Art 10.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES ■ Public Health Service
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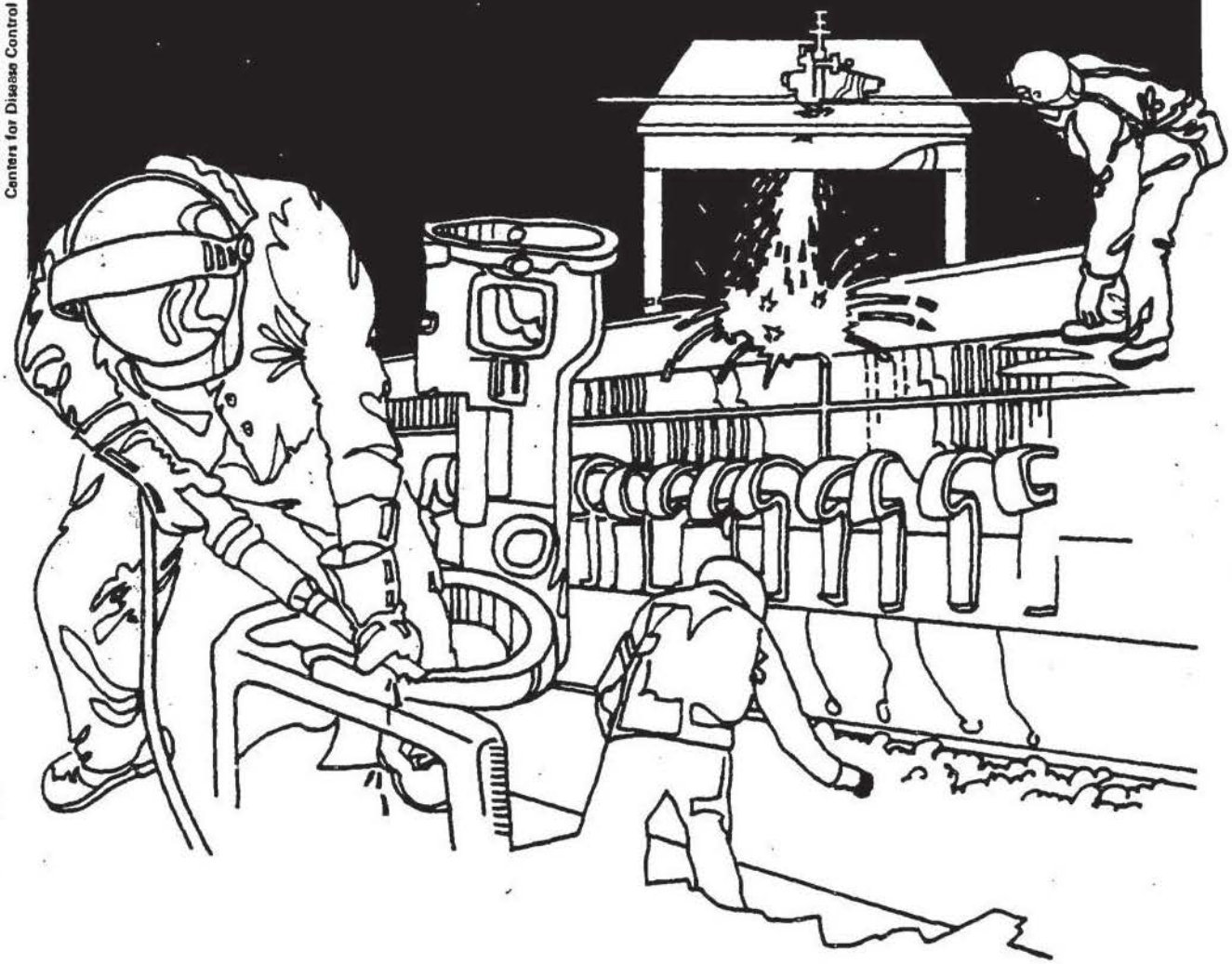
NIOSH



Health Hazard Evaluation Report

HETA 84-404-1579
FLORIDA STATE ARCHIVES
TALLAHASSEE, FLORIDA

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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FLORIDA STATE ARCHIVES
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I. SUMMARY

On June 18, 1984, the National Institute for Occupational Safety and Health (NIOSH) was requested by the Florida State Archives, in Tallahassee, Florida, to evaluate the operation of their ethylene oxide (EtO) fumigation facility. The unit had been retrofitted with control systems to help meet the recently revised OSHA permissible exposure limit for EtO of 1 part per million (ppm) as an 8-hour time-weighted average. NIOSH recommends that EtO be regarded as a potential occupational carcinogen and that exposure to EtO be controlled to less than 0.1 ppm determined as an 8-hour time-weighted average. There are four workers who may be exposed to EtO during the operation of the fumigator. On November 26-30, 1984, NIOSH investigators monitored for emissions of, and exposures to, EtO during the fumigation of two loads of items.

Monitoring was conducted using direct reading infrared spectrometers, and solid sorbent air sample collection methods. These were used for leak detection, to determine completeness of aeration, and full-shift personal and area exposure monitoring.

