees were packers who remained in the same location throughout their shifts. Paired area samples for oil mist and naphthas were also collected from four locations which included two of the automatic spray tables, one manual spray station, and a background location away from the oil application operations. Two consecutive partial shift samples were collected from the area near the manual spray station to prevent overloading of the sample media. All of the individual sample results and the calculated TWA concentrations for the two partial shift sample pairs from the manual spray operation are included in Table I.

The airborne concentrations for oil mist ranged from trace to 5.4 mg/m^3. The concentrations for the PBZ samples were all lower than the concentrations for the area samples, except for the background area sample which only had a trace amount of oil mist detected. The oil mist concentrations for the PBZ samples ranged from trace to 0.29 mg/m^3, while the concentrations for the area samples ranged from 0.21 to 5.4 mg/m^3. The oil mist concentrations were greatest at the manual spray station. The concentrations for the two consecutive partial shift samples collected from this station were 5.4 and 2.2 mg/m^3 with a TWA concentration, calculated over the entire sampling period, of 4.3 mg/m^3. One of these partial shift samples had a concentration that was above the established evaluation criterion of 5 mg/m^3; however, the calculated TWA of 4.3 mg/m^3 was below this criterion. This indicates that employees applying the rust-preventative oil with the manual spray bottle may at times be exposed to oil mist concentrations above 5 mg/m^3. The samples with trace concentrations had detectable amounts of oil mist between the analytical limit of detection (LOD) and limit of quantitation (LOQ). The LOD and LOQ for oil mist were 20 and 69 micrograms per sample (µg/sample), respectively, which equate to a minimum detectable concentration (MDC) and minimum quantifiable concentration (MQC) of 0.03 and 0.10 mg/m^3, respectively, assuming a sampling volume of 700 liters.

The airborne concentrations for naphtha ranged from 3.3 to 380 mg/m^3. In contrast to the oil mist results, most of PBZ samples had naphtha concentrations that were as high, or higher, than the area samples collected near the automatic spray tables. However, the area samples collected from the manual spray station were still much higher than the other samples. The naphtha concentrations for the PBZ samples ranged from 5.9 to 33 mg/m^3, while the area samples collected from the two automatic spray tables were 6.8 and 10 mg/m^3. The concentrations for the two consecutive partial shift samples collected from the area near the manual spray application were 240 and 380 mg/m^3. The TWA concentration for these samples, calculated over the entire sampling period, was 330 mg/m^3. All the naphtha samples were below the OSHA PEL of 2000 mg/m^3 and the ACGIH TLV of 525 mg/m^3. However, the airborne naphtha concentration for one of the partial shift area samples from the manual spray application did indicate that employees performing this operation may encounter periodic excursions above the NIOSH REL of 350 mg/m^3 for petroleum distillate mixtures. However, the TWA concentration of 330 mg/m^3 for these two consecutive samples collected during this operation only approached the NIOSH REL.

As stated previously in this report, the evaluation criteria are typically based on 8-hour workdays, or up to 10-hour workdays for NIOSH RELs, and 40-hour workweeks. Since employees applying the rust-preventative oil generally worked 12-hour shifts, it should be noted that adjustment of the evaluation criteria was considered to account for the longer exposure times associated with this type of work schedule. However, in this case, a reduction of the evaluation criteria was not required for neither oil mist or naphtha as determined using the OSHA adjustment model.[17]

The results of the environmental sampling indicated that the greatest potential for airborne exposure to the rust-preventative oil occurred during manual spray applications. These results also indicated that the automatic spray tables dramatically reduce the potential for airborne exposure to the rust-preventative oil when compared to the manual spray applications. The airborne concentrations determined for both oil mist and naphtha indicated that employees applying the rust-preventive oil with the manual spray bottle may periodically encounter airborne concentrations above the relevant evaluation criteria for these contaminants and that these airborne contaminant concentrations may comprise the greatest contribution to an employee's overall exposure. Employees involved with the application of the rust-preventative oil rotate between production lines that utilize both manual and automatic application during their 12-hour shifts. The effect of this job rotation is a reduction in the overall exposure experienced by a given employee because periods of their shifts are spent doing jobs where the potential for exposure has been reduced by engineering controls, such as the automatic spray table.

