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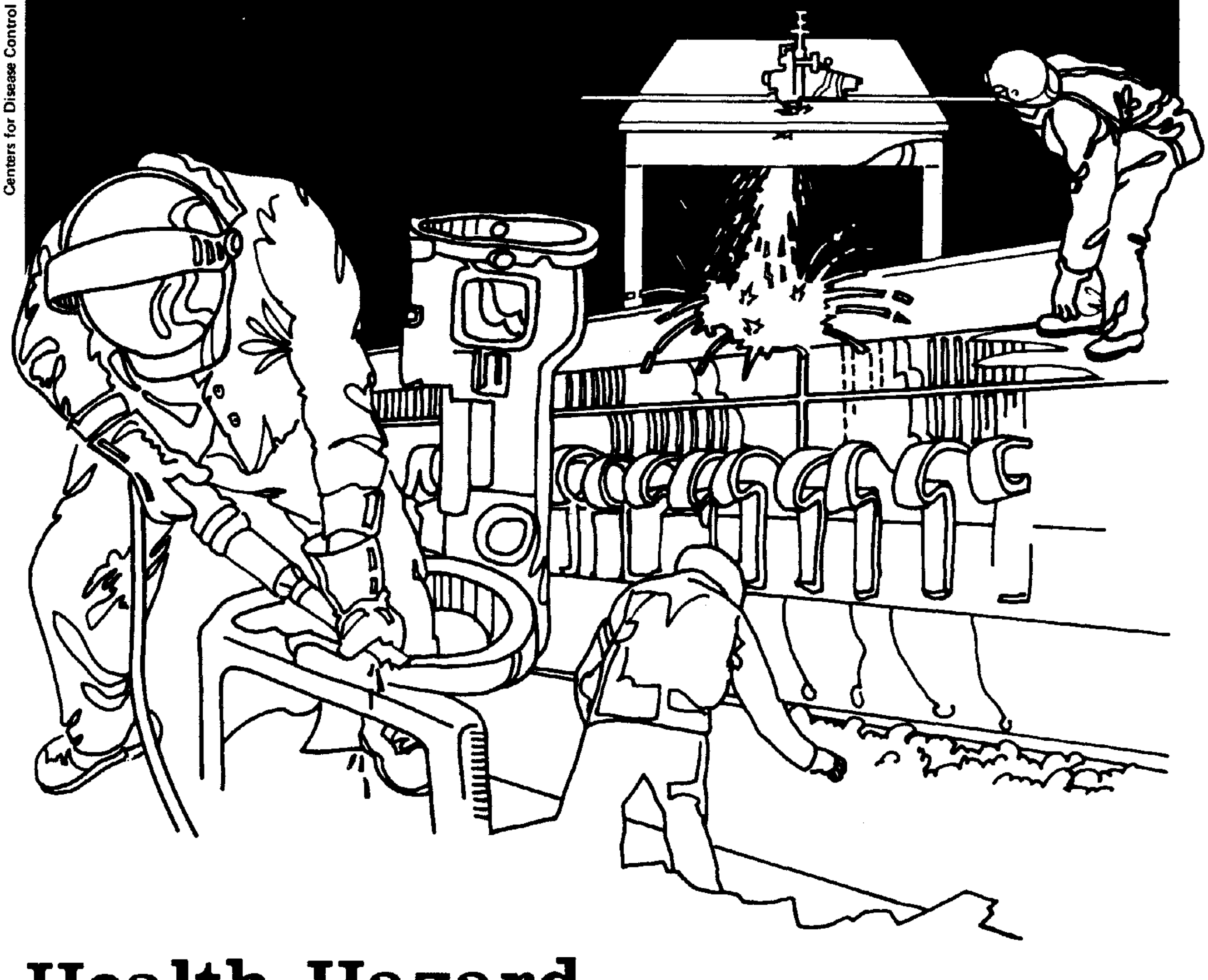

Health Hazard Evaluation Report

TA 80-095-1002
CATERPILLAR TRACTOR CORPORATION
YORK, PENNSYLVANIA

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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Caterpillar Tractor Corporation
York, Pennsylvania

NIOSH INVESTIGATORS:
Dean Baker, M.D., M.P.H.
Frank A. Lewis, IH

I. SUMMARY

In August 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Directorate of Technical Support, Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, for medical and technical assistance at the Caterpillar Tractor Company of York, Pennsylvania. The hourly employees' representative at the facility - the United Auto Workers, Local 786 (UAW) - had become concerned about eye, nose, and throat irritation appearing among up to one half of 220 machine operators in the D-2 building at the facility. They filed a complaint and OSHA responded by conducting inspections during September 1979 and January 1980. No causative chemical was identified and OSHA requested that NIOSH investigate the possibility that the respiratory problems were due to a biological agent growing in the machine coolants.

During September 1980, NIOSH visited the facility for a walk-through inspection. Fifteen employees in the D-2 building were interviewed; they reported that the eye, nose and throat irritation problems had been gradually improving since early 1980 as a result of recently increased general ventilation. No one was currently symptomatic; therefore, it was decided to monitor the health complaints prospectively for three months.

