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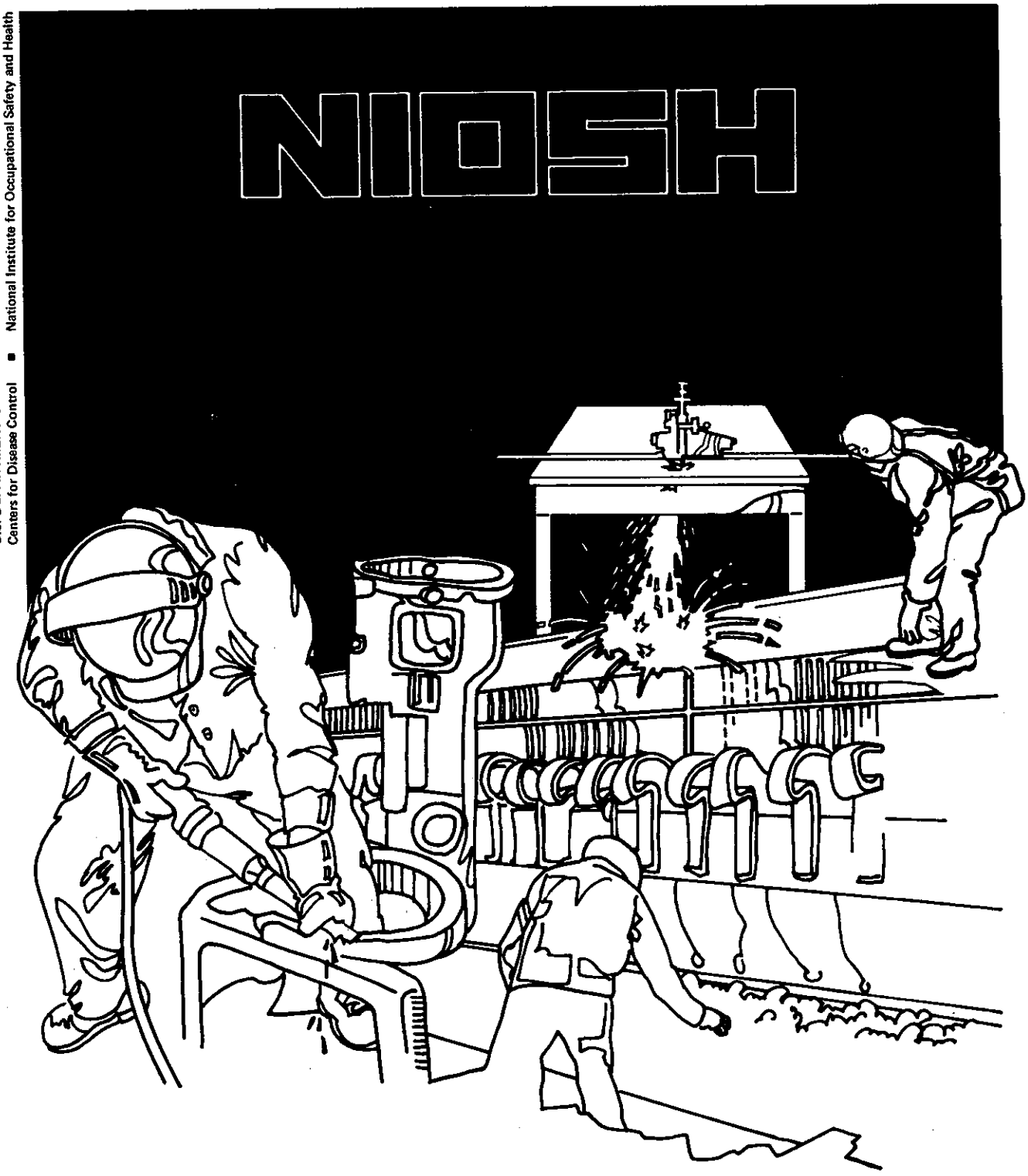
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
Centers for Disease Control ■ National Institute for Occupational Safety and Health

NIOSH



Health Hazard Evaluation Report

HETA 81-150-994
U.S. FOREST SERVICE
ST. MARIES, IDAHO

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 81-150-994
November 1981
U. S. Forest Service
St. Maries, Idaho

S-1-

NIOSH Investigators
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I SUMMARY

In December 1980, The National Institute for Occupational Safety and Health (NIOSH) received a request from the U. S. Department of Agriculture, Office of Safety and Health Management to determine the cause of illnesses reported by several U. S. Forest Service employees who work in the Federal Building located in St. Maries, Idaho.

