INDUSTRYWIDE STUDIES REPORT:
A WALK-THROUGH SURVEY

OF

GRIFFITHS LABORATORIES USA INC.
855 Rahway Avenue
Union, New Jersey 07083

and

MICROBIOTROL INC.
8E Easy Street
Bound Brook, New Jersey 08805

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DATE OF SURVEY:
September 27 and 28, 1984

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REPORT NUMBER:
67.34

Industrial Hygiene Section
Epidemiology 2 Section
Industrywide Studies Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health
Centers for Disease Control
Cincinnati, Ohio

PURPOSE:	To evaluate the industrial hygiene records, production processes, and personnel records to determine the suitability of including this facility in the NIOSH Industrywide Studies Branch mortality/industrial hygiene study of ethylene oxide (ETO).
EMPLOYER REPRESENTATIVES CONTACTED:	Robert Ufferman, Corporate Personnel Manager, Griffith Laboratories Alan J. Wright, Plant Manager, Griffith Laboratories Robert VanDerBeeK, Manager Material Handling Albert J. Lobbato, Regional Manager, Micro-Biotrol Inc.
EMPLOYEE REPRESENTATIVES CONTACTED:	None
STANDARD INDUSTRIAL CLASSIFICATION OF PLANT	2099 - Food Preparations, Not Elsewhere Classified

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I. Abstract

On September 27-28, 1984 a walk-through survey was conducted at Griffith Laboratories facilities in Union and Bound Brook, New Jersey. The primary purpose of this survey was to determine the feasibility of including these facilities in the NIOSH mortality and industrial hygiene study of workers exposed to ETO.

The Union facility has used ETO for microbial reduction of spices since 1950. ETO was also used at this facility to sterilize materials under contract for other companies, until 1979 when this operation was moved to the Bound Brook facility. The majority of sterilization or fumigation has been performed with 100% ETO. Other gases used were 100% propylene oxide and 12% ethylene oxide mixed with 88% freon.

Most operations at the Union facility appear to have fairly well controlled exposures to ethylene oxide. There still are significant exposures to the retort (chemical) operators, and to a lesser extent, grinders. Data collected since the installation of the shrouding around the retort areas is necessary to make further recommendations for the Union facility.

Limited data is available for the Bound Brook facility, however the isolation of the ETO treatment and aeration operations appears to have diminished exposures. Significant exposures still exist for the processing operators and assistant operators.

Recommendations are included in the body of the report.

These facilities meet the three eligibility requirements as defined in the study protocol, and therefore should be included in the study. These requirements are: 1) the plant must contribute at least 200 person-years to the high exposure group, or 400 person years total, 2) the plant must have adequate personnel records or other records that can be used for identifying past and present workers exposed to ETO, and 3) the plant must not have any serious confounding exposure to a known leukemogen.

II. Introduction

Ethylene oxide (ETO) is one of the 25 chemicals of highest production volume in the United States.[1] The major portion of ETO produced is used in the production of ethylene glycol (antifreeze) and as a chemical intermediate for polyester films, fibers, and bottles. A small fraction of ETO, less than 0.24%, has been used by the health care and medical supply industries over the past 35-40 years to sterilize heat-sensitive medical supplies.[1]

ETO, a colorless gas at standard temperature and pressure or a liquid at higher pressures, is miscible with water, ethanol, ether, and most common organic solvents. In addition, it is highly explosive when in concentrations of 3 to 100% (ETO) in air.[2] The biological warning properties are essentially useless since the (ether-like) odor threshold among individuals ranges from 300 to 1,500 parts per million (ppm) and adverse health effects may be elicited at levels much less than this.[3]

Due to the toxicity and possible carcinogenicity of ETO (see section on Toxicity), NIOSH researchers initiated an investigation in 1982 to assess the feasibility of conducting a cohort mortality study and industrial hygiene evaluation of workers exposed to ETO. Based on the data gathered during the feasibility study, it was concluded that the cohort of workers in the health care and medical supply industry, specifically those workers exposed to ETO in industrial sterilization processes, was the most adequate group to support a cohort mortality study.[4] This decision was supported

by the findings of a 1977 survey conducted by National Institute for Occupational Safety and Health (NIOSH) researchers which showed that it is in this industry most of the employee exposures occur.[5,6] This survey estimated that approximately 75,000 health care workers were employed in ETO sterilization operations, with an additional 25,000 employees which may have incidental exposure resulting from inadequate engineering controls.[5,6] In order to develop and refine methods to be used for data collection and exposure classification of this selected cohort, a pilot study of six industrial sterilization facilities was initiated. The information gathered during the pilot study was incorporated into the final study protocol. This walk-through survey was conducted to determine the suitability of including Griffith Laboratories/Microbiotrol in the industrywide mortality and industrial hygiene study of workers potentially exposed to ETO in industrial sterilization processes. The suitability of including these facilities was based on data gathered during this walk-through and is discussed in the Conclusion and Recommendation section. In addition, the data gathered during the walk-through survey will be used to develop, to the extent possible, estimates of exposure to ETO by department and/or job category, level and duration of continuous and peak exposures, and calendar year within this plant. These exposure estimates will then be compiled into an exposure matrix which will be used to determine the existence of a dose response relationship with any positive association observed in the mortality study.