During January 1981, bulk samples of the water-based coolants were taken from the three machine lines. Area air samples were taken for ammonia, sulfur dioxide, hydrogen sulfide, hydrocarbons, and amines in each of the work areas over an entire work shift. Analyses of the bulk samples identified butyl carbitol, 2,6 di-t-butyl-p-cresol (BHT), aliphatic hydrocarbons (alkanes and alkenes), toluene, and xylene. All area air samples indicated no significant levels of air contaminants.

During the intervening three months, employees reported very few respiratory complaints due to the coolants. Twenty employees did report symptoms of upper respiratory tract irritation on one day following the addition of caustic soda and a biocide to a coolant solution. These symptoms resolved rapidly and have not recurred.

Based on the environmental and medical findings, NIOSH has determined that no significant health hazard exists at this work site. The previously reported symptoms were likely due to chemical additives to the coolant systems and to irritants produced by micro-organisms in the coolants. These symptoms have been substantially reduced as a result of increased general ventilation. Recommendations are made to continue the higher levels of ventilation, while taking further steps to decrease the growth of micro-organisms in the coolants.

KEYWORDS: SIC 3714 (Manufacturing Motor Vehicle Parts); machine coolant, mineral oil, aliphatic hydrocarbons, butyl carbitol, ammonia, hydrogen sulfide, amines, eye irritation, upper respiratory tract irritation.

II. INTRODUCTION

In August 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Directorate of Technical Support, Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, for medical and technical assistance in an OSHA investigation in the D-2 building of the Caterpillar Tractor Company facility in York, Pennsylvania. The request stated that a "number of workers" had complained of cough, upper respiratory tract irritation, nose bleeds, and dermatitis. Twenty-one of 31 workers interviewed by OSHA implicated machine coolant as the cause of their symptoms. However, industrial hygiene sampling had not revealed the specific etiology of the complaints. Concern was expressed that the complaints may have been due to a biologic hazard (micro-organism growth in the coolant systems).

On September 26, 1980, representatives of NIOSH visited the facility and conducted an opening conference, plant operations tour, and medical interviews of 15 employees. The dispensary log, a sample of employees' medical records, and quality control records for the coolants used in the D-2 building were reviewed.

Based on this visit, NIOSH verbally recommended increasing the general ventilation in the D-2 building and establishing specific records of employees' health complaints to be reviewed in three months by NIOSH. These records were maintained and forwarded to NIOSH in January 1981.

On January 15, 1981, the NIOSH industrial hygienist conducted environmental air sampling and obtained bulk samples of the fresh coolant and coolant solutions from the three machine lines.

III. BACKGROUND

Building D-2 of the Caterpillar Tractor Company facility in York, Pennsylvania, houses 337 persons engaged over three shifts in manufacturing a diesel fuel pump. The pump uses a sleeve metering system which requires close mechanical tolerance. Thus, the building is climate controlled to reduce temperature extremes, which can cause metal parts and equipment to contract or expand too much. The building is approximately 100 square yards with a 40 foot ceiling. The supplied air usually consists of 15 to 20% fresh air mixed with oil bath-filtered exhaust air.

Approximately 225 workers are engaged in machining operations, while 100 work in the assembly areas. Assembly operates on 2 shifts - 70 persons on the day shift and 28 on evenings. Machining operates on 3 shifts - 100 persons on the day shift, 75 on evenings, and 50 on nights. The machining operation uses several high speed automatic metal-cutting and grinding machines arranged on three lines - Lamb-Transfer, Kingsbury, and Grinding. Each line uses a separate recirculating coolant system to lubricate and cool the metal parts.

In the metal-cutting tools, a hardened tool edge removes chips by different mechanical means, such as turning, planing, shaping, drilling, milling, boring, and broaching(1). Most of this work generates heat, which if not dissipated, can cause welding of metal to tool point, loss of the hardness of the tool point and distortion of the workpiece. Grinding is a kind of cutting in which metal is removed by a grinding wheel containing abrasive grains that act as miniature cutters. Cutting and grinding fluids, also known as lubricoolants, have two primary functions: (a) to cool the workpiece and tool, thus preventing heat damage, and (b) to lubricate, thus reducing frictional heat at the chip-tool interface and between the tool and the freshly cut surface. Secondary functions are to flush away chips and swarf, reduce strain hardening of the machined metal, and protect the workpiece against rusting. Considerable quantities of these coolants may be needed on high-speed machines.

The three machine lines contain 1400, 6000, and 8000 gallons of coolant solution, respectively. The coolant in each line is sprayed onto the cutting heads and, via gravity, goes into underground or open troughs which return it to a central location. It is filtered and then fed back again to the machines.

All three lines currently use the same coolant - HOCUT 736, supplied by E.F. Houghton and Company of Philadelphia, Pennsylvania. It is basically composed of mineral oil, petroleum sulfonates, rust inhibitors, kerosene deodorant, and a bactericide(2). It is used diluted with water to approximately 25 to 1. The coolant solution in each line is monitored weekly by the company for concentration, pH, residue cleanliness, tramp and total oil, and amount of dissolved oxygen. Samples are also sent to E.F. Houghton and Company for assaying concentration, pH, percent oil, and bacterial and mold counts. Each line has defined "desirable routine levels and acceptable test ranges" for each parameter. Concentration is adjusted by adding new coolant or water; pH is kept above 8.2 by adding caustic soda; and excessive bacterial or mold counts are reduced by adding a biocide - Slimex 4416 - at 250 parts per million parts of coolant solution. When a system accumulates too much tramp oil, it becomes difficult to adjust and must be dumped, cleaned and recharged with a fresh coolant solution.