EtO was found to be leaking from the fumigant cylinder, as well as from piping connections between the cylinder and the fumigation chamber. Potential peak exposures of >120 ppm were recorded by one direct reading instrument, and >500 ppm with another during the evacuation phase of the fumigation cycle. Measurements were taken at other locations (restoration laboratory and photography laboratory) where the drains share common plumbing with the fumigator. EtO concentrations from 1-8 ppm were found at these distant locations resulting in exposures to non fumigator personnel. A 13-hour area sample, collected in the non-restricted corridor between the restoration lab and the fumigation suite measured 0.05 ppm EtO.

Following the aeration period at the end of each fumigation run, all items were monitored for residual EtO. Different time periods were necessary for complete aeration of different kinds of items. From boxed loose papers, to large books and museum pieces, aeration times ranged from 17 to 39 hours.

Nine personal exposure samples were collected in the breathing zones of the three NIOSH investigators during this evaluation. Exposures ranged from none detected to 0.20 ppm EtO. Three quantifiable results averaged 0.17 ppm (sd, +0.03). The sample times averaged 218 minutes. Approved respirators were worn during exposure periods. The activities during the sample periods included monitoring items for completeness of aeration, which is not something the Florida State Archives workers would be doing, and which resulted in these relatively high exposures.

Based on these results, the NIOSH investigators concluded that a health hazard exists if the fumigation system is operated without additional controls. The general building worker population was exposed to EtO due to diffusion of the gas from the drain system shared with the fumigator. High concentrations of EtO resulted in the fumigation suite when the water/EtO mixture from the post-fumigation evacuation was discarded into the unhooded drain. This presents a potential health hazard to the fumigation system operators. Recommendations are made in Section IX to eliminate these exposures and potential exposures.

KEYWORDS: SIC (8411) Museums and Art Galleries, SIC (919) General Government, ethylene oxide, fumigation, archives

II. INTRODUCTION

On June 18, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Florida State Archives, in Tallahassee, Florida. State records, books, and museum pieces are fumigated with ethylene oxide (EtO) at the Archive's facility. The fumigation equipment had been idle for a period of time prior to the recent change in the OSHA EtO permissible exposure limit (PEL), from 50 parts per million (ppm) to 1 ppm for an 8-hour time weighted average. NIOSH was requested to determine whether the fumigator at the Archives could be operated in a safe fashion.

An evaluation was conducted by NIOSH researchers on November 26-30, 1984. EtO concentrations were monitored during two fumigation runs. Post-fumigation monitoring was performed in an attempt to empirically determime aeration parameters. Preliminary recommendations concerning the operation of the fumigator were presented to Florida State Archives officials at the closing conference on November 29, 1984.

III. BACKGROUND

The Vacudyne Altair Industrial Gas Fumigator, used by the Archives, is located in a three room suite (7100 cubic feet (ft^3)) on the ground floor of the R. A. Gray Building, at 500 South Bronough Street, in Tallahassee, Florida (Figure 1). This suite is provided with a dedicated ventilation system which keeps it under negative pressure with respect to the corridor entrance. The rooms are exhausted through floor level gratings at a rate of 4000 cubic feet per minute (cfm), with no recirculation. Fresh, outside supply air is introduced from ceiling diffusers at a rate of 2200 cfm. The fumigator is a 225 ft^3 unit, with access doors at both ends. At this facility, one end was used for loading suspected contaminated articles, and at the other end the articles were unloaded after fumigation. Each end of the fumigator was in a different room, to minimize recontamination of fumigated items. The fumigator is equipped with a post-fumigation ventilation system. This consists of an electrically operated ventilation valve, exhaust blower, and control switch that is actuated by the chamber door on the unload side. In the "door open" position the ventilation valve will open and the blower will operate. In the "door closed" position the ventilation valve is closed and the blower is off. This feature enables the chamber to be used for aeration.

Figure 2 is a phase diagram of the Vacudyne Altair fumigation cycle which consists of four principal phases:

1. pre-vacuum;
2. charging of the chamber with fumigation gas mixture (12% EtO/88% dichlorodifluoromethane);
3. fumigation exposure;
4. post-vacuums (up to 5) with exhaust of fumigation gas to drain.

The three sources of environmental EtO during normal operation of the fumigator are:

1. at the completion of the fumigation cycle, the door is opened and EtO that remained in the chamber after exhaust (and desorbing from the load) may diffuse into the environment;

2. during the exhaust phase, the bulk of the fumigation gas is drawn out of the chamber by the vacuum pump, mixed with water, and discharged down the drain - however, some of the gas escapes from the water at the drain airbreak and diffuses into the environment;

3. when the load is removed from the fumigator, it may still contain a significant amount of adsorbed EtO which diffuses into the environment if aeration is incomplete.

IV. EVALUATION DESIGN AND METHODS

Two fumigation cycles were monitored. Boxed, loosely filed papers and large, bound volumes comprised the first load. The second load contained various museum pieces, such as small farm implements, a small stuffed chair, an old croquet set, a box of garments, and large, bound volumes.

Most of the air monitoring for EtO was conducted using Wilks Miran infrared spectrometers. Two Miran Model-103's were used as stationary monitors. One was placed in the load-side room and the other in the unload-side room. These were placed centrally in the rooms to monitor peak exposure levels continually during the cycle period. Each was equipped with a Metrosonics DL-331 Datalogger, which stored current EtO concentrations every 30 seconds. At the end of the sampling period, the stored data was read and printed-out using a DB-652 Metroreader. A Miran Model-80 was used for equipment leak detection, measuring peak, worker EtO exposure, and determining completeness of aeration. The Model-80 is equipped with a microprocessor which can provide a printout of averaged data over a specified time period, or an instantaneous reading upon command. The Model-80 was also used to monitor laboratory drains which shared plumbing with the fumigator vacuum pump drain.