An initial/environmental evaluation was conducted on February 18-20, 1981. Environmental air samples were collected for polar and non polar organic vapors and gases, metals, and for 68 specific compounds. A questionnaire was filled out by the employees on which they listed any health effects they felt were related to the job, and the floor and/or building where they worked. Prior reports of investigations, which included sample results of inorganic, organic and biological substances present, and a complete study of the building ventilation system, were reviewed.

Environmental sampling and analysis indicated that there were no inorganic, organic or biological substances detected at concentrations that would cause these symptoms. Analysis of the ventilation system revealed a lack of fresh make-up air and the potential for recirculation of the restroom exhaust air and vent pipe air.

The results of the questionnaire indicated that 19% (16 of 83) of the employees experienced one or more of the following symptoms: headache, dryness of the throat, burning, itching and runny nose; dizziness; lethargy; and diarrhea. Fourteen of the 16 have worked or currently work on the second (top) floor of the Federal Building.

NIOSH concluded that a probable cause of the adverse health problems was the lack of fresh air and the non-use of all the forced air circulation units. Recommendations to improve the quality of the workroom air are included in this report.

Keywords: SIC 9199 (General Government) office building, ventilation, worker illnesses.

II Introduction

In December 1980, NIOSH received a request from the U. S. Department of Agriculture, Office of Safety and Health Management, to determine the cause of illnesses and symptoms (headaches, stomach cramps, diarrhea, light headedness and dizziness, dry throat, eye irritation, irritability or depression and a metalic taste) reported by several U. S. Forest Service employees who work in the Federal Building in St. Maries, Idaho. An environmental survey was conducted on February 18-20, 1981. An interim report summarizing the initial findings was submitted to the requestor on March 19, 1981. A second report that included the environmental sampling results was submitted on June 24, 1981.

III Background

The U. S. Forest Service occupies the major portion of the Federal Building in St. Maries, Idaho. Approximately 100 persons work in this 10 year old brick building which is 60 by 100 ft. in size and has a ground floor and a first and second floor.

The problem involves recurring illnesses experienced by several employees who believe that their illness was caused by some exposure they were receiving in their office. The employees had been periodically complaining of a variety of symptoms including headaches, stomach cramps, diarrhea, light headedness and dizziness, dry throat, eye irritation, irritability or depression and a metallic taste in their mouths. The problem appeared to be centered in the Northwest corner of the top floor where approximately five female employees were employed as engineering draftsmen. During October and November, 1979, five Federal employees were sent to a local physician, for treatment of what appeared to be a common ailment. No findings of clinical significance was found in any of the employees.

In early November, the U. S. Forest Service's Regional Office Safety Group inspected the building and recommended that the use of the GAF 240 Diazo Printer (which uses anhydrous ammonia as a developing agent and releases ammonia vapors to the atmosphere) be suspended until adequate ventilation could be provided for the unit. It has subsequently been provided with a local exhaust hood and re-vented to the roof of the building.

The Occupational Safety and Health Administration (OSHA) conducted environmental sampling in the drafting area in November 1979 and February 1980. A summary of their results are included in Section V of this report. OSHA concluded that "the results of their investigation and environmental sampling have not identified the presence of toxic substances or dangerous work practices which might be responsible for causing the occurrence of problems in the drafting department."

Bacterial and fungal cultures were made by Alpha Medical Laboratory on materials found in the air filter of the heating and cooling system. Nothing unusual was found in these cultures.