From April 1978 through December 1980, the lines were dumped and recharged 5 (Lamb-Transfer), 6 (Kingsbury), and 7 (Grinding) times, respectively. Some of these recharges were due to mechanical or other problems; otherwise, the coolant solutions were used an average of 6.5 months during this period.

Beginning gradually in 1978, personnel in the machining areas experienced intermittent burning and tearing of the eyes, sinus irritation, nose bleeds, and sore throats. Workers reported smelling ammonia, hydrogen sulfide, and "amine-like" odors. These complaints generally increased as the coolants aged within the systems. Since 1978, up to one-half of the personnel in the machining areas of the D-2 building have experienced some symptoms at least once.

In February 1979, the UAW, Local 786, filed an OSHA complaint about the reported health problems. Environmental personnel for the company met during February about the D-2 air environment and decided to improve housekeeping, increase the air exchange in the building and use deodorant in the coolant solutions. An industrial hygienist for the UAW visited the facility during March 1979, but discovered no specific etiology of the complaints.

The health complaints continued at a reduced level and, in September 1979, OSHA inspected the facility. Thirty-one workers were interviewed. They reported experiencing eye irritation(25), cough(20), dry, scratchy throat(19), nasal irritation(18), and dermatitis(17). "Twenty-one of those expressing complaints indicated that they felt their symptoms were due to machine coolant. Four felt their symptoms were from trichloroethane, and five, from oil mist."(3) The trichloroethane is occasionally used as a solvent to clean metal parts. OSHA conducted bulk sampling for qualitative analysis of air contamination from samples of the coolants. Hydrogen sulfide was detected arising from a sample of Kingsbury line coolant; no organics were detected coming from the other coolant solutions.

During January 1980, OSHA collected personal and area air samples for gas chromatography/mass spectrophotometry analysis. A personal sample using a charcoal tube on a Lamb-Transfer line machinist indicated the presence of 1,1,1-trichloroethane and 2-methyl undecane. No organics were detected on another personal air sample using silica gel on a Kingsbury line machinist. Area air samples were negative for 1,1,1-trichloroethane and hydrogen sulfide.

No etiology for the health complaints was definitely identified through the environmental sampling, and concern was expressed that the complaints may be due to a biologic hazard from micro-organism growth in the coolant systems. In June 1980, OSHA requested the assistance of NIOSH in evaluating these health problems.

IV. EVALUATION DESIGN AND METHODS

A. Environmental

Bulk and area air samples were collected in each of the three machine line areas on January 15, 1981, to evaluate the presence of potential upper respiratory tract irritants.

Bulk samples of each of the machine coolants were taken from the Lamb-Transfer, Kingsbury, and Grinding lines. These samples were analyzed for a characterization of the amines and hydrocarbons present in the solutions(4).

The amine analyses were done by gas chromatography using flame ionization detector (GC/FID) on a 6 foot, 10% K20M/2% KOH column. The coolants were injected directly into the column. For the hydrocarbon analysis, each of the coolants was extracted with carbon disulfide and analyzed by GC/FID. A 12 foot 20% SP-2100/0.1% carbowax 1500 column was used for this analysis. Further hydrocarbon analysis was done using infrared spectrophotometry. A portion of each coolant sample was heated to evaporate the water. An oily residue remained in each case. The infrared spectrum of each residue was taken as a neat film between salt plates.

Area air samples placed in each of the three machine line areas were taken for ammonia, sulfur dioxide, hydrogen sulfide, hydrocarbons, and amines. These are possible vapors or gases which could result from biological degradation of the coolants. Long-term sampling detector tubes specific for each vapor or gas were used with low-flow sampling pumps at a flow rate of 200 cubic centimeters per minute for entire work shifts.

B. Medical

During the initial site visit, the NIOSH medical officer interviewed 15 employees from the day and evening shifts. None currently had respiratory symptoms. They were asked about job descriptions, past health symptoms, and associations between past symptoms and particular environmental conditions. NIOSH obtained copies of the questionnaires administered by OSHA to a sample of 31 workers in the D-2 building. These questionnaires were analyzed for reported symptoms, environmental associations, and employees' smoking habits and histories of allergies.

NIOSH reviewed the Company's quality control records maintained on each of the coolant systems for the period from October 1978 through January 1981. These records include concentration of coolant, percent tramp oil, and pH. Quality control records maintained by E.F. Houghton and Company were reviewed for pH and bacterial and mold counts.

The NIOSH medical officer also reviewed the facility dispensary log and a sample of employees' medical records with the company physician. The dispensary log indicated that very few health complaints during the previous four months could be ascribed to air exposure within the D-2 building. However, representatives of the employees commented that many, if not most, instances of health symptoms were likely not reported to the medical office.

