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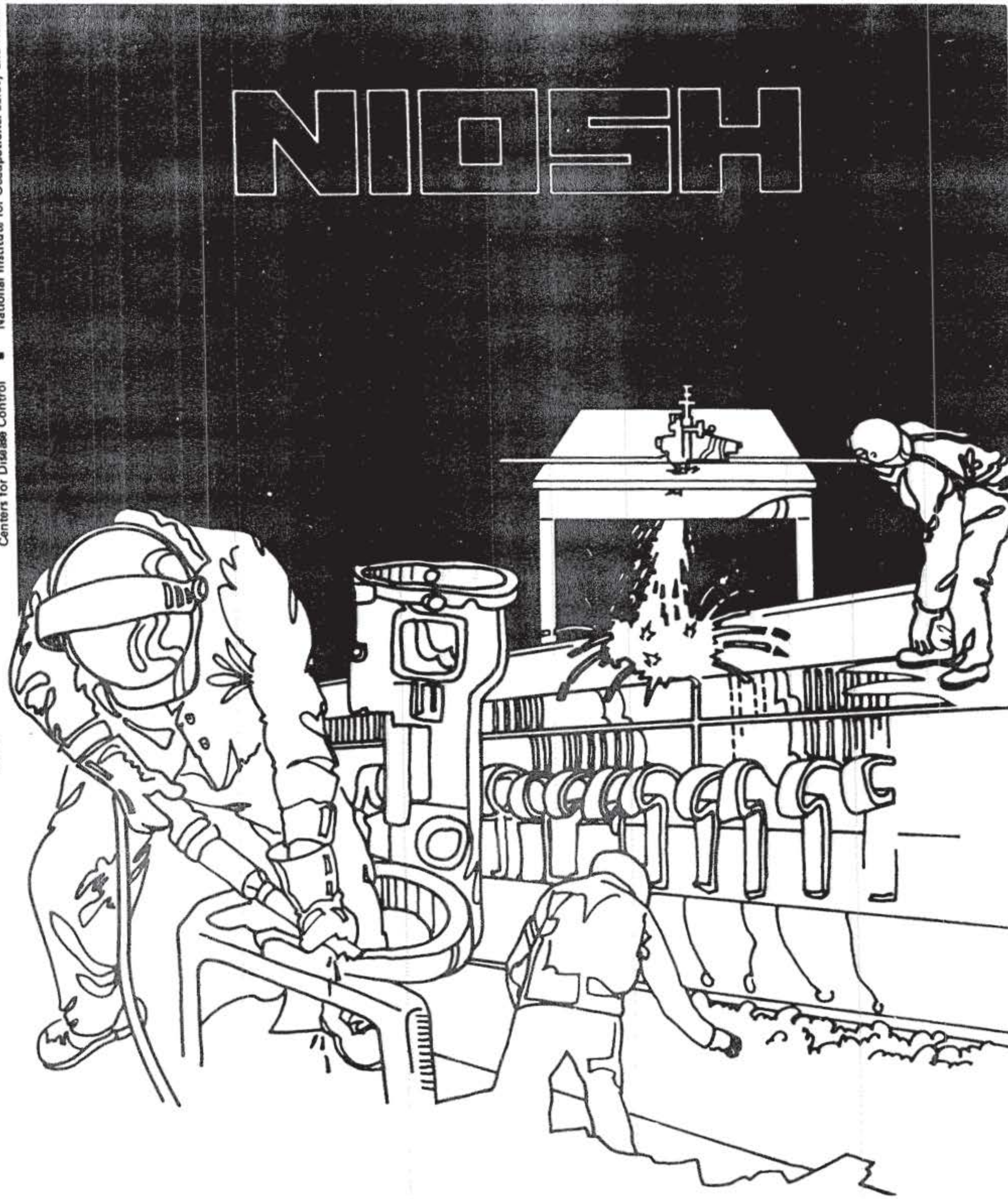

Health Hazard Evaluation Report

HETA 80-177-1166
JOHNSON MEMORIAL HOSPITAL
STAFFORD SPRINGS, CONNECTICUT

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.