Full-shift personal and long-term (up to 12 hours) area air samples were also collected. Ethylene oxide was collected on a solid sorbent (activated charcoal) as the air was sampled at a flow rate of 0.02 liters per minute (lpm) through a calibrated, battery-powered sampling pump. The charcoal was contained in two glass tubes which were connected in series for sample collection. The front tube contained 400 milligrams (mg) and the back-up tube 200 mg of charcoal. Analysis of the charcoal tube samples was conducted in accordance with NIOSH Method 1607.[1] This is a derivatization, gas chromatographic method. The EtO is desorbed using a benzene, carbon disulfide mixture (99:1). The EtO is then derivitized to 2-bromoethanol (2-BEt) by first adding hydrogen bromide, and then sodium carbonate. The amount of 2-BEt formed is proportional to the amount of EtO present. The 2-BEt is then detected by electron capture. The limit of detection (LOD) for this method was 0.20 micrograms (ug) per sample. The limit of quantitation (LOQ) was 0.90 ug per sample.

V. EVALUATION CRITERIA

A. Environmental Criteria

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH 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) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

B. Ethylene Oxide Evaluation Criteria

Ethylene oxide (EtO) is a major industrial chemical. It is used primarily as an intermediate in the production of other industrial chemicals such as ethylene glycol. Ethylene oxide is used also as a gas sterilant for heat-sensitive items in the health care industry and as a fumigant for such items as spices, books, and furniture.

Ethylene oxide is a highly exothermic reactant and potentially explosive substance. As a result, the handling, storage, and use of EtO presents potentially serious problems. EtO is a gas at room temperature and a liquid below 55°F. The liquid is relatively stable; however, vapor concentrations greater than 3% are highly flammable, and air mixtures of EtO will explode when exposed to heat or open flames.[2]

Acute Effects

The primary mode of exposure to ethylene oxide is through inhalation (breathing). Ethylene oxide is an irritant of the eyes, respiratory tract, and skin. Early symptoms of EtO exposure include irritation of the eyes, nose, and throat and a peculiar taste. The delayed effects of exposure include headache, nausea, vomiting, pulmonary edema, bronchitis, drowsiness, weakness, and electrocardiograph abnormalities.[3] There have also been reports of cases of neurotoxicity induced by ethylene oxide exposure.[4,5,6]

Dermal (skin) contact with solutions of ethylene oxide as low as 1% can cause burns with edema (swelling) and erythema (redness). Although skin contact with undiluted EtO does not cause burns, it can cause frostbite as a result of rapid evaportion.[7] The severity of skin burns from solutions of ethylene oxide appear to be influenced by both the length of contact with the skin and the strength of the solutions, with solutions around 50% appearing to be the most hazardous.[2] Both the undiluted liquid and solutions of EtO may cause severe eye irritation or damage[8] and there have been case reports of cataracts among workers exposed to high levels of EtO.[9]

Carcinogenic Effects

Ethylene oxide has been shown to be carcinogenic to animals. Inhalation of EtO has induced excess leukemia in female rats and peritoneal mesothelioma and leukemia in male rats. An increase in the number of gliomas, rare malignant tumor of the central nervous system, was also observed.[10,11] There is also some limited evidence which suggests that workers exposed to ethylene oxide may experience an increased risk of leukemia as compared to unexposed workers.[12,13]

Mutagenic Effects

Ethylene oxide has been shown to cause changes in the genetic material of lower biological species including Salmonella[14] and fruit flies[15] as well as mammals, including rabbits[16] and monkeys.[11] These genetic changes have been shown to be heritable (passed from one generation to the next) in experiments with mice.[17] Several studies have demonstrated that genetic changes can also occur among humans exposed to EtO. Workers exposed to EtO have been found to have significantly increased numbers of chromosomal aberations and sister chromatid exchanges as compared to workers unexposed to EtO.[18,19]

Reproductive Effects

Animal experiments with ethylene oxide have indicated adverse reproductive effects from EtO exposure. A decrease in the number of pups born per litter was observed among female rats exposed to EtO prior to mating and during gestation (pregnancy)[20], and an increase in the number of malformed fetuses per litter was observed among female mice administered EtO intravenously during gestation.[21] Male monkeys exposed to ethylene oxide have been shown to have reductions in sperm count and sperm motility.[11] There is also some human evidence which suggests that women exposed to EtO during their pregnancies may experience increased rates of spontaneous abortions, although this information is not conclusive.[22]

Exposure Criteria

NIOSH recommends that ethylene oxide be regarded as a potential occupational carcinogen and that exposure to EtO be controlled to less than 0.1 ppm determined as an 8-hour time-weighted average with a short-term exposure limit not to exceed 5 ppm for a maximum of 10 minutes per day. This recommendation is based on the available risk assessment data which show that even at an exposure level of 0.1 ppm, the risk of excess mortality is not completely eliminated.[23,24] Effective as of August 21, 1984, the standard of the Occupational Safety and Health Administration (OSHA) for occupational exposure to ethylene oxide was revised downward from 50 ppm to 1 ppm calculated as a time-weighted average concentration for an 8-hour work shift. This downward revision in the standard was based on the animal and human data showing that exposure to EtO presents a carcinogenic, mutagenic, reproductive, neurologic, and sensitization hazard to workers. Included in the present OSHA standard are requirements for methods of controlling EtO, personal protective equipment, measurement of employee exposures, training, and medical surveillance of the exposed employees.[25]

VI. RESULTS

The sampling and analytical results will be presented according to collection method.