C. Engineering Controls

The engineering controls implemented by DIAMET effectively reduced the potential for airborne exposure to the rust-preventative oil. However, the evaluation of the automatic spray tables did reveal design deficiencies that limited their effectiveness. These controls were installed in an attempt to reduce operator exposures to the oil mists coming from the process line. While enclosing the misting operation conforms to a key precept of control technology engineering, other design principles were omitted or inappropriately applied. Specifically, the pressure differential from the enclosure to the ambient air, and the application of local exhaust ventilation at the enclosure entry and exit points are less than optimal designs.

Local exhaust ventilation is defined by the ability of the control device to capture airborne contaminants at the source. Hood designs are classified by the hood location relative to the contaminant generation point or escape. A simple classification scheme defines three categories: enclosures, exterior hoods, and receiving hoods.[18]

Enclosures are the most desirable form of local exhaust control because the contaminants are released inside the hood. By providing a slight negative pressure in the enclosure interior, an air flow pattern from the ambient air into the hood is created that ensures that contaminants will not escape. When the static pressure in an enclosure is different (higher or lower) than the static pressure in the ambient air, a pressure differential is created between the two environments. As a consequence, air will move from the higher static pressure to the lower static pressure. The introduction of air, by the spray nozzles, into the enclosure creates a positive pressure differential relative to the ambient air resulting in air movement from and out of the enclosure. Direct observation of the oil application process revealed the inability of the enclosure to contain generated oil mists. The application of local exhaust ventilation directly outside the current spray enclosure may have contributed to the resultant escape of oil mists by significantly reducing the static pressure at the enclosure entry and exit points. Observation of the local exhaust ventilation system during operation revealed an inability of the system to capture all oil mist particles that escaped the enclosure.

Two additional factors not related to design, but which contributed to the reduced effectiveness of the engineering controls, were also observed. On one of the automatic spray tables, the investigators observed that the duct which connected the fan to the exhaust openings was partially detached. This factor significantly reduced the negative static pressure in the duct created by the fan, which therefore significantly reduced the capture efficiency of the local exhaust system. The other observation was the use of cooling fans. Cooling fans can create air currents that can also reduce the capture efficiency of the local exhaust system. This effect is dependent on the velocity and angle of the air flow from the cooling fan relative to the local exhaust opening.

D. Medical

According to DIAMET's records for OSHA-recordable injuries, there were four reported incidents of rash both in 1993 and in 1994. For respiratory injuries, one case was reported in 1993 while three cases were reported in 1994. Since DIAMET does not have a medical professional on staff, these records are maintained by the Human Resource Department. In the event of a recordable injury or other medical condition, the employee notifies Human Resources, and, if appropriate, is sent to a local occupational health clinic. In the case of employees reporting skin problems, the occupational health clinic can also provide a referral to a local dermatologist, if appropriate.

Fifteen employees from two of the scheduled shifts were interviewed either privately in a conference room or informally in the manufacturing area. Several employees associated eye, skin, and upper respiratory irritation with exposure to the rust-preventative oil, and indicated that these symptoms subsided when away from work. Several employees indicated that symptoms were most likely to occur after application of the rust-preventative oil by manual spraying. Employees also reported that the automatic spray tables helped prevent the occurrence of these symptoms, but that the automatic spray tables experience recurrent mechanical problems and are frequently not used.