Because no employees were experiencing symptoms during the NIOSH visit, and the available medical records did not indicate any recent complaints, NIOSH recommended that specific medical records be maintained for 3 months for future NIOSH review. Employees were encouraged by both the Company and the UAW to report any health complaints. During January 1981, NIOSH contacted the physician at the facility and the health and safety officer of the UAW, Local 786, and obtained reports on health complaints during the intervening 3 1/2 months.

V. EVALUATION CRITERIA

Three possible sources of irritant gases or vapors in the D-2 building include chemicals added to the coolant systems; substances produced by micro-organisms growing in the coolant solutions; and chemical reaction products of substances added to the systems or produced within the solutions.

The fresh coolant is reported to be irritating to the eyes(2). Information provided by E.F. Houghton and Company indicates that HOCUT 736 contains known eye and skin irritants, such as butyl carbitol, formalin, and ethanolamines (5,6). Butyl carbitol is a severe irritant of the eyes of rabbits at a dose of 5 milligrams(7). It should be noted that mineral oil, the major constituent of the coolant, is not a primary skin or mucous membrane irritant.

Caustic soda (sodium hydroxide) - which is added to increase the pH - is a severe irritant of the eyes, mucous membranes, and skin(8). Contact with the eyes can cause conjunctivitis followed by conjunctival edema, ulceration, and scaring. The biocide added to decrease the bacterial and mold counts - Slimex 4416 - contains ethylene bisdithiocarbamate, which has an unpleasant odor and is a mild irritant(9). Vapors or mists of these compounds can be generated during circulation of the coolant solution and reach the eyes and skin of nearby operators.

Water-based coolant solutions normally contain 1 to 60 million bacterial organisms per milliliter of solution(10). Fungi or mold also grow in these coolants, but they do not generally represent a significant health risk(11). The bacteria do not usually cause skin or respiratory infections; however, they can generate noxious chemical vapors through their biological activity. In essence, the bacteria ingest chemicals in the coolant solution and, through metabolism, produce other chemicals as by-products. These by-product chemicals include irritating substances, such as hydrogen sulfide, ammonia and amines.

The biology of metal-working fluids has been studied for over 25 years and is well summarized by Bennett(10). The most important organisms found in these solutions are Pseudomonas species, Desulfovibrio sp., and coliform bacteria. The major organisms and their capabilities for growing in water-based coolants are indicated in Table 1. Pseudomonas sp. are virtually always present as the major organisms in coolants(12). Coliform bacteria survive in the solutions for only a limited time and do not appear to cause enteric infections(13). They are present in coolants only through repeated contamination. Desulfovibrio species are anerobic bacteria which can survive and grow only when there is no oxygen. Their metabolism is primarily based on reducing substances containing sulfur and, thus, they are known as sulfate-reducing bacteria. A major product of their metabolism is hydrogen sulfide(14).

The bacteria come from dirt in the air and on the metal stock and clothing of personnel. Primary sources include the soil, water, intestinal tracts, respiratory tracts, and the skin of animals (rodents). Initially, the Pseudomonas species and other facultative anerobic organisms breakdown unsaturated aliphatic and ring hydrocarbon chemicals in the coolant to 2-carbon fragments, which are converted to organic acids. Pseudomonas sp. do not produce significant odors; however, they destroy chemicals toxic to the sulfate-reducing bacteria, allowing them to begin growing.

The further growth of the sulfate-reducing bacteria results in the production of hydrogen sulfide, ammonia, and other volatile amines, which cause the rancid odors associated with aging coolants. In addition to generating foul odors, the overgrowth of bacteria causes corrosion of metals, deterioration of the circulating system, loss of stability and lubricating qualities of the coolant, and discoloration of the metal. Dermatitis is not a direct result of bacterial overgrowth(10). Pathogenic bacterial organisms, such as Staphylococcus sp. or Streptococcus sp., do not survive in the coolant solution. The organisms that do survive do not cause primary skin infections. They can produce chemical by-products which act as primary irritants and can cause secondary infections of already damaged skin.

Factors influencing the growth of bacteria include the ratio of coolant oil to water, pH, coolant temperature, amount of circulation of the solution, and the sulfur content of the solution. An oil to water ratio of 1:25 to 1:50 is ideal for maximum growth. A pH between 7 to 9 supports growth well, while there is no growth above a pH of 9.5. The optimum temperature for bacterial growth is 98°F. Since the source of heat is the operating metal-cutting and grinding tools, general bacterial growth is enhanced when a system is in operation more than one shift per day, maintaining warmer coolant temperatures. On the other hand, circulation of a solution aerates the water and suppresses the growth of the sulfate-reducing bacteria. These organisms grow best during weekends when the system is not in operation. Increased sulfur content provides more substrate for bacteria and increases the rate of growth. All these factors affecting the growth of the bacteria influence the working life of coolant solution.

The acceptable ranges of the above parameters are primarily determined by the required lubrication and mechanical properties of the coolant solution. The coolant oil to water ratio, pH, and amount of circulation can not be easily altered to minimize bacterial growth. The major mechanisms for preventing bacterial growth are including bactericidal chemicals in the fresh coolant and establishing good housekeeping procedures to minimize contamination. Overgrowth of bacteria or mold is reduced by adding more biocide - Slimex 4416 in this case - to the coolant system. Bennett recommends that, "Efforts should be made to keep the microbial content under ten million organisms per milliliter, because a coolant so controlled will usually give satisfactory service for several years."(10) Recently, he recommended that bacteria be maintained between 1 to 10 million organisms per milliliter(15). He commented that systems with greater than 10 million bacterial organisms per milliliter should be considered "out of control".