HETA 80-177-1166
August 1982
Johnson Memorial Hospital
Stafford Springs, Connecticut

NIOSH INVESTIGATORS:
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I. SUMMARY

In June, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation request from Johnson Memorial Hospital, Stafford Springs, Connecticut, to evaluate a possible health hazard from exposure to volatile amines used in the boiler system. These were reportedly found in the atmosphere of the Administrative wing by an independent consultant using a non-specific colorimetric analytical method, and it was believed by the Hospital Administration that these amines may have been the cause of eye irritation, itchy skin, headache, and non-specific upper respiratory irritation in employees for the past five years. A previous NIOSH study (NIOSH Report No. TA 79-16), State and Federal OSHA investigations, and three private consultants, were not successful in identifying the source of employee health effects.

This evaluation was designed to determine the presence of nitrogen containing compounds in the air, identify such compounds, and possibly relate the compounds to employee health effects. As the investigation progressed, however, several changes were made at the hospital which made it difficult to absolutely identify the specific amine compounds. The changes included a complete wash down of the administrative wing of the hospital and eventually a complete renovation of that section.

NIOSH began this evaluation in July, 1980, and made several sampling visits through March, 1982, specifically for nitrogen containing compounds. Initially, hydrazine was identified in the hospital air using an experimental analytical method described in the body of this report. However, this finding could not be consistently reproduced.

NIOSH also sampled for ozone, carbon monoxide, nitrogen oxides, ammonia, sulfur dioxide acetic acid and dimethyl acetamide with negative results on colorimetric detector tubes. Ozone was also analyzed using a Columbia Scientific Model 2000 portable ozone meter, and was below the detection limit of 0.01 ppm.

The administrative wing of the hospital was re-occupied finally in March, 1982 without employee reports of health effects. Upon confirmation of the absence of symptoms, NIOSH ended its investigation.

NIOSH did not positively identify any single causative agent for employee complaints. However, analytical methods employed during this evaluation suggested the presence of hydrazine which could explain both employee health effects and the effect of rapid decomposition of rubber products within the hospital. The fact that these results could not be consistently reproduced does not allow NIOSH to make definitive conclusions based upon them.

KEYWORDS: SIC 8062, indoor air pollution, hospital, hydrazine, humidification, boiler treatment.

II. INTRODUCTION

On June 13, 1980, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from an employer representative of Johnson Memorial Hospital, Stafford Springs, Connecticut. Specifically requested was an evaluation of volatile amines used in the boiler system which were reportedly found in the atmosphere of the Administrative wing by an independent consultant using a non-specific colorimetric analytical method. It was believed by the Hospital Administration that these amines may have been the cause of employee health complaints (eye irritation, itchy skin, headache, and non-specific upper respiratory irritation) for the past five years.

A previous evaluation conducted at this facility (NIOSH Report No. TA 79-16) concluded "an already high ambient temperature, little air movement, and the accumulation of cigarette smoke, are suspected to have caused most of the symptoms reported by the Administration employees". Remedial corrective measures failed to resolve this problem.

Evaluations by State and Federal Occupational Safety and Health Administrations, the State Health Department, and three private consultants have been unable to determine the source of employee complaints.

When a fourth consultant identified the presence of volatile amines, the Administration requested NIOSH to provide assistance in confirming or denying this theory as the cause of employee health effects at the hospital. This assistance evolved into a formal Health Hazard Evaluation request in June, 1980.

III. BACKGROUND

In October, 1975, the administrative and health care functions of Johnson Memorial Hospital moved into a new facility. Four months after the move, some employees in the administrative wing and the central sterile supply area of the hospital began complaining of a myriad of symptoms which they felt were work related. Symptoms included difficulty breathing, skin and eye irritation, and difficulty swallowing. The hospital administrator, in an effort to isolate the administrative area from its occupants, moved the administrative functions out of the building into temporary trailers, and sealed off the area from the rest of the hospital. Central Sterile Supply (CSS) could not feasibly be similarly isolated.