In December 1979, the drafting group was moved to another facility several blocks away. In December 1980, they were again relocated to their present facilities, an old church that has been remodeled into an office. The affected employees still experience the adverse health effects, although not as frequently.

IV Evaluation Design and Method

General area samples were collected on the ground floor, first floor and second floor. Air samples for polar and non-polar organic vapor and gaseous compounds were collected by passing 390-540 liters of air through charcoal tubes and porous polymer tubes and analyzed by gas chromatography with confirmation by mass spectrometry. Air samples for metals were collected by passing 663 to 1513 liters of air through cellulose membrane filters and were analyzed by atomic absorption techniques. Sixty-eight separate compounds (see Table 3) were measured by passing 1000 to 4000 ml through indicator tubes.

A questionnaire was filled out by the employees on which they listed any health effects they felt were related to the job, and the floor and/or building where they worked.

V Evaluation Criteria

There is no environmental evaluation criteria or toxicity information listed here for any of the compounds identified as they were far below the applicable criteria.

VI Results and Discussion

A Environmental results

NIOSH air sample results for metal analysis are shown in Table I. Four metals, aluminum,, calcium, iron and phosphorous, were found in trace quantities (3 ug/cu m or less) in one or more locations. All other metals analyzed were less than detectable concentrations of 0.5 ug/filter. The source of these metals is not known. Aluminum, calcium and phosphorous can be found in some cleaning agents. They were found in both the Federal Building and in the old church building. Iron was found only in the church building. It is not known where it is coming from. These metals, in the concentrations found, will not produce the symptoms the workers are experiencing.

NIOSH air sample results for organic vapors and gases are shown in Table I. Only two compounds, 1,1,1-trichloroethane and the alkanes with 8-11 carbons were present in measurable quantities. 1,1,1-thrichloroethane was found only on the ground floor and 1st floor of the Federal Building. It was not found on the second floor where the persons who had health problems worked or in the old church where they presently work. The alkanes were present in all locations, with the old church building having the highest concentration. These compounds could come from propellants used in aerosol cans or adhesives used in glues. New carpet tiles were recently installed in the Federal Building but not in the church. These organic compounds in the concentrations found, will not produce the symptoms the workers are experiencing.

Sixty-eight separate compounds were sampled by NIOSH using detector tubes (Table 3). Up to 40 pump strokes were used per sample. All but four (acetone, acetic acid, formic acid and methyl bromide) were negative. These four did not exhibit the proper color change and were suspect. Sampling conducted outside and in the old church office building gave the same results. Therefore, they were considered negative.

Results of the environmental sampling conducted by OSHA are shown in Table 2. Carbon monoxide was the only compound that was present in detectable concentrations and it ranged from 2-5 ppm.

Bacterial and fungus cultures were made by Alpha Medical Laboratories of Coeur D'Alene, Idaho on materials found in the air filters of the heating and cooling system. Nothing unusual was found in these cultures.

B Questionnaire Results

A NIOSH questionnaire was completed by 83 of 85 employees present that day. Seventy-five worked in the Federal Building and 8 worked in the old church building. The workers were asked to list symptoms they felt could be caused by their work environment. Eighty-one percent (67 of 83) had a negative response while 19% (16 of 83) had one or more symptoms. Fourteen of the 16 worked on the 2nd floor (6 of these 14 presently work in the old church building.) The persons now working in the church building have a larger variety and more symptoms per person than those currently in the Federal Building. The symptoms common to both groups were headaches, throat (dryness, etc.), eyes (burn, itch, watering), nose (itch, run); dizziness, lethargy, and diarrhea.

C Ventilation System

The problem was localized on the 2nd floor of the Federal Office Building.

All floors are basically the same as far as construction, materials used, cleaning compounds used, etc. One difference is that there is an ammonia type blueprint machine located on the 2nd floor. A new exhaust ventilation system was recently installed over the unit which according to the workers greatly improved the conditions. This may have been a portion of the problem.