The authority and responsibility for conducting and reporting on field

studies in industry was given to NIOSH under the Occupational Safety and Health Act of 1970 (set forth by the 91st Congress, S.9123, Public Law 91-596). Section 20(a)7 states that NIOSH shall conduct and publish industrywide studies of the effects of chronic low level exposure to industrial materials, processes, and stresses on the potential for illness, disease, or loss of functional capacity in the aging adult.

III. Description of Facilities

Griffith Laboratories presently operates a spice treatment and processing facility in Union, New Jersey and a contract treatment operation through a subsidiary, Micro-Biotrol, Inc. in Bound Brook, New Jersey. Products are treated with ETO, propylene oxide or 12% ETO mixed with 88% freon to reduce the numbers of microbes. From 1946 to 1959, both operations were located in Newark, New Jersey. ETO has been used since 1946. In 1959 Griffith moved all operations to Union, New Jersey, and from 1979 to present, Micro-Biotrol operations have been located in Bound Brook, New Jersey. Neither location has been unionized. This report covers walkthrough surveys of both the Union and Bound Brook facilities.

The Union facility has been a spice processing facility since 1959. Raw spices are treated with ETO, processed and packaged in one building. A percentage of these spices are blended with non-spice products to form seasonings. A printing shop is located on site, as is the cafeteria. Until 1979, it also housed the contract ETO treatment operation which is now

located in Bound Brook, New Jersey.

The Bound Brook facility operates a contract ETO treatment operation for medical supplies, pharmaceuticals, cosmetics, spices and animal feed. It was occupied in September 1978 and became operational in February 1979. The entire operation is located in a one story building. The warehouse occupies approximately 28,800 ft^2 and an additional 2,400 ft^2 is office space, including the cafeteria. There have been no major changes in the location of processes at this facility.

IV. Griffith Laboratories USA Inc., Union Facility

A. Description of Workforce

According to the plant management, workers at this plant are primarily males and Caucasian. The turnover rate is supposed to be very low. There is some turnover within plant departments, particularly between the blending and packaging operations.

B. Description of Process

Raw materials enter the facility through the old warehouse. Approximately 60% of these goods are non-spice raw materials (flour, salt, and meat curing compounds) which are not ground or treated with ETO. The other 40% are spices which are placed in a staging area of receiving with no

pre-conditioning. These goods are treated in one of two retorts during a 3-1/2 hour cycle. These retorts have 1328 ft^3 and 672 ft^3 capacity (#9 and #10 respectively). They operate 1 and 1/2 shifts per day for a total of 3 loads per unit per day and are located against the rear wall in the general warehouse area. After loading, each retort has a vacuum drawn and 100% ethylene oxide pumped in. After 1 hour of exposure, 2 vacuums are drawn by a water sealed vacuum pump (29 inches vacuum), the door cracked and the retort aerated for 15 minutes by the same vacuum pump. This pump is followed by a water/gas separator with gasses exhausted directly to the atmosphere above the roof while liquids travel to a drain through a closed system.

The retort operator (chemical operator in the personnel records) is responsible for connecting the ETO drums which are located immediately adjacent to the retorts. These are not equipped with double valve connections, which may result in significant ETO exposures when the drums are changed.

The charging station, located immediately behind the retorts, is equipped with a local exhaust vent near the floor. This location of the vent is probably inadequate to control potential exposures. The operator moves the treated goods to the aeration room where they remain for 48 hours. Warehouse personnel then move 85% of these goods by forklift to the new warehouse and deliver them to processing areas. Fifteen percent of these goods are temperature sensitive (such as paprika) and are stored after

treatment in a cold room. This is kept at 58° F in summer and 60° F during winter (ambient relative humidity).

After ETO treatment, all spices are ground, and 50% undergo an additional ETO treatment ("Triple X" products). Forty percent of all spices are packaged in either 100 to 250 pound drums or unit packs (4 oz. to 50 lbs.) and sold to customers. Another 40% is shipped to other Griffith plants, while the remaining 20% is blended with non spice raw materials to form seasonings. Other uses for non-spice materials are batters and breadings which do not contain spices.

The microbiology laboratory conducts bacteria counts on spice samples. They presently perform a quality control check on every 500 pounds of raw materials. This lab uses toluene, ether, and acetone among other chemicals. It shares a Heating, Ventilation and Air Conditioning (HVAC) system with the office area. Biological indicator strips were used in the contract treatment operation until 1978. These were analyzed by the customer or an outside laboratory. A 2nd floor above the office area is occupied by the product development department. A cafeteria exists on site where most employees eat. Griffith has their own print shop on site.

There are plastic strips in all of the doorways connecting the processing departments with both warehouses. The company is presently in the process of placing plastic strips (shrouding) around the treatment area and installing new axial blade exhaust fans in the rear wall of the aeration and

treatment areas of this facility. As of the date of this walkthrough survey, this had not been completed.