Suggestions as to the cause of the problem had been advanced by previous investigators; among them being insulation containing fibrous glass in the ventilation system, fungal growth in the ventilation system, poor ventilation and excessive heat from solar radiation causing employee discomfort, and concomitant heightened awareness of sensations not normally noticed. After the recommendations of each of the investigators were implemented, the hospital tried to reoccupy the administrative area. Each time they were forced back out into the trailers due to the presence of employee symptoms.

The possibility of contamination of the workroom atmosphere by boiler water chemicals was not previously investigated, and the finding of volatile amines by a consultant in May, 1980, opened a new area for investigation.

Humidification of the hospital air was accomplished by releasing steam from the boiler system directly into the air handlers. Boiler water treatment chemicals, it was thought may also be released into the air handlers in sufficient quantities to produce the reported employee health effects.

Closed loop boiler systems employ the use of various chemicals to prevent corrosion of the system. Usually they use an oxygen scavenger (such as hydrazine) to prevent rust and corrosion in the boiler, and a return line treatment (such as diethylaminoethanol, morpholine, cyclohexylamine or aminomethyl propanol) to neutralize the carbonic acid formed in the return lines by condensation of steam in the presence of carbon dioxide.

Hydrazine is an effective oxygen scavenger and when carefully monitored will be entirely spent before the boiler water vaporizes. Problems generally only occur when hydrazine is batch added in large quantities which allow the unspent hydrazine to vaporize with the steam.

Return line treatment chemicals (above) are convenient because they can be added to the boiler water and will vaporize with the steam. They will accompany the steam through the system and condense with the steam in the return line, allowing the neutralization of the weak carbonic acid formed by the steam condensing in the presence of carbon dioxide. The amine carbonate then travels back to the boiler and upon heating under pressure, releases water and carbon dioxide, regenerating the free amine which begins the cycle again. Steam losses within the system (humidification) necessitate the continuous addition of treatment to the boiler.

Johnson Memorial Hospital had a history of using hydrazine in their boiler system and did not have a continuous feed system. The batch add method was used at JMH in the past. During this evaluation, the use of hydrazine was discontinued. Cyclohexylamine was believed to be used in the return lines.

NIOSH began this investigation on July 17, 1980, and issued one interim report in February 1981.

IV. EVALUATION DESIGN, METHODS, RESULTS AND DISCUSSION

Since there have been numerous previous investigations at this building, this evaluation was not intended to duplicate the efforts of prior investigators. However, all previous reports were reviewed and some are referenced in this report.

This evaluation was designed to determine the presence of nitrogen containing compounds in the air, identify such compounds, and possibly relate the compounds to employee health effects. As the investigation progressed, however, several changes were made at the hospital which made it difficult to absolutely identify the specific amine compounds. The changes included a complete wash down of the administrative wing of the hospital and eventually a complete renovation of that section.

The following chronology of events took place during this investigation in an attempt to characterize the work environment.

On July 17, 1980, the NIOSH Regional Program Consultant attended a meeting at the hospital to gather technical information relative to the evaluation. A presentation was delivered by a boiler water treatment chemical distributer indicating that he felt the water had a high carbonate content. The private consultant provided NIOSH with analytical data relating to chemicals found in bulk samples of the air conditioning filters.

A walkthrough survey was conducted following the meeting.

On July 28, 1980, NIOSH conducted environmental sampling with the cooperation of Mr. David Rounbehler, Senior Scientist, New England Institute for Life Sciences (NEILS), specifically to determine the presence of nitrosamines and other nitrogen containing compounds.

