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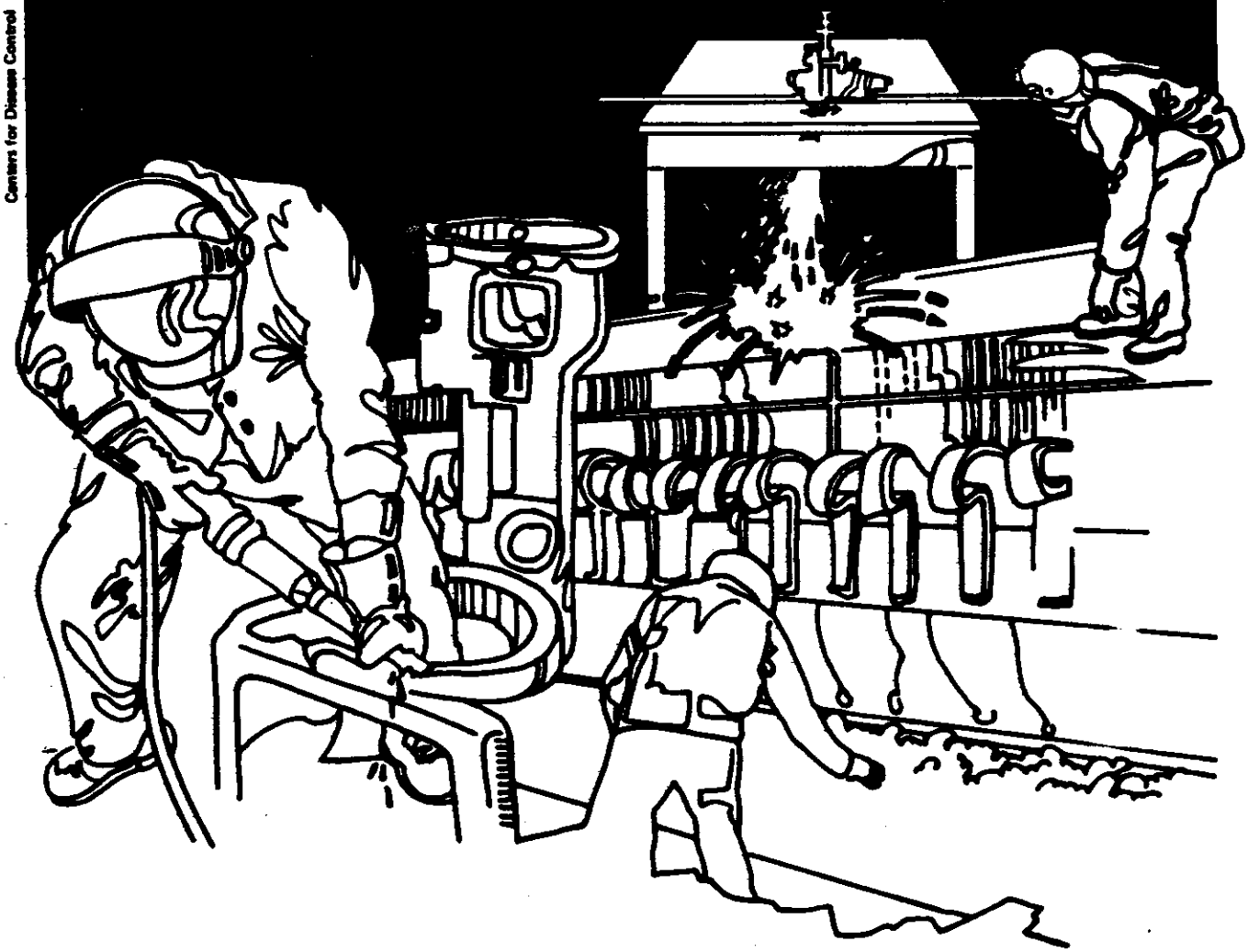

Health Hazard Evaluation Report

MHETA 88-103-1915
PITTSBURGH ENERGY
TECHNOLOGY CENTER
BRUCETON, 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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PITTSBURGH ENERGY TECHNOLOGY CENTER
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I. SUMMARY

The Pittsburgh Energy Technology Center (PETC) located in Bruceton, Pennsylvania requested the National Institute for Occupational Safety and Health (NIOSH) on December 1, 1987 to evaluate employee complaints of odors from the women's restroom of building 900A. The odors were reportedly causing the employees to have headaches, diarrhea, dizziness, nausea and chest pains.