C. Description of Past Exposures and Controls Used

No industrial hygiene data is available for the Newark plant and only 1 employee was interviewed who had worked there. It was basically one open floor of a warehouse, similar to the present operation, however there were no partitions or walls. Smaller retorts were in use from 1946 to 1964 which utilized 100% ETO. During this period the retort operator operated the actual charging and vacuums applied to the retorts while another individual unloaded and loaded the retort. The unloading of the retort was initiated immediately at the end of the cycle rather than cracking the door and waiting 15 minutes as is presently done.

The two existing Griffith retorts, #9 and #10, were acquired between 1974 and 1978. Seven additional retorts were located at this site for Micro-Biotrol's contract ETO treatment operations from 1959 to 1978. From 1959 to 1975, treated spices remained in the general production area of the old warehouse (except for those goods that were placed in the cold room). In 1975 the new warehouse was built and most spices are placed here after treatment. It has 2 bay doors and 2 overhead exhaust fans. Some raw materials began to enter through this new warehouse after its completion. At the end of 1978 the Micro-Biotrol Inc. retorts were moved to Bound Brook, New Jersey. When Micro-Biotrol Inc. was located at the Union site, their

retorts sometimes ran 3 shifts for 7 days per week. Average yearly usage of ETO is presently 99,000 pounds.

Starting in 1982, spices were first placed in the aeration room before going to the warehouse. Until this time, the ETO drums were located in this room. Two wall mounted, exhaust fans were installed in the warehouse in August 1984. A small percentage of spices are pulled directly to grinding before passing through the aeration room which would increase potential exposures downstream of the retorts.

Data from 3M badges is available from 3 surveys conducted by consultants in 1984. Personal data show the chemical operator at 6 ppm during the July and October surveys and at 4 ppm during November (all 8 hour, time weighted averages). All other job categories averaged less than 2 ppm (range 0.4 to 1.9 ppm) during the July survey. During the October and November surveys, all job categories averaged less than 1 ppm (less than 0.5 to 0.9 ppm) except for grinder (see Table I). Area data in office and laboratory locations were all below 1 ppm (all 8 hour, time weighted averages). Spice processing and warehousing areas averaged from non-detectable to 4 ppm, while areas around the retorts averaged from 3 to 47 ppm (see Table II).

There was one known accident in 1979. A safety valve on a drum blew out and the fire department was called in. The drum was thought to be almost empty before the accident. This valve has since been redesigned. The processing departments have not changed their locations.

Propylene oxide had limited use at the Union facility from 1959 to 1978. Its use was approved by the FDA and limited to cocoa nuts and starches, vegetable gums, glazed fruit, processed spices and some pharmaceutical ingredient raw materials.

D. Description of the Medical Program

All employees receive a pre-employment physical but there are no follow-up examinations. There is presently no medical area, but there is a team of first aid trained employees and one paramedic who receives 150 hours of training every 3 years.

E. Description of the Industrial Hygiene and Safety Program

Safety shoes, bump caps and hearing protection are required. Most spice processing workers wear single use, disposable dust masks. There is a training program for emergency use of respirators by retort operators, maintenance and blending employees. This includes Bendix and Hudson Self Contained Breathing Apparatus (SCBA). This equipment is checked monthly and employee training is reviewed every 6 months. Masks are pressure tested by blocking the inhalation valve and then the exhalation valve, but there is no odor test. Full-face respirators with 2 NIOSH approved, air purifying cartridges are also available for use in ETO atmospheres.

Sanitation personnel are trained in the use of pesticides. The facility is

fumigated with a pyrethrin based insecticide every 3 months in winter and monthly in summer while the employees are out of the plant. Additional spot applications are done with Oritene.

Outside consultants have visited this facility 2 times per year since 1974. This includes a review of accident records and work practices. Industrial hygiene measurement of ETO was generally conducted with a Miran for short term, area samples. Personal recollections of concentrations detected by the Miran are not available at this date. In July, 1984, an in-depth survey was conducted in all areas for compliance reasons by the engineering department. This included personal and area samples with 3M passive dosimeter badges. These are analyzed by Northview Laboratories, Inc., Northbrook, Illinois.

F. Definition of Exposure Categories for Purposes of the Mortality Study

Based upon the walk-through of plant operations and discussions with plant personnel a preliminary list of job and department operations was developed which involve potential exposure to ETO. This included: repack (dept. 500), grinding (dept. 504), mixing (dept. 506), packaging (dept. 508), vacu-gas (dept. 509), sanitation (dept. 521), shipping and receiving (dept. 523), printing (dept. 530), maintenance (dept. 542), the plant foreman (dept. 534), the plant manager (dept. 534) and the plant engineer (dept. 534).

Since this survey, based on the results from the company's industrial hygiene program (see Tables I and II) it was concluded that all personnel in this facility are potentially exposed; although, exposures in the areas listed above would be the most significant. Evidence for all workers at this plant being potentially exposed to ETO was derived from the fact that Office workers, who have no direct exposure to ETO in 1984 had an average exposure of 0.4 ppm. Although these exposures are currently quite low, in the past when Micro-Biotrol was located in the Union facility exposures were possibly higher. Thus all workers employed at this facility for at least 3 months would be included in the mortality study.