On September 8, 1980, the results of the sampling were reported to NIOSH. (See Appendix 1 for the full report). Essentially, no nitrosamines were detected in the hospital atmosphere. However, additional work-up on the samples using an experimental method described in Appendix 1, confirmed the presence of a nitrogen containing compound which when flushed with acetone, behaves similar to hydrazine. (The acetone derivative of hydrazine was subsequently confirmed by the NIOSH analytical laboratory by means of GC/Mass Spec. in December, 1980).

Since the presence of hydrazine could possibly explain some of the employees symptoms, another sampling visit was arranged to attempt to positively identify the chemical.

On September 12, 1980, NIOSH collected air samples using Thermosorb™/N collection media to attempt to gain better collection efficiency. The samples were analyzed on September 15, 1980 using the same experimental method. No hydrazine peaks were observed on any of the samples. Subsequently it was learned that the Thermosorb™/N media will react with hydrazine and is not suitable as a collection media.

On September 19, 1980 NIOSH collected environmental samples for hydrazine which were analyzed both by NIOSH and NEILS. The NIOSH method used was that of P&CAM 248, bubbling hydrazine through 0.1N HCL in impingers, with some modifications during analysis.[1]

NIOSH also attempted to differentiate between hydrazine and hydrazine salts by preceeding some of the impingers with AA filters. The method used by NEILS was the experimental method using various collection media (magnesium silicate, fluorosil, and molecular sieve) to try to gain better collection efficiency.

One sample (magnesium silicate media) was analyzed by NEILS within 3 hours after collection. The analysis consisted of washing the sample with .1N HCL, taking three equal aliquots of the wash and derivatizing with three different agents: acetone, propionaldehyde, and acetaldehyde. The derivatives were injected into the experimental nitrogen detecting device prior to running standards. Huge peaks were observed on all three samples. Standards were prepared and analyzed. The retention time of the peaks observed from the samples matched identically with the retention time from the standards. Estimates of the concentration were calculated in the 5 mg/M^3 range.

A second injection of each derivative was made about one hour after the first. The peaks were noticeably smaller on the second run. A third injection of each produced peaks even smaller than the second run. (Evidence that the derivatives decompose rapidly in the acid solution) No other samples were analyzed on that day.

On September 22, 1980, the NIOSH samples were shipped to the lab for analysis. Two samples (filter and impinger) were retained for analysis by NEILS. Also on this day NEILS reported that no peaks were observed on the rest of the samples. Only a trace amount was seen on the molecular seive media. (Evidence that the collected compound was not stable on either magnesium silicate or molecular seive)

On September 23, 1980, the two NIOSH samples that were retained were analyzed by NEILS. No peaks were observed. This information was forwarded to the NIOSH lab.

On October 23, 1980, the NIOSH lab reported that no hydrazine derivatives were observed on any of the samples.

On December 10, 1980, a NIOSH chemist visited NEILS to try to resolve the laboratory differences. The experimental method was discussed and appeared to have a sound basis.

On December 11, 1980 additional environmental samples were collected for analysis by NEILS. The samples were collected as in Appendix 1. A NIOSH physician conducted an initial walkthrough during this visit and confirmed the ongoing presence of symptoms.

Analysis of the samples two hours after collection produced negative results.

During the month of December, 1980, the hospital engaged in a clean-up procedure designed to eliminate suspected hydrazine contamination. On the advice of a consultant, all surfaces of the administrative wing were washed with a 3% hydrogen peroxide solution.

On January 14, 1981, NIOSH medical and environmental personnel returned to the hospital to determine the effectiveness of the clean-up. Environmental samples were collected and analyzed by NEILS. Medical interviews were conducted and determined the ongoing presence of symptoms. Analysis of the samples again produced negative results.

Information was related to NIOSH concerning reports throughout the hospital of rubber surfaces deteriorationg. The Director of Engineering reported that the baseboards in the hospital, which were held on by rubber cement, were falling off continuously. Rubber diaphragms used to control the ventilation system, have had to be replaced at an astonishing rate. Rubber electrical cords and elastic bands were always cracking.