On December 2, 1987, a NIOSH investigator conducted a site visit of building 900A to obtain background information, history of complaints, interview employees, make visual observations and collect some preliminary measurements. Preliminary measurements were made using direct reading instruments such as the H-NU photoionizer, detector tubes and smoke tubes. Industrial hygiene surveys were conducted on January 14 and February 17, 1988 throughout building 900A, the women's restroom and the crawl space underneath the women's restroom. Only area sampling was conducted. Airborne samples were collected for sulfur dioxide, hydrogen sulfide, carbon dioxide, carbon monoxide, formaldehyde and organic gases and vapors. Two soil samples from underneath building 900A were also analyzed.

No carbon monoxide, hydrogen sulfide, or sulfur dioxide were detected. Formaldehyde was detected in only one of 12 samples at 0.01 parts per million (ppm) and toluene was detected in three samples between 0.005-0.16 ppm. Carbon dioxide levels increased from the early morning (415 ppm) to late afternoon (1000 ppm). This increase in carbon dioxide indicated that there was very little fresh air being introduced into the air handling system. Two soil samples revealed a cyclo-octa form of elemental sulfur (molecular weight=256), extremely low levels of aliphatic hydrocarbons (carbon range C_{12}-C_{25}) and a few phthalate esters. The hydrocarbons and esters were too low to quantitate. It is hypothesized that soluble forms of sulfur are leaching out of the soil during rainy or wet periods, and oxidizing to produce an odor.

Additional environmental measurements were taken for temperature and relative humidity. The temperature ranged from 69-77°F with a relative humidity of 11-24 %.

On the basis of information and data that has been obtained at building 900A, it was apparent that fresh air was not being added to the ventilation system and that the odor is from the elemental sulfur in the soil. No other significant exposures were detected from the environmental sampling. Recommendations for additional ventilation to control odors and other contaminants can be found in section VIII of this report.

Key words: SIC 9199, carbon dioxide, carbon monoxide, hydrogen sulfide, formaldehyde, organic vapors, indoor air quality.

II. INTRODUCTION

On December 1, 1987, the Pittsburgh Energy Technology Center (PETC) requested that the National Institute for Occupational Safety and Health (NIOSH) visit building 900A to determine if the approach PETC had taken to evaluate the presence of an odor was appropriate. On December 2, a NIOSH industrial hygienist visited building 900A, talked with PETC Health and Safety personnel, the maintenance supervisor with Burns and Rowe, employees, and the PETC nurse. At the end of the visit, NIOSH was asked to conduct a health hazard evaluation of building 900A to determine if an odor that was present in the women's restroom of building 900A could be causing employee complaints of headaches, nausea, diarrhea, dizziness and chest pains.

III. BACKGROUND

Building 900A is Located within the Department of Energy complex just off of Wallace Road in Bruceton, Pennsylvania; it houses approximately 40 employees from the Personnel and Oakridge University (ORAU) Program. Building 900A consists of two-double wide trailers joined end to end which were set up for temporary occupancy 10 years ago. Part of building 900A is set up on a cinder block foundation, while the other half is on a concrete slab.

On December 2, when the walk through of building 900A took place, the NIOSH investigator detected an odor which was perceived to be mercaptans. Mercaptans are sulfur containing compounds which are added to natural gas to give it a detectable odor. Consequently, a natural gas leak was suspected. The maintenance supervisor accompanying the NIOSH investigator reported that no natural gas or sewer leaks had been detected and that all of the sewer traps did have adequate liquid levels to control sewer odors. Personnel and visitors from building 900A have described the odor from the women's restroom as a sulfur or sewage-like odor and that the odor is stronger in the morning with Monday mornings being the worst. The odor, according to building 900A personnel, became more noticeable during the month of September 1987. Seven employees from September to December 1987 complained that the odor was causing headaches, diarrhea, stomach and chest pains. These complaints were reported to the PETC nurse's office. One employee who has worked in 900A since January 1984 has had similar complaints in addition to complaints of breathing and swallowing difficulty, skin rashes, joint and muscle pain, limited energy, esophageal spasms, urticaria, and reflux.