Fungi or mold are a different class of micro-organisms which also inhabit water-based coolants(10,11). They do not cause primary irritation of the eyes, nose, and throat, or primary dermatitis. Like bacteria, they may cause secondary infections of already damaged skin. Bacteria and mold compete for the same substrates so that the growths of the two types of micro-organisms are inversely related. Where bacteria predominate, molds are rarely present as active sub-populations(11). The major adverse consequence of fungal overgrowth is that the mold colonies can foul pumps or filtration equipment. The level of growth that will cause this problem depends upon the type of equipment used in a system and can not be predicted _a priori_. Bennett recommends that fungi be maintained between 200 to 2500 organisms per milliliter(10).

Finally, additional irritating substances can be produced through chemical reactions between the various additives to the system and the substances generated by the micro-organisms. These substances can not be predicted _a priori_ and should be assayed by periodically sampling the coolant system.

The environmental evaluation criteria for substances mentioned above or detected in the analysis of the bulk samples are shown in Table 2. The criteria are the (1) NIOSH recommended standards, (2) Threshold Limit Values (TLV) of the American Conference of Governmental Industrial Hygienists (ACGIH), and (3) Federal occupational health standards as promulgated by the Occupational Safety and Health Administration, U.S. Department of Labor (29 CFR 1910.1000).

VI. RESULTS AND DISCUSSION

A. Environmental

The three bulk samples of machine coolants were taken from the Lamb-Transfer, Kingsbury, and Grinding lines.

No low molecular weight amines were detected in the coolant samples; however, a broad band of unresolved peaks was found. These peaks were also detected in the carbon disulfide extracts of the samples. An extract of one coolant sample was analyzed by gas chromatography/mass spectrophotometry (GC/MS) for peak identification. A 25 meter, SP-2100, fused silica capillary column was used in the GC/MS analysis, but the high boiling components were still unresolved. Only butyl carbitol and 2,6 di-t-butyl-p-cresol (BHT) were positively identified. The other peaks were identified only as aliphatic compounds, possibly including alkanes (saturated hydrocarbons), alkenes (unsaturated hydrocarbons with one or more double bonds), and other unsaturated hydrocarbons.

The extract of the sample was then passed through a silica gel sep pak so that interfering components could be trapped and additional peaks identified by GC/MS. Although most compounds were not trapped, toluene, xylene, a molecular weight 120 aromatic compound, and C_{10}, C_{11}, and C_{12} n-alkanes could be identified.

The major peaks in each infrared spectrum were assigned to hydrocarbon bonds. These peaks matched those typically obtained for mineral oils in both wavelength and intensity. In addition, all three spectra contained three smaller absorbence peaks which were broad. These smaller peaks varied in intensity from sample to sample and may be due to a minor component which is present is all three samples. There was no evidence that carbonyl compounds were present.

Long-term detector tube samples collected over an entire work day for ammonia, sulfur dioxide, hydrogen sulfide, hydrocarbons, and amines did not show any significant concentrations of these gases or vapors.

Since none of the suspect gases or vapors were detected and a visual inspection of the workplace did not indicate any significant oil mist problem, NIOSH concludes that no significant air contaminant hazard currently exists. Analyses of the bulk samples revealed the presence of some irritating chemicals, such as butyl carbitol, toluene, and xylene. The broad spectrum of saturated and unsaturated aliphatic and aromatic hydrocarbons detected likely includes compounds capable of irritating the eyes and skin. Intermittent increases in the small quantities of these substances in the air could account for the reported health problems.

B. Medical

None of the 15 workers interviewed by NIOSH during September, 1980, was currently symptomatic. All of them reported experiencing eye and nose irritation due to coolant vapors at some time during the previous two years. Three odors identified consistently were ammonia, hydrogen sulfide, and "Slimex". The odors of ammonia and hydrogen sulfide were most apparent after the coolant solutions had been used for several months. These odors were intermittent and transient, being generally worse on Mondays after the systems had been shut down for the weekend. Most of the employees also noted that the odors and eye irritation seemed worse when the outside weather was particularly warm or humid. Several persons felt that the odors had lessened since early 1980.

Six of the 15 persons complained about odor from the Slimex biocide. Initially, the biocide was added as a batch, causing complaints about eye irritation. Recently, the biocide has been added gradually during the last shift before the weekend. This new method of adding the biocide seems to have decreased the problem.

Analysis of the 31 questionnaires administered by OSHA revealed that the most commonly reported symptoms were eye irritation(25), cough(20), dry, scratchy throat(19), and nasal irritation(18). The reported associations between symptoms and environmental conditions were similiar to those reported to NIOSH. Most employees indicated that the problem was worse during 1977 or 1978, and had improved gradually since then. Operators on all three machining lines experienced symptoms. Fourteen of the respondents (45%) smoked cigarettes. Smoking was not associated with the reporting of symptoms. Very few respondents reported having known allergies. Atopicity can not account for the health complaints. In sum, the symptoms of upper respiratory tract irritation were experienced intermittently by several machine operators on each of the three lines and can not be ascribed to personal factors such as smoking habits or allergies.