The heating is provided by two systems. One is a hot water perimeter system and the other is a fuel oil fired forced air system. Currently the hot water heat is the primary heating system with the forced air being used only when the temperature outside is low. The forced air unit is on all day to provide continuous air movement. Until 1 to 1-1/2 years ago, the fuel oil fired forced air system was the primary heating system. Each of the four forced air units provide air to one of the four zones on each floor. (e.g. unit #1 provides air to zone 1 on all three floors.) With this type of recirculation of air, the air throughout the building becomes basically homogeneous. During our visit the unit providing air to the north side of the building was not in operation.

In the Fall of 1979, as a fuel conservation measure, the fresh air intakes to these forced air units were covered over with plastic. This resulted in no fresh air being brought into the building via the ventilation system causing the air to become stale. Many of the complaints started after this date. The plastic was removed just 2 weeks prior to our visit. Several workers stated that it was better the past few weeks. The louvers were in the closed position. Smoke test tubes indicated that a minimal amount of fresh air was entering the system through leaks around the louvers. The louvers should be adjusted to bring in a minimum of 10 to 15% fresh air.

There were numerous complaints that when the furnaces are on the workers can smell fuel oil. Because the air intakes had been blocked off it is unlikely that exhausted furnace combustion gases were re-entering the system. The building maintenance person stated he had visually checked the heating chamber for leaks. Small leaks may not be found through visual inspection.

Another complaint with this heating system is that the air alternates from hot to cold. This is because the burners are either on full blast or off. They cannot be regulated. A phone

conversation with a former GSA employee, familiar with this building, stated that in the past plans had been proposed to use hot water heat coils in the unit instead of fuel oil heat. This type of unit could be better regulated to provide more constant air temperature passing through the system.

The engineering firm of Bergourt Engineer and Company Inc. completed a detailed study of the ventilation systems. Portions of this report dated Dec. 24, 1980 are in Attachment 1.

On the roof next to the heating air conditioning units are 2 large pressure relief vents. The restroom exhaust fans and the sewer vents both terminate several feet from one of these pressure relief vents. When the plastic was over the air intakes and the bathroom exhaust fans and the blue print exhaust in operation, the building would be under negative pressure. Whenever air is removed from a building it must be replaced. The make-up air enters through open windows and doors or through the pressure relief vents. Because of the close proximity of exhaust vents to the pressure relief vent, it is possible for the exhausted bathroom air and sewer vent gases to re-enter the building.

The church building currently being used by the drafting department has electric baseboard heat with no provision for air circulation or make-up air. There were 16 pest strips hanging from the ceiling.

VII Conclusion

The results of a questionnaire indicated that 19% (16 of 83) of the employees experienced one or more of the following symptoms: headache; dryness of the throat; burning, itching and irritation of the eyes; itching and runny nose; dizziness; lethargy and diarrhea. Fourteen of the 16 have worked or currently work on the second (top) floor of the Federal Building.

Environmental sampling and analysis indicated that there were no inorganic or organic or biological substances detected at concentrations that would cause these symptoms. Analysis of the ventilation system revealed a lack of fresh make-up air and the potential for recirculation of the restroom exhaust air and vent pipe air. A probable cause of the adverse health symptoms was the lack of fresh air and the non-use of all the forced air circulation units.

VIII Recommendations

1 Provide a minimum of 10-15% fresh make-up air through the ventilation system at all times that the building is occupied.

2 Operate all 4 ventilation units at all times that the building is occupied.

3 Modify the heating and air condition systems per the consulting engineers recommendation.

4 The combustion chambers of the four furnaces located on the roof should be pressure tested to determine if there are any leaks which permit the gases and odors to enter the forced air system. Another method would be to place a non-toxic, highly odorous substance such as mint oil in the combustion chamber. Any detection of the odor in the building would indicate a leak in that system.