V. Micro-Biotrol Inc., Bound Brook Facility

A. Description of Workforce

According to the plant management, workers at this facility are primarily males and caucasian. The turnover rate is reportedly very low. There is extremely low turnover among the sterilizer operators, which is a relatively well-paid position.

B. Description of Process

Pre-packaged goods enter the facility through the shipping/receiving dock on the east side of the building. They are stored in the warehousing area and are taken to the pretempering room by shipping and receiving employees when

scheduled for ETO treatment. This room is kept at a minimum of 90°F and 45% relative humidity (RH). Doors are shrouded with overlapping plastic strips allowing minimal air exchange. There are typically 10 to 15 strips per doorway and each strip is 12 to 18 inches wide. Goods are then moved by the retort operators (processing operators or assistants) from the pretempering room directly into the retort room at the south end of the plant where 9 retorts (vessels) are located. There is restricted access to the retort room which allows entry only to retort operators on a regular basis.

There are nine retorts at this location, seven of which had previously been located in Griffith's Union facility. The retorts operate on a 6 to 15 hour cycle, depending on the product, the average lasting 7 to 9 hours. The temperature is elevated to 90 - 140° F, the RH increased, and the goods are exposed to ETO for 3 to 6 hours. These vessels recirculate the ethylene oxide during the treatment period. At the end of the treatment cycle, the retort has 1 to 6 vacuums pulled (13 to 28 inches of vacuum). For retorts 1 and 4, this air is pulled by an oil sealed pump and then is exhausted to the atmosphere above the roof. The other retorts use water sealed vacuum pumps. The ETO/water mixture travels to a liquid/gas separator with all gasses exhausted to the atmosphere above the roof while the water is flushed into a drain. This has always been through a closed system.

Either a semi-automated method of charging the retorts using the volume and mass of ETO or an automatic method operated by pressure is used by each retort. The retort operator is responsible for connecting the ETO drums

which are located behind the retorts. The ETO drums are not equipped with double valve connections, which may result in significant exposures during changing of the ETO drums. The control room for the retort operators is under positive pressure with air supplied from an 8" duct from the main supply air duct.

For the majority of goods, 100% ETO is used. This includes medical devices (syringes, diagnostic trays, catheters, scrub sponges), pharmaceuticals, cosmetics, and spices. 12/88 (12% ETO; 88% fluorocarbon 12) is used for 10 to 20% of all goods and propylene oxide for less than 5%. The general method of treatment is to use an excessive amount of ETO (1500 mg/liter) to destroy all microbial contamination. Although all retorts can use ETO, approximately 3% of all goods are treated with steam in either retort #2 or #9, and 0.5% are treated with dry heat in retort #1, 2, 4, 5, or 9. Another 0.5% of all goods are treated with a vacuum process and this can be done in any of the existing retorts.

This facility operates 24 hours/day, 5 days per week. They sterilize approximately 20 loads per day with weekly output varying from 80 to 100 loads per week. Production was slightly higher during 1982. The average yearly consumption of ETO is 191,000 pounds. Biological indicators are not regularly used at this facility. When requested by a customer, they are placed and removed by the retort operators. There are no inhouse facilities for testing of these strips.

After treatment, all goods are placed by the retort operator in the aeration

room at room temperature for a minimum of 2 days. They are transported by the shipping and receiving workers to the loading dock when ready for shipment. Some products are quarantined on the request of the manufacturer. Medical devices are typically quarantined in the aeration room for a total of 3 to 4 days before shipment. The Quality Assurance (Q.A.) inspector has overall responsibility for safety, Good Manufacturing Procedures (GMPs), and record keeping for the FDA. This individual spends approximately 1/2 of his time in the production areas and 1/2 in the office.

C. Description of Past Exposures and Controls Used

In 1978, prior to its use by Micro-Biotrol, this facility was one large open floor with the office area operating under a separate HVAC system with 100% recirculated air. Now, the warehouse has 4 exhaust fans mounted on its walls. The ETO drums have been located on scales in 9" deep, open pits behind retorts #1, #4 and #6 since 1980. The first two pits supply 4 retorts each with ETO while the pit behind retort #6 is dedicated to that retort. There are non-flanged slot ducts located near the bottom of the pits. This system exhausts directly outside the plant.

In late 1979, a cinder block and sheet rock wall was built that separated the retort room from the rest of the warehouse area. There are three doorways in this wall; one to the control room, one where goods enter from the pre-tempering room, and one where treated goods pass into the aeration room. There is also a bay door in the east wall which is sometimes left

open in summer. The entry way has no door or plastic shrouding while the aeration room door has shrouding. In 1981, the control room was built. Sterilizer operators may eat there with other workers in the cafeteria.

The original retorts brought to this facility from the Union plant in 1978 are retorts #1-5, #7 and #8. In 1980, #9 retort was acquired and in 1981, #6 retort. Number 1 and 4 retorts have a capacity of approximately 265 ft^3 (3 pallets). Number 2, 5, and 9 retorts have a 450 ft^3 capacity (5 pallets) while number 3, 6, 7, and 8 have 550 ft^3 (6 pallet) capacity. In 1981, 2 exhaust fans and vents were placed in the rear of the treatment area. In September of 1983, 2 retorts were equipped with rear exhaust venting which is started whenever the retort door is opened. This air is vented outside the building. In March 1984, the other 7 retorts were equipped similarly. Three fans are connected to 2 retorts each, while a fourth fan is connected to 3 retorts.