On January 28, 1981, NIOSH conducted an ozone survey at the hospital using a Columbia Scientific Model 2000 portable ozone meter and colorimetric detector tubes. This strategy was implemented since both hydrazine and ozone are known to attack rubber. Ozone was not detected by either method. (Detection limit 0.01 ppm).

Additional detector tube samples were collected for: nitrogen oxides--none detected; carbon monoxide--none detected; ammonia--none detected; sulfur dioxide--none detected; dimethyl acetamide--positive interference; and acetic acid--positive interference. The reaction principle for the last two tubes indicated that the most likely chemical composition of the hospital contaminant was a low molecular weight amine salt.

Over the next 12 months, the hospital engaged in a complete renovation of the administrative wing which included tearing out and replacing the old walls, rugs, and ceilings; replacing the non-openable windows with openable ones; and increasing the ventilation.

One site visit was made during this time (11/18/81) in order to collect a bulk sample of the insulation material for analysis by NEILS. The sample was extracted with acetone and water. No peaks were observed.

During the renovation project the Engineering Department located two design flaws in the ventilation system. First, the exhaust from the laboratory hood was venting directly into the return air plenum. This was corrected by installing ductwork directly to the outside. Secondly, the exhaust duct from the ethylene oxide sterilizer was not sealed properly, and it was estimated allowed about a 10% leakage into the return air plenum. This duct was replaced with an air tight duct that eliminated any such leakage.

These two findings eliminated two sources of chemical contamination, which along with the increased amount of air circulation in the administrative wing of the hospital, should greatly reduce the incidence of employee health effects.

The administrative wing of the hospital was re-occupied finally in March, 1982 without employee reports of health effects. Upon confirmation of the absence of symptoms, NIOSH ended its' investigation.

V. EVALUATION CRITERIA

A. Environmental Criteria

The environmental criteria described below are intended to represent airborne concentrations of substances to which workers may be exposed for eight hours a day, 40 hours per week for a working lifetime without adverse health effects. Because of wide variation in individual susceptibility, a small percentage of workers may experience discomfort from some substances at concentrations at or below the recommended criteria.[TLV] A smaller percentage may be more seriously affected by aggravation of a pre-existing condition or by a hypersensitivity reaction. The time-weighted average (TWA) exposure refers to the average concentration during a normal 8-hour workday. The Short-Term Exposure Limit is the maximum allowable concentration, or ceiling, to which workers can be exposed during a period of up to 15 minutes, provided that no more than four excursions per day are permitted, with at least 60 minutes between exposure periods.

The primary sources of environmental evaluation criteria considered for this study were: 1) NIOSH criteria documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) federal occupational health standards. The criteria judged most appropriate for this study are as follows:

Substance	Short Term Exposure Limits (15 Min.)	8-Hour Time Weighted Average	Source
Hydrazine	0.03 ppm		NIOSH
Ozone		0.1 ppm	OSHA

NOTE: ppm = parts per million parts of air

B. Toxicity

Ozone

Ozone is irritating to the eyes and upper respiratory tract. Symptoms of chronic exposure include headache, weakness, shortness of breath, drowsiness, reduced ability to concentrate, slowing of heart and respiration rate, and visual changes.[2]

Hydrazine

Hydrazine is a severe skin and mucuous membrane irritant in humans; in animals it is also a convulsant and a carcinogen. In humans, the vapor is immediately irritating to the nose and throat and causes dizziness and nausea; itching, burning, and swelling of the eyes develop over a period of several hours.[3]

VI. CONCLUSION

NIOSH did not positively identify any single causitive agent for employee complaints. However, analytical methods employed during this evaluation suggested the presence of hydrazine which could explain both employee health effects and the effect of rapid decomposition of rubber products within the hospital. The fact that these results could not be consistently reproduced does not allow NIOSH to make definitive conclusions based upon them.