5 The bathroom exhaust vents and the sewer vents should be extended to terminate at least 8 ft. above the roof.

IX DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this complete Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio, 45226. After ninety (90) days, the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. 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 U. S. Department of Agriculture, Washington, D.C.

2 U. S. Forest Service, St. Maries, Idaho.

3 NFFE Local 1295 St. Maries, Idaho.

4 U. S. Department of Labor, Occupational Safety and Health Administration, Region X, Seattle, Washington.

For the purpose of informing the 14 affected employees, the employer shall promptly post this Determination Report in a prominent place(s) near the work area of the affected employees for a period of thirty (30)calendar days.

XI ACKNOWLEDGMENTS

Report prepared and survey conducted by:

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Originating Office:

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TABLE I

NIOSH SAMPLE RESULTS

ORGANIC VAPOR AND METAL
AIR CONCENTRATIONS

February 18-20, 1981

U. S. Forest Service
St. Maries, Idaho
HETA 81-150

Location	Sample Vol. Liters	1,1,1,-trichloro-ethane ppm	Alkanes C-8 to C-11* ppm	Sample Vol. Liters	METALS - ug/cu m Aluminum	Calcium	Iron	Phosphorous
Ground floor Room C-15	540	0.05	0.07	1513	0.6	0.8	N**	1.8
1st Floor Mail Room	540	0.05	0.07	1513	N	2.9	N	2.0
2nd Floor Room 203 Former drafting Area	390	0.02	0.02	1513	N	0.7	N	1.8
Church Bldg. Present Drafting Area	405	0.02	0.12	663	N	2.4	0.9	1.4

* C-10 was the dominant peak. Concentrations calculated at C-10

** N-less than 0.5 ug/filter

The following elements were less than 0.5 ug/filter in all of the samples: Arsenic, Beryllium, Cadmium, Cobalt, Chrome, Copper, Lithium, Magnesium, Manganese, Molybdenum, Nickel, Lead, Platinum, Selenium, Silver, Tin, Tellurium, Titanium, Thallium, Vanadium, Tungsten, Yttrium, Zinc and Zirconium.

TABLE 2

SUMMARY OF OSHA SAMPLE RESULTS

November 1979 and February 1980

U. S. Forest Service
St. Maries, Idaho
HETA 81-150

SUBSTANCE	CONCENTRATION
amines	ND*
ammonia	ND
carbon monoxide	2-5 ppm
charcoal tube samples	no organic substances in significant amounts were identified
chlorine	ND
formaldehyde	ND
freon-22	ND
mercury	ND
nitrogen dioxide	ND
ozone	ND
relative humidity	32-45%
sulfur dioxide	ND

*ND - Less than detectable limits

TABLE 3

LIST OF SUBSTANCES SAMPLED FOR
USING DETECTOR TUBES

February 18-20, 1981

U.S. Forest Service
St. Maries, Idaho
HETA 81-150

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acetaldehyde
acetic acid
acetone
acrylonitrile
ammonia
aniline
arsine
benzene
carbon dioxide
carbon disulfide
carbon tetrachloride
chlorine
chloroformiates
chloroprene
cyanogen chloride
diborane
diethyl ether
dimethylacetamide
dimethyl formamide
dimethyl sulfide
dimethyl sulfate
epichlorohydrin
ethyl acetate
ethyl benzene
ethylene
ethylene oxide
ethyl glycol acetate
formaldehyde
formic acid
n-hexane
hydrazine
hydrocarbons
hydrochloric acid
hydrocyanic acid
hydrogen chloride
hydrogen cyanide
hydrogen fluoride
mercaptan
mercury
methanol
methyl acrylate
methylacrylonitrile
methyl bromide
methylene chloride
methyl methacrylate
natural gas
nickel tetracarbonyl
nitric acid
nitrogen dioxide
nitro-glycol
nitrous fumes
olefin
oxides of nitrogen
ozone
n-pentane
perchloroethylene
phenol
phosgene
phosphates
phosphine
styrene
sulfur dioxide
systox
tetrahydrothiophene
toluene
1,1,1-trichloroethane
trichloroethylene
triethylamine
vinyl chloride
xylene

ATTACHMENT I

Portions of the report from Bergourt Engineers and Company, Inc. on the heating and air conditioning system at the Federal Office Building at St. Maries, Idaho.