During the walk-through tour, the NIOSH medical officer examined the exposed skin of approximately 30 employees. Most had no skin problems. None had apparent skin infections; none had folliculitis. Some workers demonstrated mild erythema, dryness, peeling, and cracking of the skin on the fingers. Most of these workers had direct skin contact with lubricating coolant. These physical signs are consistent with defatting of the skin and mild irritation due to exposure to organic solvents. The prevalence of the dermatitis is fairly low and can be expected among persons with direct exposure to water-based lubricating coolants(16). Dermatitis is not a general problem among the employees exposed only to vapors, gases, or the coolant mist.

Parameters recorded in the Company's coolant quality control records which could influence the growth of micro-organisms were reviewed by NIOSH. Coolant concentrations in the three systems varied substantially, but were usually within the range conducive to bacterial growth. Thus, concentration was not a major factor influencing the amount of bacterial growth. The pH of the solutions was virtually always below 9.5 - the level which prevents bacterial growth. In fact, the pH was often below the accepted test range of 8.2 to 9.2. The pH tends to drop because the metabolism of the micro-organisms produces non-volatile organic acids, which stay in the solution, and ammonia, which is volatile and off-gases. Thus, low pH can indicate an overgrowth of bacteria. The ranges of pH measured by the company approximately weekly from October 1979 through January 1981 are summarized below:

Machining Line	Number of Times pH was Measured in the Range: (below 8.2)	(8.2 to 9.2)	(above 9.2)
Lamb-Transfer	15	44	0
Kingsbury	32	32	0
Grinding	38	34	1

Thus, during the 2 1/2 year period, the measured pH for the three lines was below 8.2 from 1/3 to over 1/2 of the time. These measurements suggest that bacterial overgrowth could have been occurring during a substantial proportion of the time on each of the three lines.

The coolant quality control sheets maintained by E.F. Houghton and Company were analyzed for pH and bacterial counts. The pH measurements were similar to those obtained by Caterpillar, but their samples collected at essentially the same times consistently indicated a lower pH by about 0.5 to 1.0. This discrepancy implies that the samples changed between the time of collection and analysis by Caterpillar and the time of analysis by E.F. Houghton and Company. A possible cause of the difference may be continued bacterial growth within the collected samples.

The record of bacterial and mold counts indicates that the number of microorganisms varied widely from week to week. There was no clear seasonal pattern in the recorded level of bacteria. All three lines did demonstrate a higher level of bacterial growth during January 1979, following a halt in production during late 1978 through early 1979. Dumping and recharging the systems did not appreciably reduce subsequent bacterial counts. Apparently, residual contamination of the circulating systems leads to rapid recolonization of the coolant solutions. Most of the bacterial counts during the weeks after the biocide was added were the same or higher than the counts on the respective previous weeks. Mold counts were usually reduced. The sustained bacterial counts are suggestive of relative bacterial resistance to the current biocide.

To evaluate the average level of bacterial growth within the systems, the bacterial counts on the weekly samples were used to calculate the log mean concentration of bacteria in each system over the period from November 1978 through September 1980.* The results are summarized in Table 3. The average (log mean) bacterial counts for the three lines were: Lamb-Transfer - 73.2 million organisms per milliliter of solution (M/ml); Kingsbury - 30.5 M/ml; and Grinding - 75.2 M/ml. Thus, the average concentrations of bacteria in the coolant solutions in the three lines were from 3 to 7 1/2 times greater than the level of 10 M/ml recommended by Bennett water-based metal working fluids(10).

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* The "log mean" concentration is the most reliable indicator of central tendency when evaluating the growth of biological systems. Bacteria grow by dividing into two; thus, their growth pattern is exponential, rather than linear. Examination of a frequency histogram of the bacterial counts confirms that the curve is skewed to the right. Logarithmic transformation of the frequency curve of counts results in a near-normal curve.

It should be noted that the samples obtained for the quality control records were collected at approximately weekly intervals, but were not strictly random. Repeat samples were sometimes collected when there was a problem with the system, including after biocide or fresh coolant addition. Also, as mentioned above, additional bacterial growth may have occurred between the time of sample collection and analysis. The actual influence of these factors on the average of recorded bacterial counts can not be estimated, but are likely quite small.

The E.F. Houghton and Company records also indicate that Slimex 4416 was added to the coolant solutions on 59 occasions during the period covered. The usual procedure for adding the biocide was to add it to a level of 250 parts per million parts of solution, which was generally repeated after two to four days. The major criterion for adding biocide is when the bacterial or mold counts exceed the accepted maximum concentrations of organisms in the coolant solutions. The Company's accepted maximum concentration of organisms in the solutions are 275 million bacterial organisms per milliliter (M/ml) and 50 mold organisms per milliliter of solution. Of the 59 occasions that Slimex was added to a system, the mold count was excessive 50 times; bacterial count - 3 times; and both counts - 6 times. In other words, the major apparent reason for adding the biocide was that the Company's criterion for mold counts was exceeded. Only rarely was the biocide added specifically to control bacterial growth.