The corrective measures employed by the hospital during this investigation appear to have eliminated the causitive agent from the environment, or at least reduced the levels of contamination below the level that produces the employee symptoms.

Which of the corrective measures was responsible for eliminating employee complaints was not determined. Fixing the exhaust ducts in both the laboratory and the sterilizer room eliminated two potential sources of chemical contamination. However, the increased ventilation and openable windows in the Administrative wing may have reduced the levels of contamination below those which produce adverse health effects.

VII. RECOMMENDATIONS

To assure proper operation of the ventilation system at all times, NIOSH recommends that a preventive maintanence program be implemented that includes inspection at regular intervals (ie. monthly) and repair of the rubber diaphragms that control the system. These diaphragms have a history of failure at the hospital which may be due to the humidification system. Therefore, there is a need for regular inspection to detect faults.

VIII. REFERENCES

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IX. AUTHORSHIP AND ACKNOWLEDGEMENTS

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Johnson Memorial Hospital, Stafford Springs, Connecticut
2. Connecticut Health Care Associates, Wallingford, Connecticut
3. NIOSH, Region 01
4. OSHA, Region 01

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.

New
England
Institute for
Life Sciences

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September 8, 1980

Wesley E. Straub
Industrial Hygienist
NIOSH - Region 1
JFK Federal Bldg.
Boston, MA 02203

Dear Mr. Straub:

RE: Analysis of area air samples collected at the Johnson Memorial Hospital in Stafford, CN during a visit on July 28, 1980

Five area air samples were collected at this hospital using ThermoSorb air cartridges containing 3 grams of 60/80 mesh magnesium silicate. The air samples were collected using DuPont 2500 air pumps operating at 1.7 to 2 L/min with air sample volumes ranging from 275L to 390L total. The contents of the cartridges were desorbed by backflushing with acetone (1-1.5 ml) two of these cartridges were also further backflushed with 3 ml of 1N KOH. Using the methods of Rounbehler et al (Analytical Chem. 52, 273, 1980) the acetone eluates were examined for the presence of N-nitroso compounds and at a detection limit of 0.05 $\mu g/m^3$ for N-nitrosomorpholine and 0.02 for N-nitrosodimethylamine, none were detected (see enclosed chromatographs). N-nitrosomorpholine was a possible contaminant in the air because 1) Morpholine was reported to have been used in the hospital steam system and 2) this steam is used to humidify the air in the hospital and 3) morpholine has been shown to readily form N-nitrosomorpholine on surfaces in the presence of ambient levels of oxides of nitrogen (Rounbehler et al, Analytical Chem. 52, 273, 1980).

While we did not detect any N-nitroso compounds we did detect a nitrogen containing compound which has gas chromatographic properties similar to hydrazine (see enclosed chromatographs). This discovery was made using an experimental nitrogen detecting device and the methods used to detect hydrazine are experimental and as such have not been fully explored or validated. Briefly, the methods we used were as follows:

• The nitrogen detector consisted of a gas chromatograph interfaced to a TEA™ Analyzer equipped with a catalytic oxidative pyrolyzer for low temperature conversion of chemically-bound nitrogen to nitrogen oxides (NO) with subsequent detection with a standard TEA. These methods have been described in patents and publications by Fine et al. Using this system and a gas chromatograph containing a 12' x 1/8" stainless steel column packed with 80/100 mesh Chromosorb W coated with 5% Carbowax 20M and operating at 75°C with 15 ml/min argon, we can detect 25×10^{-12}g of hydrazine in a 2 μl injection with a retention time of about 2.5 min. Because of the operating principlas of this system, only easily oxidized nitrogen containing compounds can be detected. For example, nitrogen gas can not be detected. Amines and other ammonia-like compounds will, however, also be detected by this system. A system which is specific for hydrazine-like compounds is being developed in our laboratories. However, it was not available at the time.