In January of 1984 the aeration room was completed and since this time the general warehouse area has stored only untreated goods. Air is exhausted from the aeration room to the roof through 2 exhaust fans, each connected to 15 vents located 2 feet above the floor on the east and west walls. Micro-Biotrol Inc. reports that there are 250 air changes per hour in this room. NIOSH investigators observed a significant air flow through the doorways on the north and south walls of the aeration room and to these vents. In 1984 an additional large volume fan was installed near the north east corner of the warehouse. It delivers heated air, drawn from outside

the building, to the general warehouse area in winter (typically December to March). In the same year, a make up air duct was installed in the retort room close to the door leading to the aeration room.

Four corporate reports from 1983 and 1984 for ETO sampling with 3M passive dosimeter badges are summarized in Table III. These badges are analyzed by Northview Laboratories, Inc., Northbrook, Illinois. There is a marked decline in personal concentrations measured on the same individual after the aeration room was operational (January 27, 1984). Before this date, average concentrations within each job category, including office areas, were from 4 to 9 ppm. After this date average concentrations ranged from the limit of detection (0.5 ppm) to 0.7 ppm in the office area and from 0.6 to 4 ppm in other job categories.

There have been no known spills or accidents involving ETO. Skilled trade jobs are contracted out.

D. Description of the Medical Program

All employees receive a pre-employment physical but there are no follow-up examinations. Six employees are trained in CPR and one in first aid. A clinic equipped with an emergency room is located nearby.

E. Description of the Industrial Hygiene and Safety Program

Safety shoes are the only regularly required personal protective devices.

Goggles and gloves are used when handling ETO drums. Air supplied respirators are available for emergency use but none were worn regularly at the time of this visit. Starting January 1985, the retort operators will wear full face piece, ETO air purifying cannister respirators.

Outside consultants have surveyed the facility every 3 months since operations began, including a review of accident records and work habits. ETO concentration data has been collected from this facility by NIOSH researchers and is reviewed in the past exposure section.

F. Definition of Exposure Categories for the Purposes of the Study

Based upon the walk-through of plant operations and discussions with plant personnel it was determined that at the Bound Brook facility all of the hourly employees work in areas with potential exposure to ETO. Salaried workers were excluded because they worked in the offices, which are on a separate HVAC system from the rest of the plant. Since this survey, however, the results from the company's industrial hygiene program have been reviewed, which indicate that the office areas may have been exposed to levels as high as 5 ppm (see Table III). Thus, all employees (hourly and salaried) who had worked for at least 3 months at the Bound Brook facility will be included in the mortality study.

VI. Description and Review of the Personnel Record Keeping System

Personnel file folders for active employees from the Union and Bound Brook

facilities are maintained by the personnel office at the Union facility. Files for Union employees are separated from the files for Bound Brook employees. For the Bound Brook facility there are 9 records for active hourly workers, and 5 records for active salaried workers. For the Union facility there are 56 records for active hourly workers, and 32 records for salaried employees. There are also 17 records for sales people which are filed separately.

The personnel file folders contain application forms, preemployment physical exam reports, and "wage, salary and transfer records." Demographic information (i.e. date of birth, sex) needed for the mortality study could be obtained from the application forms. The wage, salary and transfer records are filed each time there is a change in position or salary, and thus could be used for constructing detailed work histories.

Hourly and some salaried workers have "rate cards" which contain most of the information required for the mortality study including: detailed work histories, sex, social security number and birthdate. For hourly workers the rate cards are filed separately from their personnel file folders; whereas, for salaried workers the rate cards are filed with their personnel file folders. Since these cards contain all of the information needed for this study on one document, they would be a far more convenient source of information than the personnel files described above.

Personnel files for workers that terminated employment at Union or Bound

Brook over the past 3 years are maintained at the personnel office in Union. Records for workers terminated prior to this time are maintained at the Alsip facility in Chicago, Illinois. From a previous visit to the Alsip Facility it is estimated that there are approximately 400 records of former employees from the union plant. The personnel office in Union does maintain a file card system for all former employees since about 1961. These cards contain name, social security number, birthdate, first date employed, last date employed, and sometimes the initial position held. There were approximately 860 of these cards on file. Although these cards could not be used for constructing detailed work histories, they could be used for verifying the completeness of the personnel files.

A randomly selected sample of personnel files was reviewed. This review included records for active workers, and workers that terminated employment within the past 3 years. Unfortunately records for workers who terminated employment more than 3 years ago are maintained at corporate headquarters in Alsip, Illinois and could not be included in this review.

Potentially exposed workers, as defined by the previously stated criteria, could readily be identified from the personnel records. Information on sex, year of first exposure and duration of exposure was recorded for workers judged to be potentially exposed. A summary of the findings from this review is presented in Table IV. All of the workers were male. The average first year of exposure was relatively recent, particularly for the Bound Brook facility which only began operation in early 1979. The average

duration of exposure was fairly long reflecting the fact this is a fairly stable workforce. Based on these records alone it is anticipated that this plant would contribute 795 person-years to this study. This does not include, however, workers who terminated employment more than 3 years ago, and thus is extremely conservative.