In May 1985, after continued complaints from this employee, PETC requested a local industrial health foundation group to do environmental monitoring. The group sampled for formaldehyde, carbon monoxide and methylene chloride. The levels were well below federal and consensus standards. No recommendations were made by the industrial health group.

Underneath the women's restroom there is a cinder block pit (4'x 4') with a sump pump. The maintenance supervisor explained that approximately every 6 months when the water lines serving the fire extinguishing systems are flushed, the water would not always drain away. Consequently, the water would have to be pumped out so the ground could dry. As a result, the pit and sump pump were installed in September 1987.

IV. METHODS

During the initial site visit on December 2, smoke tubes were used to determine air flow patterns, detector tubes to sample for carbon monoxide and hydrogen sulfide, and the H-NU photoionizer to detect organic vapors in the offices and underneath 900A. In addition, one employee was interviewed who had medical problems felt to be work related.

On December 24, Bill Hoyle, PETC industrial hygienist, sent two soil samples from underneath trailer 900A to be analyzed by gas chromatography and mass spectroscopy (GC/MS) at NIOSH's Cincinnati Laboratory. On January 12, 1988, Jerry Hebb, PETC safety engineer, called a meeting with the employees in 900A to discuss what NIOSH was doing on the investigation and where the investigation would go based upon NIOSH findings. At this meeting, NIOSH distributed 40 questionnaires. The questionnaires were to be filled out and returned via self-addressed stamped envelopes. See Appendix A for example questionnaire.

On January 14, NIOSH returned to conduct airborne sampling for sulfur dioxide (SO_2), hydrogen sulfide (H_2S), carbon dioxide (CO_2), temperature, and relative humidity. Long term colorimetric detector tubes were used to determine if SO_2 and CO_2 were present. These tubes were used in conjunction with low flow battery-operated pumps calibrated at 17-20 cubic centimeters (cc) per minute. Hydrogen sulfide was monitored with short term colorimetric detector tubes in line with a Drager hand pump. The detector tubes were used to get a semiquantitative estimation of building 900A's environment. Temperature and relative humidity were monitored using a sling psychrometer.

On February 17, 1988, NIOSH sampled for organics and formaldehyde underneath and in building 900A. Bulk air samples were collected for organics/formaldehyde at flow rates of 1.0 liters per minute (lpm) for qualitative identification. Side by side air samples were collected at a flow rate of 200 cubic centimeters per minute (cc) for quantitative analysis based on the qualitative identification.

V. EVALUATION CRITERIA

Evaluation criteria are used as guidelines to assess the potential health effects of occupational exposures to substances and conditions found in the work environment. These criteria consist of exposure levels for substances and conditions to which most workers can be exposed day after day for a working lifetime without adverse health effects. Because of variation in individual susceptibility, a small

percentage of workers may experience health problems or discomfort at exposure levels below these existing criteria. Consequently, it is important to understand that these evaluation criteria are guidelines, not absolute limits between safe and dangerous levels of exposure.

Several sources of evaluation criteria exist and are commonly used by NIOSH investigators to assess occupational exposures. These include:

1. The U.S. Department of Labor (OSHA) Federal Occupational Health Standards; permissible exposure limits (PEL's);(1)

2. The American Conference of Governmental Industrial Hygienist (ACGIH Threshold Limit (Exposure) Values (TLV's);(2)

3. NIOSH criteria documents and recommendations. (Recommended exposure limits or REL's).(3)

These criteria have been derived from industrial experience, from human and animal studies, and when possible, from a combination of the three. Consequently, due to differences in scientific interpretations of these data, there is some variability in exposure recommendations for certain substances. Additionally, OSHA considers economic feasibility in establishing occupational exposure standards; NIOSH and ACGIH place less emphasis on economic feasibility in development of their criteria.

The exposure criteria described below are reported as time-weighted average (TWA) exposure recommendations averaged over the full work shift; short term exposure limit (STEL) recommendations for a 10-15 minute exposure period; and ceiling levels (C) not to be exceeded for any amount of time. These exposure criteria and standards are commonly reported as parts contaminant per million parts air (ppm), or milligrams of contaminant per cubic meter of air (mg/m^3). Occupational criteria for the contaminants evaluated in this study are as follows:

Substance	NIOSH (REC.)	ACGIH (TLV)	OSHA (PEL)
Carbon Dioxide	10,000 ppm	5,000 ppm	5,000 ppm
Carbon Monoxide	35 ppm	50 ppm	50 ppm
Formaldehyde(1)	LFL	1 ppm	1 ppm, 2 ppm (STEL)
Hydrogen Sulfide	10 ppm (10 min. ceiling)	10 ppm	50 ppm 20 ppm(C)
Sulfur Dioxide	0.5 ppm (10 hrs)	2 ppm	5 ppm
Toluene	100 ppm (10 hrs) 200 ppm(C)	100 ppm	200 ppm 300 ppm(C) 500 ppm(10 min)

(1)- Considered a potential human carcinogen by NIOSH and ACGIH.
- These standards/exposure levels refer to time-weighted averages (TWA) unless otherwise specified as Short term exposure limits (STEL), or ceiling values (C).
- ppm - Parts contaminant per million part air.
- mg/m^3 - Milligrams contaminant per cubic meter of air.
- LFL - Lowest feasible limit, STEL - short term exposure limit.

Some research suggests that industrial exposure criteria may be inappropriate for evaluating indoor air quality problems in office buildings. The American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) is one organization with environmental criteria designated to maintain acceptable IAQ in office building environments. ASHRAE recommends that outdoor air acceptable for ventilation (without treatment) meet the requirements established by the U.S. Environmental Protection Agency in the National Ambient Air Quality Standards and Additional Ambient Air Quality Guidelines. These ASHRAE criteria for the contaminants evaluated in this study would include:

	SHORT TERM	
	Level	Time
Carbon Monoxide	35 ppm	1 hour
Formaldehyde	0.1 ppm	ceiling

ASHRAE also recommends criteria[1] for indoor temperatures and ventilation rates for office buildings as detailed below:

Temp./Relative Humidity		Air Changes Per Hour	Minimum Outdoor Air
Winter	Summer		5 cubic feet per min. (CFM)/person (non-smoking)
70-74°F	74-78°F	4 to 10	
20-30% RH	40-50% RH		20 CFM/person (smoking)

1- ASHRAE is in the process of revising their recommendations on minimum outside air requirements for office buildings; however, the revisions are not final.

The ASHRAE estimated occupancy for offices is 7 persons per 1000 square feet (ft^2) or 143 ft^2 per person.

Carbon dioxide (CO_2) concentrations in indoor air are often used as an indirect measure of a buildings capability to dilute indoor generated odors and irritants. The following CO_2 criteria have been used to assess indoor air quality in office environments:

CARBON DIOXIDE (PPM)	COMMENTS
Less than 600	Adequate outside air intake.
600-800	There may be occasional complaints, particularly if the air temperature rises.
800-1000	Complaints more prevalent.
> 1000	Insufficient make-up air, complaints are general.

VI. RESULTS

No carbon monoxide or organics were detected in the air samples of building 900A on December 2. The smoke tubes did reveal that there was very little air flowing in the hallways and offices of 900A. It was also discovered that no fresh make-up air was being introduced, therefore the existing air is 100% recirculated air. Recirculation of existing air without the recommended addition of 10-15% fresh make-up air will permit contaminants to buildup.(4)

Since January 1984, one individual has had medical problems which were believed to be work related. The problems arose three months after being located in building 900A and have been ongoing ever since. From discussions with this individual on Dec. 2, 1987 by me and Abe Reich of DOE Headquarters, the individual expressed that the medical problems experienced at work were also experienced at home, on the weekends, and sometimes, 24 hours a day. However, it is unlikely that this individual's medical problems are related to anything so far detected at PETC. This individual's problem is not typical of work related problems. The other employees who were questioned, experienced their problems while at work, and upon leaving work, their problems cleared up. This is typical of work related problems. While the above individual does have some of the same symptoms as the other employees, the problems are still present upon leaving work. It's possible, that conditions at work may exacerbate the medical problems the individual has, but this is not concluded.

The soil sample analyses revealed that the soil contained a cyclo-octa form of elemental sulfur (molecular weight=256), and extremely low levels of aliphatic hydrocarbons (carbon range C_{12}- C_{25}) and a few phthalate esters. It's unknown at this time what the source of the aliphatic hydrocarbons and phthalate esters is, but natural gas lines are underneath building 900A. Aliphatic hydrocarbons are found in natural gas and fuel oils. Its possible the gas lines are a source and its possible that run-off from the street above building 900A is also a source. There is oil on the street from vehicle traffic. For the esters, they are general contaminants of virtually all soil and water ecosystems and it is difficult to not analyze any soil or water without detecting them.(5) According to the NIOSH chemist, the levels of esters and hydrocarbons were too low to quantify.