Miran Model 103

The Model 103's were used as full-time monitor in the rooms at both ends of the fumigator (0900 on 11/27/84 - 0900 on 11/29/84). The results printed-out from the Metrosonics Dataloggers showed that there is a potential for high exposure to ethylene oxide during the post-fumigation evacuation phase of the fumigation cycle. These results are plotted in Figures 3 and 4. In the unload-side room, EtO concentrations peaked at greater than 100 ppm within minutes of the first fumigator evacuation, during the first run. Dilution ventilation decreased these concentrations to below 1 ppm within 30 minutes (Figure 3). Similarly, the EtO concentrations peaked and fell off in the load-side room. The peak concentration on this side was around 50 ppm. The source of this EtO was the unhooded floor drain. During the evacuation phase at the end of the second fumigation run, EtO concentrations were measured as high as 80 ppm in the unload-side room, and stayed below 10 ppm on the load-side (Figure 4). The EtO was cleared in about 35 minutes.

Miran Model 80

Measurements taken with the Model 80, are presented in Table 1, in a chronological fashion. This instrument was used to detect leaks in equipment, determine adequacy of aeration periods, and spot check general air concentrations of ethylene oxide.

Prior to connecting the cylinder of fumigant, low levels of EtO (<1 ppm) were detected in the unload-side room where the cylinder had been stored, and where it is attached to the system. We monitored the top of the cylinder and found it to be leaking at the valve connection. While attaching the cylinder to the fumigation system, which took less than five minutes, the Archives Preservationist, who is the primary system operator, was exposed to from 0.8 to 1.6 ppm EtO.

The first fumigation run commenced about 0930 on 11/27/84 and finished at about 1550 the same day. Subsequent to charging the fumigator for the first run, EtO leaks, ranging from 1 to 6 ppm, were detected at fittings between the cylinder and the fumigant vaporizer. The instrument was left in the unload-side room to monitor the first evacuation following the exposure phase of the fumigation run. EtO concentrations as high as 536 ppm were recorded.

The chamber was opened around 0845 the next day, 11/28/84. The Miran 80 probe was placed inside the chamber door and measured <0.1 ppm EtO. This load consisted mainly of cardboard boxes containing loosely bound papers or papers in file folders, and two tightly bound, large (20x24x3 inches) ledger-type books. The probe was placed inside each box and each book long enough for the EtO concentration to equilibrate inside the Miran sample cell (about 2 minutes). The measurements (<0.1 ppm detected) indicated that this particular load of boxed material had aerated for a sufficient length of time. The large books each had significant concentrations of EtO trapped inside their pages, ranging from 14 to 46 ppm. One of the books was removed from the fumigator (leather bound corduoroy) and placed in front of an exhaust ventilation grill, in a leafed open position, to aerate further. The other book (leather bound buckram) was left in the fumigator while the second load was fumigated. The boxed materials were removed from the fumigator.

The second fumigation run commenced at approximately 1015 on 11/28/84. The exposure phase was completed at approximately 1500. Following the first evacuation of the fumigator, we monitored sink drains which shared the same plumbing as the drain for the fumigator vacuum pump discharge. In the Restoration Laboratory, 1.0-3.2 ppm EtO was detected at a sink drain. In the Photography Laboratory, low concentrations of EtO were detected in the area near the sink (0.4 ppm). At the drain of this sink, 2.1-8.0 ppm EtO was detected.

A filter in the EtO line to the fumigator is required to be changed periodically as part of the maintenance of the system. The archivists wished to know what the exposure potential was for this procedure, and if they should attempt to do this themselves. During a simulated attempt to change this filter, EtO concentrations reached 12 ppm. This procedure was never completed, since it was judged to be unsafe if performed while the system was under pressure. This would have caused a large release of fumigant into the workroom air.

At all times when exposure to EtO was indicated the NIOSH investigators wore approved respiratory protection.

The chamber door was opened at 10:00 on 11/29/84, following the second fumigation run. This load contained museum pieces and the ledger from the first run. These articles contained residual EtO in pores and dead air spaces which would require additional aeration time for diffusion of the fumigant away from them. EtO concentrations found on these pieces ranged from 1 to 76 ppm. After two and a half hours of aeration in the fumigator, with the internal ventilation system operating, the range of EtO concentrations had decreased to <0.1 to 18 ppm. By the next morning, after an additional 20 hours of aeration, EtO levels were <0.1 ppm for all articles fumigated.