VII. Toxicity

Evidence from animal studies suggests that ETO may have carcinogenic properties.[7,8] A group of ETO manufacturers sponsored a study at the Bushy Run Research Center in which male and female Fischer 344 rats were exposed to ETO at airborne concentrations of 10, 33, or 100 parts per million (ppm) for 6 hours per day, 5 days per week for two years.[7] Two other groups of animals served as controls. Initially, there were 120 animals of each sex, in each exposure group. The researchers observed a statistically significant increase in the incidence of mononuclear cell leukemia among the female rats, and peritoneal mesothelioma among the male rats exposed to ETO. The increase in leukemia incidence was found to increase linearly as a function of ETO exposure. An elevation in mortality from brain cancers (glial type) was also observed in the rats exposed to ETO.

NIOSH researchers have recently reported on the results from an animal experiment which corroborated the findings of the Bushy Run Study.[8] Male Fischer 344 rats were exposed to ETO for 7 hours/day, 5 days/week for 2 years at airborne concentrations of 0, 50, or 100 ppm. There were 80 rats

in each exposure group. Increases in the incidence of mononuclear leukemia, peritoneal mesothelioma, and cerebral gliomas were observed among the ETO exposed rats, relative to non-exposed controls.

Only a few epidemiologic studies have examined the potential human carcinogenicity of ETO.[9-11] Hogstedt, et al, conducted a retrospective cohort mortality study of a group of workers in a Swedish chemical factory that had previously been included in a hematologic investigation.[9] This facility produced ETO via the chlorohydrin process in which, in addition to ETO, there was potential exposure to ethylene, ethylene chlorohydrin, ethylene dichloride, and small amounts of bis(2-chloro-ethyl) ether. Among 89 "full-time" exposed workers, a statistically significant (p less than .01) excess of leukemia mortality was observed (2 observed versus 0.14 expected). In addition, a statistically significant (p less than .01) excess of stomach cancer was observed (3 observed versus 0.4 expected). Because of the mixed exposures, these findings could not be attributed to ETO; however, ethylene oxide and ethylene dichloride were the prime suspects.

Morgan, et al, conducted a retrospective cohort mortality study of workers involved in the production of ETO at a Texaco Facility.[10] A total of 850 workers were included in the study, of which 767 were potentially exposed to ETO. No ETO was detected in most samples taken in the production area, and all measurements in this [illegible] were below 10 ppm. No cases of leukemia were observed in this study; however, the authors estimated that the lowest relative risk that they had a high probability of detecting (80% power) was 10.5.

Hogstedt also reported on three cases of leukemia that occurred in a small group of workers at a Swedish company.[11] The company used a mixture of 50% ETO and 50% methyl formate to sterilize hospital equipment. The 8-hour TWA exposure for ETO at this facility was estimated at 20 ppm. According to national statistics, only 0.2 deaths due to leukemia were expected in this cohort. One of the cases was exposed to benzene, a known leukemogen, and it was speculated that the combined exposure of ETO and methyl formate might produce a special risk.

ETO is also a potent alkylating agent capable of causing irreversible changes or mutations in cellular proteins and DNA in animals.[12,13] ETO is also a positive mutagen in several in vitro systems such as Salmonella typhimurium, viruses, and Tradescantia poludosa.[6]

Chromosomal aberrations related to ETO exposure have been observed in a number of animal studies and epidemiologic investigations.[8,13-20] Yager and Benzene observed a dose related increase in sister chromatid exchanges (SCEs) among New Zealand white rabbits that were exposed via inhalation to 50 to 250 ppm of ETO.[14] NIOSH (Lynch, et al) recently reported preliminary findings in which cynomolgus monkeys were exposed to 0, 50, or 100 ppm of ETO for 7 hours per day, 5 days per week.[8] After 24 months of exposure, statistically significant increases were observed in the frequency of chromosomal aberrations (including quadriradial chromosomes) and SCEs in the peripheral lymphocytes of the 50 and 100 ppm exposed groups versus the controls.

Garry, et al, examined the occurrence of SCE in the peripheral lymphocytes of 12 ETO exposed workers and 12 nonexposed controls in a hospital sterilization facility.[15] The exposed group showed statistically significant elevations in the number of SCEs compared to the controls. Particularly high SCE frequencies were observed among 4 workers that had reported either neurologic or respiratory symptoms. The maximum peak exposure level of ETO measured at this facility was 36 ppm.
Cytogenetic abnormalities have also been observed in several studies of workers exposed to ETO. Ehrenberg, in a study of workers at a factory manufacturing and using EtO, observed a high frequency of chromosomal aberrations in 8 workers who were accidentally exposed to high concentrations of ETO. One case of leukemia was also observed among the 37 workers studied.[16]

American Hospital Supply initiated a cytogenetic survey of workers that were exposed to ETO in the sterilization of medical devices in 1978.[17,18] Seventy-five exposed workers at 9 facilities were studied, as well as 37 nonexposed workers who served as controls. Compared to controls, exposed workers were found to have statistically significant increased frequencies of SCEs and chromosomal aberrations.