Of the 40 questionnaires brought to the January 12 meeting, 25 were taken by employees and 13 were returned to NIOSH. These questionnaires indicated that 11 of the 13 respondents complained of cigarette smoke in their work areas, two felt their illness was work related, four considered the workplace hazardous, and six employees felt their headaches and sore throats were a result of the odors.

On January 14, 1988, five air samples each were collected for SO_2 and H_2S using long and short term detector tubes; neither of these gases were detected. Eleven air samples were collected for carbon dioxide over a 7 1/2 hour period : six morning samples for CO_2 ranged from 415-826 parts per million (ppm) with a mean of 607 ppm; four afternoon samples for CO_2 ranged from 541-1000 ppm with a mean of 830 ppm. An outdoor (afternoon) sample for CO_2 for comparison was 190 ppm. The CO_2 measurements indicated that the carbon dioxide levels increased from morning to afternoon due to the lack of adequate intake air. Over the day, indoor temperatures ranged from 69-77^{o}F with a relative humidity ranging from 11-24%.

During the February 17, 1988 survey, toluene was detected in the women's restroom of 900A, the xerox room, and hallways of 900A. The toluene levels found ranged from 0.005-0.16 ppm. The highest value (0.16 ppm) was found in the hallway outside of room 14. The toluene levels are well below the Federal Standard of 200 ppm and NIOSH's recommended standard of 100 ppm. The compound limonene was detected in the hallway near room 14. Limonene has odor properties of menthol and is used in cleaning compounds and aerosol sprays. Twelve air samples were collected for formaldehyde. Formaldehyde was found in only one sample at the limit of detection (LOD) of the instrument conducting the analysis. The LOD was 0.01 ppm. This is well below any of the evaluation criteria.

Also, during the February survey, a medical release form was provided to the PETC nurse to be distributed to those individuals who had seen a physician while employed in building 900A. A copy of the form can be seen in Appendix B. There was no response from any employee.

VII. DISCUSSION/CONCLUSION

Employee medical complaints in building 900A since September 1987 follow some of the typical complaints of employees studied in "tight" buildings. Tight building syndrome is defined as a building in which worker complaints of ill health are more common than might be reasonably expected. From the questionnaires, the building 900A employees have complained of headaches, nausea, dizziness, and diarrhea. These same complaints are also the most prevalent complaints found among white collar workers. The symptoms are transient and usually intensify as the day progresses. In most cases, the complaints disappear after being out of the building.[6] In addition to the complaints above, the odors in building 900A have exacerbated the medical complaints between September-December 1987. In an office-type environment like building 900A, pollutants arise from many sources: human metabolism, smoking, building components, biological contamination, and office equipment.

Consequently, sampling was conducted primarily for the organics, aldehydes, carbon dioxide, carbon monoxide, and odors. Biological monitoring was not conducted because: 1) current knowledge related to office building problems associated with heating, ventilation and air-conditioning systems is limited, 2) the statistics on the number of organisms found in office building's can not be compared to any number or value to establish if there is/is not a problem, 3) sampling procedures (times, flow rates, etc.) are still questionnable and field analysis and interpretations are not uniform. It was also my observation that biological monitoring was not needed. Since the source of the odors did appear to be coming from the restroom area, an attempt was made to identify the odors by using activated charcoal.

It would appear from the information that has been obtained so far that:

1. Elemental sulfur is the most likely cause of the odor because; (1) from the lab analysis of the two soil samples, the chemist found primarily elemental sulfur in pieces of coal, and (2) the activated charcoal samples did not reveal any significant compound in the air. It was surmised by the chemist that the soil underneath building 900A has coal that contains sulfur. Pure sulfur is an odorless, pale yellow solid at room temperature, but many of it's compounds have vile, penetrating odors. Two common gases containing sulfur are hydrogen sulfide and sulfur dioxide; both possess distinct odors. The soluble forms of sulfur may be leaching out of the soil underneath building 900A during rainy periods or when the soil is wet due to leaking plumbing fixtures. It is possible for water to get underneath 900A from the leaking shower in the women's restroom and from natural drainage flow from the land behind building 900A. This leaching allows sulfur to combine with air and oxidize to an odor possessing compound. The compounds SO_2 and H_2S were not detected by colorimetric detector tubes. Therefore, it is likely that these compounds are not present and are not the compounds causing the odor. The odor threshold for SO_2 and H_2S are 3-5 ppm and 0.13-0.77 ppm respectively, while the detection limit of the tubes for SO_2 and H_2S are about 0.1 ppm and 0.5 ppm respectively.[7] It is possible that SO_2 and H_2S are present at other times, but since screening with the detector tubes did not reveal any levels, further testing for these compounds were not conducted. Other sulfur containing compounds may be causing the odor, but were present in concentrations too low to be detected by gas chromatographic analysis. While odors may be annoying and increase employee anxiety about air quality, there is no health hazard.

2. From the testing for CO_2, there is inadequate fresh air. The CO_2 levels indicate the existing ventilation system is not supplying fresh make-up air. At CO_2 levels between 800-1000 ppm, it is well recognized that complaints of stuffiness, eye irritation, nausea and headaches from office workers are prevalent.[8] In building 900A, these levels were found.

To help solve the non-existant ventilation in the women's restroom, DOE has let a contract to Trimark engineering of Pittsburgh, Pa. to install a supply air (700 cfm) and exhaust air (800 cfm) system for the women's restroom in building 900A. A contract should also be let out for bid for a supply and exhaust air system for the rest of building 900A, since the existing ventilation system is not set up to bring in outside air. There are many sources of indoor air contamination within offices today and the only mechanism for removing these pollutants is to provide an adequate supply of outdoor air. Since the CO_2 levels increased from morning to afternoon, it was indicative that contaminants were not being diluted with fresh air, but were building up as a result of the contaminants being recirculated. Therefore, per ASHRAE guidelines for offices, a supply of outdoor air necessary to dilute CO_2 is 5 cfm of air per person. For a smoking environment, 20 cfm per person is required.[4] With the addition of a new ventilation system to building 900A and the women's restroom, the odor and complaint problem should be corrected.

3. Exposure to cigarette smoke was a complaint of several employees; 85% of the employees considered smoking a problem and disliked smoking in their work areas. In buildings where smoking is unrestricted, complaints of nose and throat irritation, headaches and nausea, and aggravation of existing respiratory problems are common. Because of the number of employees that complained about smoking in their workplace, a no-smoking policy should be initiated. With the writing of this report, DOE is awaiting union approval before implementing a no-smoking policy DOE wide.

4. The relative humidity is borderline in building 900A; twelve relative humidity readings were taken. Six readings were between 11-19% and six readings were between 20-24% and a temperature range between 69-77°F. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommends a relative humidity between 20-30% and a temperature of 70-74°F for winter months. When relative humidity is low or borderline, odors can be more perceptible, complaints of eye, nose, and throat irritation increase, and there are increases in respiratory ailments.[4]

5. The formaldehyde found in building 900A could have come from anyone of over 3000 products. It's found in construction materials, cleaning materials, carbonless paper, carpeting, furniture, wall paper and cigarette smoke. Toluene is a solvent found in cleaning products, paint and adhesives. These two compounds were detected <u>well below</u> recognized federal standards and consensus guidelines. Neither compound could be considered to be a health hazard.

6. From the soil and air sample analyses, the only significant compounds found were elemental sulfur and carbon dioxide. Based on the sampling that has been conducted, visual observations, and questionnaires, further sampling is not warranted.

7. It should be noted that during both surveys, construction work was ongoing outside of building 900A. Also, in December, ventilation had been added to the 900A restroom area by DOE to remove odors. Consequently, to simulate previous conditions, the restroom fans were turned off all day during sampling. Odors were not detected on either survey with the fans on or off.

VIII. RECOMMENDATIONS

1. If the odors underneath 900A are generated during rainy or wet periods, then consideration should be given to: (a) re-directing water flow away from building 900A and (b) make sure that all of the foundation vents to building 900A are open for cross-ventilation and (c) make sure that all leaking plumbing fixtures have been fixed.

2. Provide better ventilation by installing an air handling system at one end of 900A to supply fresh air per ASHRAE guidelines and an exhaust system at the other end of 900A to exhaust the air.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

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1. United States Department of Energy
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2. Occupational Safety and Health Administration
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