Solid Sorbent Sampling

Samples collected using NIOSH Method 1607 are presented in Table 2. Nine samples were collected in the breathing zones of the three NIOSH investigators, over three days. Exposure concentrations ranged from non-detectable values to 0.2 ppm EtO. Four of the personal exposures were listed as "trace", indicating that they were between the LOD and the LOQ (<0.1 ppm). The three exposures above the LOQ averaged 0.17 ppm (sd +0.03, n=3). Sample E-13, collected in the corridor outside the entrance to the fumigation suite, showed a 0.5 ppm concentration of EtO. This sample was collected on the day of the second fumigation run. A sample taken on a day when the fumigator was not operated (E-101), showed 0.6 ppm EtO in the area near the cylinder containing the fumigant.

VII. DISCUSSION

It is apparent that while operating the fumigator at the Florida State Archives, as during this evaluation, there is a potential for exposure to ethylene oxide. High exposures (>100 ppm) could occur if workers are in the area of the fumigator during certain phases of its operation, such as during the post-fumigation evacuation period. However, if the process is properly controlled, exposures would, most likely, remain below the NIOSH recommendation and the OSHA PEL. The exposures above the NIOSH recommendation experienced by the NIOSH investigators were due to activities considered as out of the ordinary for normal operation. These exposures occurred during the monitoring of fumigated articles for residual EtO for the purpose of determining aeration parameters. The NIOSH personnel wore respiratory protection approved for use in EtO contaminated environments.

The ventilation system dedicated for this operation worked well. Measurements showed the suite of rooms to be under sufficient negative pressure to prevent contamination of other areas of the building. A suggestion was made that small louvered sections be added to the entrance doors to aid inward airflow. If other control measures can be up-graded to the technology of the ventilation system, this will be a state-of-the-art fumigation system.

Adsorbed or absorbed EtO on fumigated articles, leaks in the cylinder to vaporizer to chamber piping connections, and leaks from the vacuum pump plumbing appear to be the sources of exposure from this system.

The vacuum pump discharge down the drain not only causes the high EtO concentrations in the fumigation suite, but is an exposure source for employees in areas which share the same plumbing. EtO concentrations ranging from 1.0 to 8.0 ppm were measured at drains remote from the source. A long-term air sample detected low levels (0.05 ppm) of EtO in a non-restricted corridor.

The solution to these problems would be either a dedicated, hard-piped or hooded drain for the current evacuation system, or a different system not requiring this sort of discharge. An exhaust hood should be placed at the fumigant cylinder to capture emissions created during cylinder and supply line filter change procedures. A suggested procedure for the supply line filter change is included in the Appendix. These changes, in combination with the repair of leaks in the fumigant charging system, would leave only the fumigated articles as an EtO source.

In many applications of EtO as a fumigant/sterilant, aeration times remain relatively constant from batch to batch. An example is the health care industry where therapy and surgical equipment are sterilized using EtO. When similar equipment is sterilized in every run, aeration times are easily controlled. This is not the case in the archiving business. As witnessed during this evaluation, a wide range of materials are required to be fumigated. Unless on-site monitoring equipment is available to determine completeness, a time period sufficient for the most difficult articles to aerate would be prudent. During this evaluation, the large ledgers were the most difficult pieces to aerate. The ledger in the second fumigated load aired passively (without the internal chamber ventilation operating) for 17 hours, and then actively (with internal chamber ventilation operating) for 22 hours. A 40-hour active aeration period, beginning within an hour of the end of a fumigation cycle, should be sufficient for most articles fumigated. At the end of the post-vac phase of the cycle, a properly protected operator could open the fumigator door (about 12 to 18 inches), thus activating the internal ventilation system, and leave the area with a minimum of exposure.

As an aid in the aeration of the variety of articles fumigated by the Archives, they should use different placement configurations inside the fumigation chamber. As examples, internal modifications to the chamber would allow bars to be used to hang clothing articles, instead of placing them in boxes, and racks could be designed to hold large books in a leafed open position, instead of laying them flat and closed.

VIII. CONCLUSIONS

The operation of the fumigation facility at the Florida State Archives as it existed during the survey would pose a potential health hazard to operators, and personnel not involved in fumigator operation, from exposure to ethylene oxide.

IX. RECOMMENDATIONS

The following recommendations are made to help reduce the potential for exposure to ethylene oxide and ensure the safety of workers during the operation of the fumigation system at the Florida State Archives. These recommendations are based upon the results of a health hazard evaluation, observations made during the evaluation, and discussions with Florida State Archives officials. They should be instituted before operation of the fumigator is considered.

1. In order to reduce high EtO concentrations in the fumigation suite, and to eliminate EtO exposure to personnel not involved in fumigator operation, the system evacuation pump should be connected to a hooded, dedicated drain. An alternative to this would be a different type of evacuation pump, which would not require the discharge of EtO contaminated water.

2. A dedicated exhaust hood should be installed to capture EtO emissions during fumigant cylinder connect/disconnect procedures, and for supply line filter changes. A good design would include a flexible duct to allow hood movement for optimal capture, depending upon which task is being performed.

3. An emergency eye wash station and deluge shower should be installed in the unload-side room of the suite.

4. All personnel involved in the operation of the fumigator should be trained in the standard operating procedures for the system, as well as emergency procedures.

5. Emergency procedures should be posted in a prominent position in each room of the suite.

6. All personnel involved with the operation of the fumigation system should be provided with proper respiratory protection. That is, a full facepiece respirator with an EtO approved canister (MSA Gas Mask Canister, type GMEO-SSW, Part # 473881). Employees should be fit tested with the respiratory equipment.