Employee health records for ten employees were reviewed. These records included health evaluations conducted by the occupational health clinic from June 1993 to June 1994. The diagnoses included hand dermatitis (five employees), hand and face dermatitis (two), respiratory irritation (two), and nasal irritation (one). In all cases, the rust-preventative oil was considered by the occupational health clinic personnel as a possible cause of the health complaint. In one of these cases, a dermatologist's records indicated the diagnosis of a form of dermatitis in which job-related oil exposure played an exacerbating role. Recommendations from the dermatologist included the use of impermeable gloves with cotton liners and the frequent changing of such gloves to reduce exposure through damaged gloves.

The photographs taken of the affected skin surface of one employee previously diagnosed with dermatitis showed areas of erythema (redness), excoriated papules (scratched off skin bumps), and mild scaling involving the dorsal surface (backs) of the hands and fingers and lower forearms. The findings are consistent with a nonspecific dermatitis (inflammation of the skin). The many causes of this skin condition include exposure to irritants and/or allergens. In addition, the findings may be consistent with atopic (allergy-related) skin disease. A more specific cause of the dermatitis shown in the photographs could not be determined.

VII. CONCLUSIONS

The results of the environmental sampling indicated that the greatest potential for airborne exposure to the rust-preventative oil occurs during manual spray applications. Although the TWA concentrations for the PBZ and area samples did not exceed the relevant evaluation criteria for oil mist and naphthas, partial shift samples collected during the manual spray application indicated that employees performing this task may be periodically exposed to airborne concentrations above these criteria. The results also indicated that the installation of the automatic spray tables as an engineering control dramatically reduced the potential for airborne exposure to the rust-preventative oil, as compared to the manual spray applications. The evaluation of the automatic spray tables installed by DIAMET revealed design deficiencies that limited their effectiveness.

Review of medical and employee health records revealed that from June 1993 to June 1994, ten employees reported dermatitis and respiratory tract irritation that was considered by the occupational clinic personnel to be related to the rust-preventative oil. According to the MSDS, this product contains petroleum naphtha, petroleum lubricating oil, and sulfonic acid. Effects of overexposure to naphtha include skin and eye irritation and depression of the central nervous system. Specifically, skin contact may cause an irritant dermatitis by dissolving the natural protective oil on the skin.[19]

VIII. RECOMMENDATIONS

The following recommendations are based on the findings of this investigation and are offered to help reduce the potential for employee exposures to the rust-preventative oil and prevent future health problems.

1. The decision to replace or modify the existing local exhaust ventilation system should be based on the type of oil mist application (manual spray or automated spray nozzle), the level of exposure control desired, and the resources available to support any redesign. For control of oil mists generated by spray bottles (manual spray), the simplest approach would be based on a small paint spray booth design. For small paint spray booths, the American Conference of Governmental Industrial Hygienists (ACGIH) recommends a hood design air flow of 125 cubic feet per minute per square foot (cfm/ft^2) for face areas up to 4 ft^2 and 100 cfm/ft^2 for face areas over 4 ft^2.[20] The specific ventilation system (VS) print is shown in Figure 1.

2. Oil mist exposure from the automated spray nozzles can be reduced with modifications to the existing system. The original design intent of the process enclosure was to promote an environment capable of coating each manufactured part to a predetermined specification, and to minimize operator exposures to the generated oil mists. However, without exhausting air from the enclosure interior, effective control of the generated oil mists is limited. In addition, the two design concepts can conflict. Specifically, continuously exhausting air from inside the enclosure can limit the oil mist available to coat the manufactured product. Both design criteria can be satisfied by limiting the volumetric space occupied by the exhaust hood and optimizing the hood locations to the enclosure entry and exit points. An isometric view of the proposed design modification is shown in Figure 2. This design modification is similar to the ventilation system recommended by ACGIH for dishwashers (VS-912 as shown in Figure 3).[20] However, please note that the canopy hood recommended in the first panel uses thermal convection currents created by a dishwasher and should not be applied to the proposed system. The latter two panels are generally applicable with modification. To test the feasibility of the proposed system, enclose the current slotted pipe on all sides (except the bottom). This type of baffling will focus the efforts of the current system on preventing the escape of oil mist from the enclosure. Based on a successful determination, design modifications to optimize the efficiency of the proposed system can then be initiated.