While the bacterial counts only rarely exceeded the Company's criterion of 275 M/ml, it almost always exceeded a count 10 M/ml. Table 3 also indicates the number of times the recorded counts were greater than 275 M/ml or below 10 M/ml. Only 12.0% of the samples exceeded the Company's criterion; 8.7% of the samples had bacterial counts below 10M/ml. The majority of the counts (79%) were below the Company's action level, but above the level for bacterial growth recommended in the literature.

Finally, during January 1981, NIOSH contacted Caterpillar Company and the UAW to review any health complaints during the preceding 3 1/2 months. The UAW reported that there had been only a few complaints about eye irritation by workers in the D-2 building. Workers still occasionally noticed odors such as ammonia or hydrogen sulfide. These odors would develop suddenly and last only a few minutes. The physician at the facility reported no on-going complaints about the coolant vapors.

There was one discrete episode of complaints beginning November 20, 1980. Over 4 days, 20 workers (mostly working on the Grinding line) reported to the medical office with complaints of smelling an ammonia odor and experiencing eye, nose and throat irritation and some headaches. The physician noted that the complaints seemed to develop after an addition of Slimex to the coolant system on the Grinding line. However, the Company's coolant record indicates that 3.5 gallons of caustic soda were added to the Grinding line system on the morning of November 20. The pH of the solution increased from 7.4 to 10.9 that day. The pH was 9.6 on November 21 and 8.5 on November 24. Most likely the addition of caustic soda was responsible for the odor and health complaints. This episode was the only time during the past 3 years that the pH in any system exceeded 9.2. Thus, while the symptoms of irritation were similar to earlier health complaints, this episode was not representative of earlier environmental problems. The factors responsible for the earlier health complaints were largely controlled during the 3 1/2 months of follow-up.

C. Conclusions

Environmental sampling for air contaminants conducted during January 1981 was essentially negative. None of the substances that could produce the odors reported by the employees was detected in the air. Analyses of the bulk samples of the coolant solutions revealed the presence of some substances known to be primary irritants of the eyes and skin. Since none of these substances was detected in an excessive quantity, NIOSH can not determine their role in causing the reported symptoms. NIOSH determines that there is no on-going health hazard from air contaminants in building D-2.

Medical interviews with workers in building D-2 and a review of the questionnaire administered by OSHA indicate that the employees reported intermittently smelling odors and experiencing upper respiratory tract irritation. The problem was worse in 1978 and 1979 and has improved substantially since that time.

The coolant quality control records indicate that the average levels of bacterial growth in the coolant solutions over the past three years ranged from 3 to 7 1/2 times greater than level of 10 M/ml recommended by Bennett. On the other hand, these bacterial counts were usually below the Company's criterion of 275 M/ml. Literature on the biology of metal working fluids indicates that bacterial overgrowth can cause the reported odors and health complaints and can shorten the useful life of coolants through biological degradation(10,11,13-16). Since the employees generally associated their symptoms with exposure to the aging coolants, and since the average life of the coolant solutions has been a relatively brief 6.5 months during the past three years, NIOSH concludes that there effectively has been bacterial overgrowth within the three coolant systems. This excess growth of bacteria could be responsible for the past health complaints and could have shortened the useful life of the coolant solutions. While improved housekeeping and increased general ventilation have largely alleviated the health complaints, the Company's criterion for acceptable bacterial growth within the coolant solutions is probably too high and does not provide for adequate primary prevention of the adverse effects of bacteria overgrowth.

...ile the Company's criterion for bacterial growth was rarely exceeded, its criterion for fungal growth of 50 organisms per milliliter was exceeded at least 53 times on the three lines during a 2 1/2 year period. Biocide was added on most occasions primarily to control fungal overgrowth. Since bacterial counts were generally sustained even after the addition of the biocide, it appears that the bacterial population within the coolant solutions has become relatively resistant to the current biocide. Because the overgrowth of either bacteria or fungi can have undesirable consequences, an appropriate ecological solution would be to establish acceptable ranges of bacterial and mold counts which would minimize the combined adverse effects of excessive growth of either type of organism. Appropriate biocides should be used to control the growth of both bacteria and fungi.

VII. RECOMMENDATIONS

1. Since the increase in the fresh air make-up of the recirculating general ventilation system substantially alleviated the health complaints, NIOSH recommends that the higher level of ventilation be maintained to ensure that low levels of air contaminants do not build up to concentrations that could cause upper respiratory tract irritation problems.

2. The major additives to the coolant solutions - HOCUT 736, caustic soda, and Slimex 4416 - contain known primary irritants. These substances should be added to the circulating coolant systems gradually (rather than as a batch) to prevent episodes of off-gassing of irritant vapors.

3. The criterion for acceptable bacterial growth within the coolant solutions should be lowered. It is suggested that Caterpillar Tractor Company, in consultation with E.F. Houghton and Company, contact appropriate persons knowledgeable in the area of metal working fluids to help develop revised criteria for their coolant solutions.