7. According to OSHA regulations, signs demarcing regulated areas and entrances or accessways to regulated areas shall be posted bearing the following legend:

   DANGER
   ETHYLENE OXIDE
   CANCER HAZARD AND REPRODUCTIVE HAZARD
   AUTHORIZED PERSONNEL ONLY
   RESPIRATORS AND PROTECTIVE CLOTHING MAY BE REQUIRED
   TO BE WORN IN THIS AREA

   After the above recommendations have been instituted, safe operation of the fumigator may proceed. The following recommendation should provide for complete aeration of fumigated articles.

8. All fumigated items should actively aerate inside the fumigation chamber with the internal ventilation system operating for a minimum of 40 hours. Modifications should be made to the chamber interior, such as those mentioned in the Discussion section, to aid in the aeration process.

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1. Florida State Archives, Tallahassee, Florida
2. Museum of Florida History, Tallahassee, Florida
3. Bureau of Industrial Safety and Health, State of Florida, Tallahassee, Florida
4. NIOSH, Region IV
5. OSHA, Region IV

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.

Appendix

Changing of Supply Line Filters

Filters in the sterilizer liquid line must be changed when necessary, by the following procedure:

1. Close the cylinder valve and the hose valve.
2. Disconnect the cylinder hose (piping) from the cylinder.
3. Open the hose valve and bleed slowly into a proper ventilating system at or near the in-use supply cylinders.
4. Vacate the area until the line is empty.
5. Change the filter.
6. Reconnect the lines and reverse the valve position.
7. Check hoses, filters, and valves for leaks with a fluorocarbon leak detector (for those sterilizers using the 88 percent chlorofluorocarbon, 12 percent ethylene oxide mixture (12/88)).

Table 1

Miran Model 80 EtO Measurements

Florida State Archives
Tallahassee, Florida
HETA 84-404
November 27-30, 1984

Phase/Activity - Date	Probe Location	EtO Concentration Range (ppm)	Time (if noted)
Pre-Run - 11/27/84	General area (unload-side)	0.1-0.7	0830
	Fumigant cylinder top	0.9-1.2	
	Worker breathing zone while attaching fumigant cylinder to system	0.8-1.6	
	Fumigant cylinder top	1.2-1.8	
	Ante room	<0.1	
	General area (unload-side)	0.8-1.9	
	Above fumigator door (load-side)	0.9-1.4	
First Fumigator Run-11/27/84	Near fumigator door (load-side)	0.5-1.3	0930
Started at 9:27	Ante room	<0.1	1000
Ended at	General area (unload-side)	0.7-1.0	1005
	Fumigant cylinder top	1.1-3.7	1007
	Fitting at vaporizer	1.8-6.0	
	Fittings between cylinder and vaporizor	0.6-5.4	1018
	General area (load-side)	<0.1-0.9	1025-1340
First Evacuation after Exposure Phase of Cycle	Next to fumigator door (unload-side)	2.9-536	1355
	Ante room	<0.1	1408
	General area (load-side)	<0.1	1413
Opening Chamber Door-11/28/84	(after 16 hr. passive aeration)		0847
	General area (unload-side)	<0.1	
	Inside chamber	<0.1	
	Boxed loose papers	<0.1	
	Inside leather/buckram ledger	14.0	
	Inside leather/corduroy ledger	22.1	
	Inside file boxes	<0.1	
	Inside plastic/aluminum probate records	<0.1	
	Water condensate on fumigator floor	<0.1	
	Inside leather/buckram ledger	46.4	
	Between leather/corduroy ledger and exhaust ventilation grill	0.7-1.0	0917-0925
	General area (unload-side)	<0.1	0930-1100

(continued)

Table I (Cont.)

Phase/Activity - Date	Probe Location	EtO Concentration Range (ppm)	Time (if noted)
Drain Monitoring-11/28/84	At drain, restoration lab (RL)	1.0-3.2	1515
	6" above drain (RL)	<0.1	
	6" to side at sink surface (RL)	0.4-0.7	
	In photo lab near sink	0.4	1530
	At drain in photo lab	2.1-8.0	
-11/29/84	General area restoration lab	<0.1-0.5	0755-0830
	Ante room	<0.1	0830-0900
Simulated Fumigant Filter Change - 11/29/84	Worker breathing zone	3.6-12.1	0903-0910
Opening Chamber Door-11/29/85	(after second run and 16 hr. passive aeration)		1000
	Inside leather/buckram ledger	76	
	Croquet mallet	10	
	Inside box of dresses	16	
	Inside wooden farm implement	20	
	Antique chair (padded)	1.2	
	Metal oil can	10	
	Cobbler's mallet	4.0	
	Inside of chamber	29	
	Inside of leather/corduroy book aerating next to exhaust ventilation grill for 24 hrs.	9.0	
Monitoring Articles-11/29/84	(after 2.5 hrs. active aeration)		1230
	Inside wooden farm implement	17	
	Inside box of dresses	18	
	Child's dress from box wrapped around probe	1.2	
	Child's green dress wrapped around prove	3.1	
	Child's green dress after shaking out for 1 minute	1.9	
	Large dress after shaking out	<0.1	
	Cobbler's mallet	2.0	
Monitoring - 11/30/84	(articles after 22 hrs. active aeration)		0800
	All	<0.1	