In response to the findings from the American Hospital Supply study, Johnson and Johnson initiated a cytogenetic study of workers that were also exposed to ETO in the sterilization of medical products.[19,20] Approximately 50 workers not exposed to ETO were compared to 50 exposed workers at three

facilities with 8-hour Time-Weighted Average (TWA) exposures to ETO of less than 1 ppm, 1-10 ppm, and 25-200 ppm, respectively. Statistically significant elevations in SCE frequency were observed in the latter two facilities, and these changes have persisted after one year. The frequency of SCEs appeared to increase in a dose response manner. Chromosomal aberrations were also elevated in the high exposure groups; however, these findings were not statistically significant.

VIII. Applicable Standards and Recommended Levels

Prior to June 22, 1984, the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for ETO was 50 ppm as a TWA concentration for an 8-hour workshift.[21] OSHA established a new PEL of 1 ppm as an 8-hour TWA on August 21, 1984.[22] In addition, an "action level" of 0.5 ppm as an 8-hour TWA was established (by OSHA) as the level above which employers must initiate periodic employee exposure monitoring and medical surveillance. The Environmental Protection Agency (EPA) supported the OSHA PEL of 1 ppm in the Federal Register (June 22, 1984).[23]

In 1977, NIOSH recommended a ceiling level of 75 ppm as determined during a 15 minute sampling period.[6] This level, however, was set prior to the recognition of the carcinogenic potential of ETO. Based on recent findings, NIOSH recommends that ETO exposures not exceed 5 ppm for a maximum of 10 minutes per day and that exposures be controlled to less than 0.1 ppm determined as an 8-hour TWA (NIOSH Policy Statement, July 20, 1983). The

American Conference of Governmental Industrial Hygienists (ACGIH) recommends a Threshold Limit Value (TLV) of 10 ppm for an 8-hour TWA based on data available prior to 1982.[24] However, in 1982, the ACGIH issued a notice of intended change in which it was proposed that the TWA concentration be lowered to 1 ppm. This recommendation was reviewed and adopted in 1984. ACGIH has also designated ETO as an A2 carcinogen.[24] An A2 carcinogen is defined as an industrial substance suspected of having carcinogenic potential for man. This designation is based on either (1) limited epidemiologic evidence, exclusive of clinical reports of single cases, or (2) demonstration of carcinogenesis in one or more animal species by appropriate methods.

IX. Conclusions and Recommendations

Most operations at the Union facility appear to have fairly well controlled exposures to ethylene oxide. There still are significant exposures to the retort (chemical) operators, and to a lesser extent, grinders; data from the vicinity of the retort area documents that substantial exposure still exists. Data collected since the installation of the shrouding around the retort areas is necessary to make further recommendations for the Union facility.

Limited data is available for the Bound Brook facility, however the isolation of the ETO treatment and aeration operations appears to have diminished exposures. Significant exposures still exist for the processing

operators and operating assistants and this should be the area of primary concern.

Union should install double valves on their ETO supply lines. Other companies have observed that significant ETO exposures may occur when employees disconnect these lines due to residual ETO in the lines. The present local exhaust operation at the ETO drum location is inadequate and should be redesigned. The vent should be relocated to the source of emissions at the coupling point.

Since many of the employees at the Boundbrook facility used to work at the Union facility, these facilities are being considered one plant population for the purposes of this study.

These facilities meet the three eligibility requirements as defined in the study protocol, and therefore should be included in the study. These requirements are: 1) the plant must contribute at least 200 person-years to the high exposure group, or 400 person years total, 2) the plant must have adequate personnel records or other records that can be used for identifying past and present workers exposed to ETO, and 3) the plant must not have any serious confounding exposure to a known leukemogen.

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TABLE I

Griffiths Laboratories, Union, New Jersey

Ethylene Oxide - Mean Personal Exposures (parts per million)[A]
Mean (Number of Samples)
(Range)

JOB TITLE	7-84	10-84	11-84
Chemical Operator	6.3 (2)	6 (2)	4 (1)
Range	(6.1 - 6.5)	(both 6)	-
Grinder	1.3 (11)	1.3 (13)	2.0 (6)
Range	(1 - 1.7)	(0.25 - 2) [B]	(0.7 - 5)
Laboratory Employee	0.75 (9)	0.25 (10)	-
Range	(0.5 - 1.5)	(all 0.25)	
Lift Truck	1.3 (4)	0.6 (5)	-
Range	(0.9 - 1.7)	(0.6 - 1)	
Maintenance	1.6 (4)	0.6 (6)	-
Range	(0.6 - 4.2)	(0.25 - 0.9)	
Mixer	0.7 (11)	0.9 (12)	0.6 (3)
Range	(0.25 - 1.3)	(0.25 - 3)	(0.25 - 1)
Office	0.4 (21)	0.25 (18)	-
Range	(0.25 - 1.4)	(all 0.25)	
Packer	0.5 (8)	0.5 (10)	0.25 (1)
Range	(0.25 - 1.1)	(0.25 - 2)	-
Painting (Temporary)	1.1 (1)	-	-
Printer	1.2 (1)	0.25 (1)	-
Sanitor	1.2 (4)	0.4 (5)	-
Range	(0.5 - 1.9)	(0.25 - 0.5)	
Supervisory	0.7 (1)	0.5 (2)	-
Range	-	(0.25 - 0.8)	
Warehouse	1.9 (3)	0.25 (2)	-
Range	(0.7 - 3.5)	(both 0.25)	

A All samples reported as 8 hour, time weighted averages. Data collected by Griffiths Laboratories with AMSCO badges.