• What we found using this analytical system was a chromatographic signal at, or near, the retention time for known hydrazine standards. When we injected the acetone eluate we found hydrazine like signals ranging from approximately 1 to 15 ng injected in a 2 μl injection. These amounts corresponded to 2-24 μg/m^3 of free hydrazine. We further examined one of these samples (NO. 20000) by adding a portion of the acetone eluate to an equal amount of BaOH saturated 1N KOH solution followed by injecting 2 μl of this into the system. This time we found approximately 20 x the original signal which seemed to indicate a hydrazine-like salt was present in the acetone eluate. Assuming that all of the samples will behave similarly, then 40-480 μg/m^3 of hydrazine and its salts may be in the hospital atmosphere. In a further test we re-washed the acetone eluted cartridges with 2 ml of 1N KOH. Analysis of these washings indicated that we had not succeeded in desorbing all of the hydrazine-like compounds from the cartridges. Analysis of cartridge No. 20005 indicated the presence of approximately 1/3 the amount of the hydrazine-like compound on cartridge No. 20004. Cartridge No. 20005 was in series with No. 20004 as an indicator of trapping efficiency. In short we did not efficiently trap this compound. Because of the inability of the chosen sorbent (magnesium silicate) to trap this compound and the incomplete desorption our estimate of the hydrazine-like compound in the hospital air is on the low side.

We speculate that the chromatographic signal that we are observing is hydrazine because of 1) its chromatographic retention time is similar to hydrazine 2) the system used to detect this signal is specific for nitrogen containing compounds 3) the salt-like character of the compound (hydrazines readily form salts) 4) hydrazine has been used in the hospital steam system that provides humidity for the hospital air, and 5) hydrazine compounds could explain the more common complaints of the hospital personnel, i.e. eye irritation rashes, etc. We also examined a sample of the Monocoat™ insulation that had been sprayed onto the ceiling and we found that it contained this hydrazine-like compound. The space between the ceiling and the acoustical tile ceiling had been used as the air return duct. Airborne hydrazine and its salts could be trapped in this material.

In opposition to our speculation that we are observing hydrazine, we were not able to confirm this finding by GC mass spec. Using glass capillary gas chromatography interfaced to a high resolution mass spec, Vernon Reinhold of Harvard Medical School was unable to detect hydrazine in either the acetone eluate from the air sample or from an acetone extract of the Monocoat insulation. Because of hydrazine's low molecular weight ∿32 and interfering signals from oxygen and methanol (the methanol resulted from the fragmentation of acetone) the sensitivity of the mass spec analysis was limited. By calculation we estimate that 100 x more hydrazine than was present in the air samples would be needed for detection or a solvent which does not result in a methanol fragment would have to be used to elute the air cartridges. This analysis does not rule out hydrazine. However, it does not confirm its presence either. In a further test we attempted to determine if hydrazine was present in an aqueous extraction of a sample of the Monocoat by forming the yellow colored complex with P-dimethylaminobenzaldehyde. The results of this test were negative with low color formation. However, we are not convinced that the Monocoat sample is homogeneous or that water is sufficient to remove the hydrazine compound. If we had observed a positive color formation this would have constituted fairly convincing evidence that the hydrazine-like compound was indeed hydrazine.

In summary, we have found a nitrogen-containing compound that behaves like hydrazine on a gas chromatograph but we are unable to confirm its identity. We are convinced that a nitrogen containing compound is in the air of the hospital and this compound has a nonvolatile salt-like form. We speculate that this unknown compound is present in the air at mg/m^3 amounts or more and it is present in the Monocoat insulation. We suggest developing analytical techniques which will be able to determine the structure of this hydrazine-like material with a solvent system that would not interfere with the GC mass spec analysis. Until structural identification of this unknown compound can be obtained, we will be unable to determine its possible role in the hospital atmosphere.

If you have any questions, please let me know.

Sincerely,

David P. Rounbehler

David P. Rounbehler, Head
Environmental Section

DPR/nlb

Chromatographs

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