II. DIGEST

The building, as it now stands, does not meet basic building codes for providing adequate ventilation or outdoor air for the occupants. The ventilation air systems have been and are always turned off for the winter months. Hence, only the hallways and toilets have any air changes. The windows in the office areas are sealed units which are not designed to open for cross-through ventilation. The top floor has keyed operators to permit window washers to open the windows, since they are so high off the ground that scaffolding would be expensive, but even those windows are not intended to provide ventilation air to the spaces.

For employee and occupant well-being, the ventilation systems should not be turned off, but on the other hand the building operators have very good reasons for leaving these particular fans turned off.

First, the units' oil burners are grossly oversized. This makes them virtually impossible to control during the heating mode.

Second, they use up fuel oil at an astounding rate if operated during the wintertime.

Third, we found evidence that the operating personnel do not fully understand the control system of the fans or radiation in order to program the operation of the building for different seasons. Our investigation tells us (from our point of view) the ventilation hardware and related control system was poorly conceived in the beginning, poorly located for access, inadequately maintained and serviced by the control manufacturer. There were no properly executed written directions for the operation of the controls or components of the heating and ventilating system. No building operator should be expected to understand or comprehend the control systems under such conditions.

III. BACKGROUND DATA

Exhibits A, B, and C, are included to show that typical codes require ventilation air to each space. Where these codes are enacted, it is not lawful to simply put air in the corridor and exhaust it through toilets. The law states that each occupied space should receive a certain quantity of air from the outdoors or a combination of air from the outdoors and

recirculated air from other spaces. The purpose of this law is to prevent people from becoming sick. We have highlighted the exhibits and they speak for themselves. Even the code for energy conservation in new building construction requires that each occupied space have a small amount of outdoor ventilation air and a larger amount of air recirculated from other spaces.

We have reproduced from the ASHRAE 1977 Fundamentals Handbook, pages 12-1 and 12-2 of chapter 12, titled "odors," and marked same as Exhibit D. Quoting from the standard, "Various factors conspire to make odor control a primary consideration in ventilation engineering." Please refer to Exhibit D, particularly the areas that are highlighted, for authentication that ordinary odor control (even without toxic substances present) is necessary to keep people from becoming sick.

We found the building ventilation systems to be turned off, and in fact, the fresh air intakes were sealed up with plastic, taped air tight, and a stick was jammed into the damper linkage to keep the return air open and prevent the fresh air damper from opening. Even if the fan systems were operated, there would not be the outdoor air brought into each corner of the building that the law requires. Furthermore, if the tape were removed, the plastic thrown out, and the stick in each damper linkage disposed of, one could not expect the fresh air damper linkage to operate properly since there is a pneumatic air line and damper operator exposed to the winter air. Since it is impossible to remove all moisture from this control air, the subfreezing temperatures on the roof will render the operator useless if a minute amount of moisture should freeze in the control line or operator.

These extreme measures have been implemented, we believe, because of some very glaring problems in controlling the ventilation system both from a comfort and energy cost standpoint. From our viewpoint, it is impossible to reactivate the ventilation system to meet minimum ventilation standards without major retrofitting of the fan systems. Our position is thus stated because of the following conditions:

1. We found the oil burners were grossly oversized. This coupled with the fact that oil burners are either all on or all off and are not able to modulate like hot water heating systems do, makes the system, in our opinion, impossible to control. By adding up the design engineer's estimate of the heating needs of the four units located on the roof, we arrived at a total of 490,000 btu's per hour. In light of the fact that there are hot water radiators surrounding the perimeter of the building and using our best judgment (derived from interviews at the site) as to what should be on these four fan systems, we believe the engineer's estimate of 490,000 btu's per hour to be overly generous. Taking the

actual installed output of 940,000 btu's per hour, we believe the heating system approaches four times the capacity that it should be even at the extreme cold outdoor temperatures at night in the middle of the wintertime, say 15 degrees below zero. Taking a typical winter day during normal office hours, temperatures of 20 to 30 degrees above zero will be experienced which makes the heating oil burners on the ventilation air seven to eight times as large as they should be. Since the thermostat cannot modulate, there is no way you can control the air temperature entering the room. Consequently, if the operator is not able to operate the fans, he is probably justified in sealing off the fresh air intakes even though this impairs the well-being of the building occupants.