Table II

Personal and Area Long-Term, Solid Sorbent
Ethylene Oxide Sample Results

Florida State Archives
Tallahassee, Florida
HETA 84-404

November 27-30, 1984

Job/Area	Sample	Duration	EtO Concentration (ppm)
11/27/84			
NIOSH investigator	E-1	0857-1512	Trace*
NIOSH investigator	E-2	0904-1512	0.15
NIOSH investigator	E-3	0904-1512	Trace
11/28/84			
On table, unload-side	E-11	0831-1446	Trace
NIOSH investigator	E-12	0832-1056	Trace
In corridor, across from Ante room door	E-13	0836-2156	0.05
NIOSH investigator	E-14	0836-1054	ND**
NIOSH investigator	E-15	0837-1054	ND
11/29/84			
Near fumigant cylinder	E-101	0829-1616	0.60
NIOSH investigator	E-102	0815-1301 1536-1617	0.15
NIOSH investigator	E-103	0815-1301	Trace
NIOSH investigator	E-104	0815-1301 1536-1607	0.20
Near exhaust ventilation grill, load-side	E-105	0820-1606	ND
Criteria: 8-hour TWA		NIOSH OSHA	0.10 1.0

* Trace - Detected values which were below the limit of quantitation.
** ND - None Detected

Figure I

Fumigation Suite Diagram

Florida State Archives
HETA 84-404

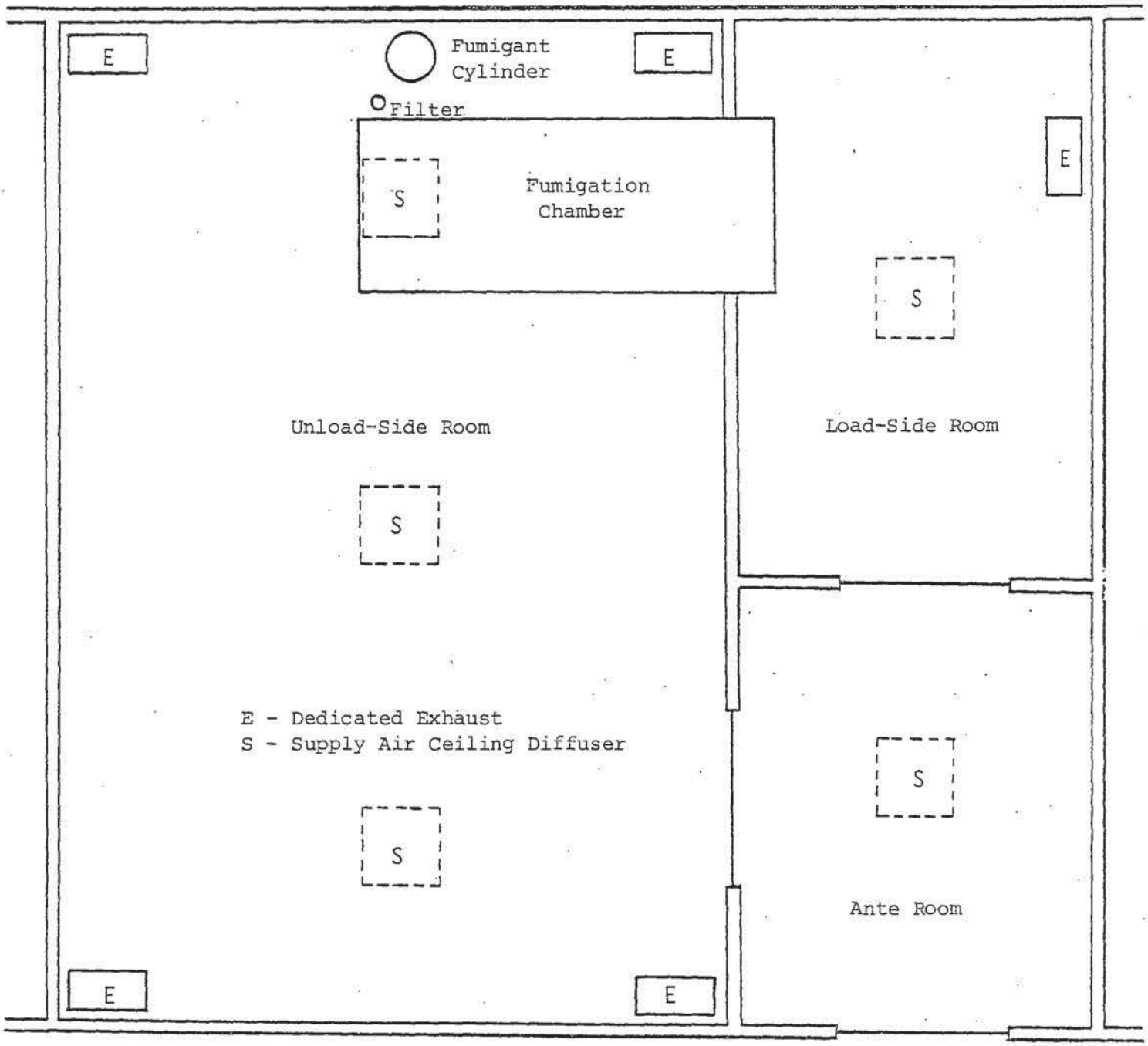
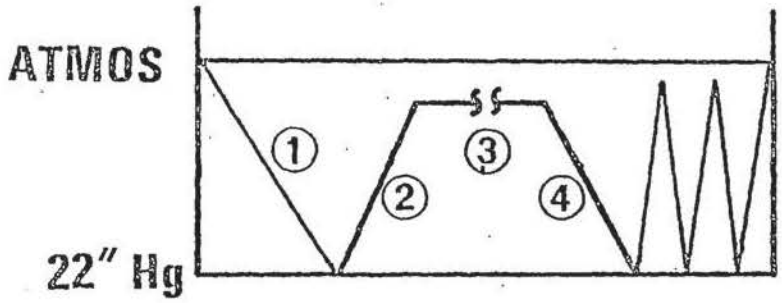