4. The factors predominantly responsible for bacterial growth - temperature, concentration, pH, and sulfur and hydrocarbon content - are determined by the required mechanical properties of the coolant and can not be easily altered. Thus, control of bacterial growth requires the addition of an appropriate biocide to the coolant solution. The procedures for testing the solutions and adding the biocide should be improved in the following ways:

   a. The time between sample collection and analysis should be minimized. Plating the solutions to count bacteria could be done at the facility to improve accuracy of the bacterial counts.

   b. Currently, only total bacterial counts are performed by E.F. Houghton and Company(17). Bacteria in coolant solutions have a tendency to develop resistance to biocides(10). Therefore, bacterial culture and sensitivity testing should be performed periodically to determine the *in vitro* effectiveness of the biocide.

   c. Biocide should be added on a regular schedule to maintain low levels of bacterial and mold growth. Adding biocide only when bacterial counts become excessive increases the risk that the exponential growth of bacteria will become uncontrolled.

5. Bacterial growth within the coolant solutions should also be restricted through control of the primary sources of the bacteria:

   a. Employees should be notified that all dirt and foreign matter should be kept out of the coolant systems. This notification may include having periodic training sessions of employees, as well as posting educational notices.

   b. Appropriate housekeeping procedures should be established to minimize contamination of the coolant systems.

VIII. AUTHORSHIP AND ACKNOWLEDGEMENT

Evaluation Conducted and Report Prepared by:	Dean Baker, M.D., M.P.H. Medical Officer Hazard Evaluations and Technical Assistance Branch
	Frank A. Lewis Industrial Hygienist NIOSH, Region III Office
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies

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X. DISTRIBUTION AND AVAILABILITY

For the purpose of informing the "affected employees", the employer should post this report for at least 30 days in a prominent place(s) near where employees work.

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Copies of this report have been sent to:

Caterpillar Tractor Company, York, Pennsylvania
United Auto Workers, Local 786
E.F. Houghton and Company, Philadelphia, Pennsylvania
Pennsylvania State Department of Health
Occupational Safety and Health Administration, Directorate of Technical Support
Occupational Safety and Health Administration, Region III
NIOSH, Public Health Service, Region III

TABLE 1

THE MOST IMPORTANT ORGANISMS FOUND IN METAL-WORKING FLUIDS*

ORGANISMS	TIMES ISOLATED (percent)	CAPABILITY OF GROWING IN COOLANTS
Pseudomonas species	100	+++++
Desulfovibrío species	85	++
Escherichia species	48	++
Paracolobactrum species	47	+++
Proteus species	55	+++++
Klebsiella species	32	++++
Aerobactera species	18	+++
Fungi	14	+++

* From reference 10 - page 240.

TABLE 2

ENVIRONMENTAL CRITERIA FOR SUBSTANCES POTENTIALLY PRESENT IN THE AIR OF BUILDING D-2*

SUBSTANCE	NIOSH Recommended Standard[a] (mg/m^3)[c]	ACGIH - TLV[b] (mg/m^3)	OSHA Standard[b] (mg/m^3)
Ammonia	34.8[d]	18	34.8
Hydrogen Sulfide	15[e]	21[f]	30[e]
Oil Mist, Mineral	--	5	5
Sodium Hydroxide	2[f]	2	2
Toluene	375[g]	375	750
1,1,1-Trichloro-ethane	1910[f]	1910	1910
Xylene	435[h]	435	435

a. 10 hour work day, 40 hour work week, except as noted
b. 8 hour work day, 40 hour work week
c. milligrams of substance per cubic meter of air
d. 5 minute ceiling
e. 10 minute ceiling
f. 15 minute ceiling
g. also a 10 minute ceiling of 750 mg/m^3
h. also a 10 minute ceiling of 868 mg/m^3

* During NIOSH environmental sampling, none of these substances was found in significant quantities.

TABLE 3

SUMMARY OF BACTERIAL GROWTH IN THE COOLANT SYSTEMS IN BUILDING D-2
(Analysis of samples submitted approximately weekly from November 1978 through September 1980 to E.F. Houghton and Company)

MACHINE LINE	NUMBER OF SAMPLES	LOG MEAN OF BACTERIAL COUNTS (M/ml)*	95% CONFIDENCE INTERVALS (M/ml)	NUMBER OF SAMPLES IN THE RANGES: (Above 275) (M/ml)	(Below 10) (M/ml)
Lamb-Transfer	90	73.2	53.2 - 100.7	6	5
Kingsbury	68	30.5	14.1 - 65.6	9	10
Grinding	59	75.2	49.8 - 113.6	11	4

* M/ml = million bacterial organisms per milliliter of coolant solution.

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16. Abstracts

In August 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Directorate of Technical Support, Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, for medical and technical assistance at the Caterpillar Tractor Company of York, PA. During September 1980, NIOSH visited the facility for a walk-through inspection. Fifteen employees in the D-2 building were interviewed; they reported that the eye, nose and throat irritation problems had been gradually improving since early 1980 as a result of recently increased general ventilation. No one was currently symptomatic; therefore, it was decided to monitor the health complaints prospectively for three months.

17. Key Words and Document Analysis. 17a. Descriptors

sic-3714, mahcine coolant, mineral oil, aliphatic hydrocarbons, butyl carbitol, ammonia, hydrogen sulfide, amines, eye irritation, upper respiratory tract irritation.

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

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