2. The fans are not needed for heating except on the most extreme winter days, and then are needed only for a short period in the morning to warm the building up.

3. The time clocks which control these units are located above the ceiling in not too accessible locations. There is no attempt at running a portion of the ventilation air systems, since there are no manual timers located in readily accessible spots.

4. We believe the control system has received improper attention by the control manufacturer who was probably frustrated with an impossible situation from the beginning.

5. Improper instruction has been left for the building operating maintenance personnel to assimilate since it is pretty difficult to instruct the operation of something that is inoperable.

The windows are a sealed unit which does not permit them to be open. The occupants have found the keys the window washers can use to open the top floor only and these have helped in providing outdoor air at spaces where the occupants are able to open the keyed window. The bottom two floors, however, do not have this provision since window washers can reach the windows from the ground level.

We found the radiation on the perimeter of the building to be inadequately controlled. Without proper air moving through the rooms from the interior air system, the radiation is overheating the spaces terribly. The spaces on the south side of the building were particularly stifling since the radiation is not controlled from a thermostat indoors which senses the solar gain from the sun, but is simply controlled from outdoor ambient termperature. Even the fact that there is a different control point or schedule for each exposure of the building doesn't permit the proper control with respect to whether the sun is shining or

not. Furthermore, we found the radiation control instruments were out of calibration and the maintenance personnel on duty at the time of our survey did not understand or comprehend how the various exposures are controlled as related to the perimeter radiation system. We velieve this lack of temperature control contributes to provoking the "Seat of Emotion" in the building's occupants.

In the boiler room, there exists some puddles of oil, as might be expected, located in well-kept oil pans and the like. The boiler room of any oil-fired plant will necessarily smell of fuel oil or diesel. In the context of a boiler room with building stationary engineers being accustomed to such odors, they are not considered unpleasant because those persons are accustomed to same. However, if these odors are allowed to drift into adjacent spaces where an employee or the general public doesn't expect to encounter same, they can cause suspicion and trigger sickness. Because the building is under a negative pressure, with the toilet exhaust fans running and the fresh air intakes being sealed up, air can enter the boiler room through the combustion air opening at the outside wall air inlet well, pass through the boiler room, and over the oily drain pans and exit into the hallway through an improper grille located in the door of the boiler room. We say this is improper based on good practice and at least one building code (Uniform Building Code) as shown in Exhibit C, sheet 2, which states that every room containing a boiler should be isolated from the rest of the building by not less than a one-hour fire-resistant occupancy separation (note the exception does not apply since the boiler has over a million btu per hour input).

Not only is the odorous air passing through the door louver, but on numerous occasions, the operator's defeat the door closure and prop the door open in order to let "useful heat" escape from the boiler room into the building corridor.

Mix this oily smell with body odors, perfumes, smoking, etc., and this building with its lack of air changes in the occupied spaces can definitely make people sick.

We found evidence that the controls in the rooftop units are neglected. Such evidence included a very rusty junction box where the cover had been left open to the weather and various terminals were quite rusted. We also learned there had been a fire in one of these furnaces. This fire was caused when a blower belt broke and the high limit control didn't keep the burner from overheating. This, in itself, is a very serious condition that can result in loss of life.