B Non-Detectables were less than 0.5 ppm; For purposes of averages and this table, 0.25 ppm was used.

TABLE II

Griffiths Laboratories, Union, New Jersey

Ethylene Oxide - Mean Area Levels (parts per million)[A]
Mean (Number of Samples)
(Range)

AREA	7-84	10-84	11-84
Aeration Room	15.6 (2)	3 (2)	47.5 (2)
Range	(14.7 - 16.5)	(1 - 5)	(10 - 85)
Blending	0.95 (2)	0.8 (2)	-
Range	(1 - 0.9)	(both 0.8)	
Canteen	0.25 (1) [B]	0.25 (1)	-
Cooler Room	4.9 (2)	8.3 (3)	10.5 (2)
Range	(4.5 - 5.2)	(8 - 9)	(9 - 12)
Gasing Station	4.5 (1)	19.3 (3)	3 (2)
Range	-	(17 - 22)	(2 - 4)
Laboratory	0.7 (1)	0.75 (2)	0.25 (1)
range	-	(0.5 - 1)	-
New Warehouse	1.2 (2)	0.6 (2)	-
Range	(1.1 - 1.3)	(0.25 - 1)	
Office	0.3 (4)	0.25 (4)	-
Range	(0.25 - 0.5)	(all 0.25)	
Old Warehouse	1.2 (4)	0.3 (5)	-
Range	(0.9 - 1.8)	(0.25 - 0.5)	
Packaging	0.25 (1)	0.25 (1)	
Retort	3.7 (4)	8.5 (4)	-
Range	(2.7 - 4.6)	(3 - 19)	
Spice Grinding	1.9 (2)	1 (2)	3.5 (2)
Range	(1.7 - 2.1)	(both 1)	(2 - 5)

A All samples reported as 8 hour, time weighted averages. Data collected by Griffiths Laboratories with AMSCO badges.

B Non-Detectables were less than 0.5 ppm; For purposes of averages and this table, 0.25 ppm was used.

TABLE III

Micro-Biotrol
Bound Brook, New Jersey

Ethylene Oxide - Mean Personal Exposures (parts per million)[A]
Mean (Number of Samples)
(Range)

JOB TITLE	6-83	10-83[B]	3-84	10-84
Department Head	6 (1)	3 (1)	0.8 (1)	0.6 (1)
Office	4.5 (4)	3.8 (4)	0.25 (4)	0.7 (4)
Range	(4 - 5)	(2 - 5)	(all 0.25[C])	(0.25 - 2)
Maintenance	9 (1)	7 (1)	1 (1)	-
Processing Assist.	8.7 (3)	6.7 (3)	1.9 (3)	2.3 (3)
Range	(7 - 10)	(3 - 11)	(0.6 - 3)	(1 - 3)
Processing Operator	7.7 (3)	8.3 (3)	1.3 (3)	3.7 (3)
Range	(5 - 10)	(4 - 13)	(0.9 - 2)	(1 - 7)
Quality Assurance Technician	5 (1)	-	6 (1)	0.71
Warehouse Clerk	6 (2)	4 (2)	1.45 (2)	0.9 (2)
Range	(both 6)	(2 - 6)	(0.9 - 2)	(0.8 - 1)

A 72% of these samples were reported as 8 hour, time weighted averages. The balance ranged from 6.4 to 10.2 hours. Data collected by Griffiths Laboratories with AMSCO badges.

B Aeration Room operational 1-27-84.

C Non-Detectables were less than 0.5 ppm; For purposes of averages and this table, 0.25 ppm was used.

TABLE IV

SUMMARY OF RESULTS FROM REVIEW OF A SAMPLE OF PERSONNEL RECORDS[a,b]

LOCATION	PAY SYSTEM	EMPLOY STATUS	TOTAL # RECORDS (# SAMPLED)	EST % EXP	EST # EXP	AVERAGE YR 1ST EXP	AVERAGE DUR EXP	EST P YRS[c]
1) Union	Hourly	Active	56(12)	100	56	1974	9.9	504
2) Union	Salary	Active	32(6)	33	11	1968	16.0	165
3) Bound Brook	Hourly	Active	9(9)	100	9	1979	3.4	36
4) Union & Bound Brook	Hourly & Salaried	Former last 3 yrs	23(5)	80	18	1978	4.5	90
			120(32)		94			795

a) The following abbreviations are used in this table. Est for estimate, employ for employment, EXP for exposed, YR for year, Dur for duration and P YRS for person-years.

b) Statistics are based on data from the workers considered to be potentially exposed in this review.

c) Person years were estimated by multiplying the estimated number of exposed workers times the length of time between 1983 and the average first year of exposure.