Figure 2

Fumigation Cycle

Florida State Archives
HETA 84-404



① PREVAC
② GAS CHARGE
③ EXPOSURE
④ POSTVAC/EXHAUST

Figure 3

EtO Concentrations During Post-Fumigation Exhaust Phase

Florida State Archives
HETA 84-404

November 27, 1984

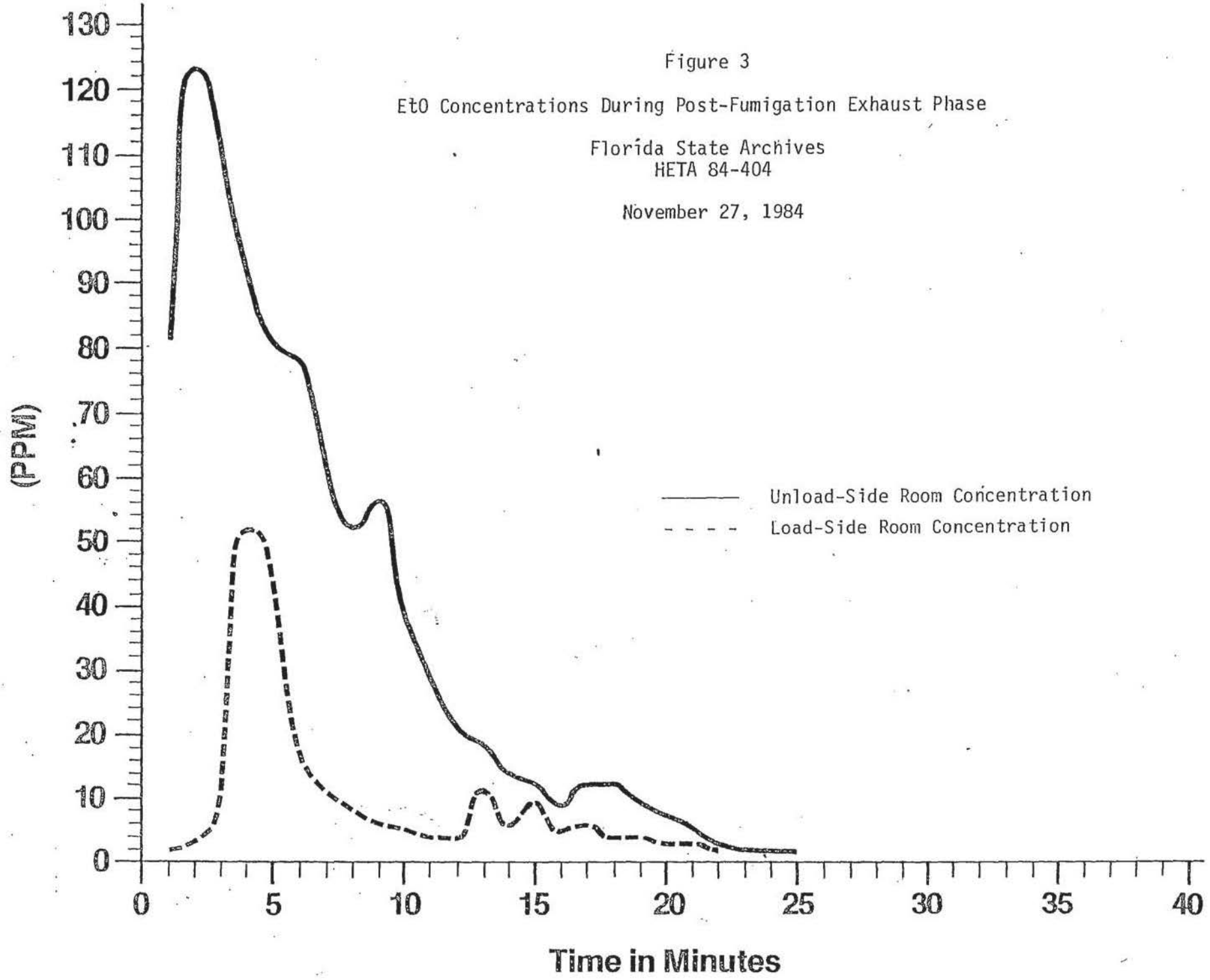


Figure 4

EtO Concentrations During Post-Fumigation Exhaust Phase

Florida State Archives
HETA 84-404

November 28, 1984