Overheating of the heat exchanger that caught fire or even wide fluctuations in temperature on the other heat exchangers may cause some to crack, which would permit products of combustion to enter the duct and be supplied to the occupied spaces. We are not equipped, nor do we employ a service technician to test for tightness if the heat exchangers. If these units are to be operated in the future (which we do not recommend without extensive modifications), the occupied spaces should be tested for carbon monoxide or other products of combustion while the burners are in operation.

On the roof, we found more drip pans which contain a lot of oil. Consequently, if the four units are operated in the summertime with the fresh air damper open, it is possible to draw an oily smell into the building with the close proximity of the fresh air intakes to the oily drip pans. Figure 7 of Exhibit E shows the relationship between one oil pan and the fresh air intakes. This situation is particularly bad since the operator is stymied no matter which way he goes. To take in outside air, he pulls in oil smell, or with no outside air he can't replace the air in the space.

IV. POSSIBLE SOLUTIONS AND RETROFITTING IDEAS

To solve the aforementioned problems of control and energy consumption would be a major undertaking. To keep the smell of the boiler room out of the hallway is relatively easy and consists of modifying the door between the boiler room and the hallway by weatherstripping and blocking off the louver so the door is airtight and if kept closed, should contain the oil smell in the boiler room. Adequate ventilation or combustion air should be brought through the door leading to the outside air well in the boiler room. This louver has 2.5 square feet of opening so it should be adequate as is.

We learned the air conditioners are also oversized and really don't have to operate until 2:00 in the afternoon on a warm, sunny day. This fact should be acknowledged and verified before any major retrofitting action is taken.

We believe the building envelope should be updated, which would cause the boiler to have a lot of additional capacity. This capacity should be used to provide the additional hot water needed for a more precise control of a wintertime ventilation system which used hot water in lieu of oil burners. We suggest an independent fresh air fan and exhaust fan system be investigated which would distribute fresh air to each of the four duct systems. After taking air through an air-to-air heat exchanger, which recaptures heat in the exhaust air stream, we believe the supply duct of the four systems should be modified for better winter

and summer operation and the four oil-fired burners in the rooftop equipment be removed. A heated equipment room enclosure should be built to enclose the independent fresh air and exhaust air system with heat exchanger. Other modifications could consist of two-speed operation on the rooftop air conditioners so each can be run at a lower speed during the heating season. Simply closing down the blower with pulleys would work also, but speeds would have to be increased for summer conditions to prevent icing on the refrigeration coil. The possibility of abandoning or removing one or more of the rooftop air conditioners should be explored since there appears to be an overdesign on the air conditioning system, particularly if the exterior envelope is modified on the south side. Note that a reflective film has been installed on the south-side glass which would already contribute to a lower peak heat gain in the building. This reflective film should be considered a temporary measure, however, and the glass to wall ratio as well as exterior shading should be looked at on this building.

A means should be employed to utilize the economy cooling or cooling with outdoor air during the summer months and along the south side in the winter. This outdoor air cooling is used to purge the building of unnecessary or excess heat. In the summer, from the hours of 4:00 a.m. until 12:00 noon or better, when the temperatures at St. Maries start to climb above 75 degrees, outdoor air is extremely effective and useful. In order to maintain control of such a system, the relief air hoods that are now operated by gravity-powered backdraft dampers (which incidentally have been sealed up with plastic) should be replaced with a return/relief air fan and the customary control dampers that go with it.

The pneumatic control system should be completely revamped and the controls made more accessible and readily understood.

An air distribution system which employs variable volume should be used in order to cut down on the drafts and so forth associated with a system sized for peak air conditioning load. Using the variable volume controlled at the room will reduce the air quantity and permit the two-speed operation suggested above to be used more effectively.

A consulting engineer or architect/engineering team should be engaged to prepare plans and specifications for such major retrofitting examples cited above. Anything less than a thorough engineenring study complete with calculations, equipment sizing, and follow through with instructions and monitoring may result in conditions less than satisfactory. Items such as shading on the outside of the building on the south side, cascading of fresh air to the interior spaces before it hits the exterior spaces, and the use of an air-to-air heat exchanger all require the attention of an experienced building systems design team.

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