3. Cooling fan placement, which produces air current patterns in the capture zone of the local exhaust ventilation system, may impede the system's ability to efficiently remove contaminants which escape from the spray table enclosure. Therefore, the use of cooling fans should be monitored to prevent placement where they can adversely affect the capture efficiency of the local exhaust ventilation system.

4. Employees involved with the application of the rust-preventative oil should receive basic training in the operation of the automatic spray tables. This would assist employees in recognizing when these systems are not operating properly.

5. The use of personal protective equipment (PPE) should be continued to prevent dermal overexposure to the rust-preventative oil. The nitrile rubber gloves currently used offer appropriate protection against petroleum naphtha. DIAMET should institute a training program to ensure that all employees have knowledge of the hazards associated with exposure to the rust-preventative oil, the proper use of PPE, and the need for appropriate sanitary practices. The PPE training should include the proper use and maintenance of the PPE, as well as the proper donning and removal of PPE. The PPE should be easily accessible, and PPE which is torn or soaked with oil should be immediately replaced.

6. Any direct contact with the rust-preventative oil should be immediately washed off with soap and water. The use of proper personal hygiene practices should also be encouraged.

7. DIAMET should be wary of employee reliance on barrier creams for skin protection from solvents, because the benefit of barrier creams is controversial.[21] They must be applied regularly and may contain additives which can actually cause or induce dermatitis in some individuals. DIAMET should ensure that all employees properly use the protective nitrile gloves.

8. Employee health complaints should be fully evaluated by a health care professional. DIAMET should review their current worker health program to ensure that it is adequately addressing the needs of the employees.

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Copies of this report have been sent to:

1. DIAMET Corporation
2. Employee Representatives
3. Confidential Requestors
4. OSHA, Region V

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.

TABLE I

Airborne Oil Mist and Naphtha Concentrations

DIAMET Corporation
Columbus, Indiana
HETA 94-0179
August 9, 1994

Sample Description*	**Sample Volumes (Liters)****	**Oil Mist (mg/m^3)**	**Naphtha (mg/m^3)**
Material handler on Lines 2 & 3	748 / 77	0.25	14
Material handler on Lines 2 & 6	768 / —	0.12	—
Material handler on Lines 3 & 2	741 / 76	0.15	5.9
Material handler on Lines 5 & 2	729 / 75	0.29	17
Packer on Lines 6, 5, & 3	— / 64	—	8.9
Packer on Lines 6 & 5	701 / 73	0.12	7.8
Packer on Line 3‡	450 / —	trace	—
Packer on Line 3‡	— / 46	—	33
Spray table on Line 2 - Area	743 / 76	0.65	10
Spray table on Line 6 - Area	708 / 72	0.21	6.8
Manual spray station on Line 5 - PS Area	*483 / 50*	*5.4*	*380*
"	*246 / 25*	*2.2*	*240*
TWA for manual spray station on Line 5	729 / 75	4.3	330
Plant background - Area	681 / 69	trace	3.3
Evaluation Criteria	NIOSH OSHA ACGIH	5 10 STEL 5 5	350 1800 C 2000 525

* Samples are personal breathing zone unless noted as "area" samples.
** Sample volumes for both analytes in liters as follows: oil mist / naphtha.
‡ Samples were collected from two adjacent employees who remained at this location throughout the sampling period.
trace - detected value was between the minimum detectable concentration (MDC) and minimum quantifiable concentration (MQC) of 0.03 and 0.10 mg/m^3, respectively, assuming a sampling volume of 700 liters.
PS - consecutive partial shift sample
TWA - time-weighted average concentration for the two consecutive partial shift samples collected from the manual spray station on Line 5.

mg/m^3 - milligrams per cubic meter; STEL - short-term exposure limit; C - ceiling limit.