INDUSTRYWIDE STUDIES REPORT:
A WALK-THROUGH SURVEY OF

BECTON, DICKINSON AND COMPANY, INCORPORATED
Grace Way Road
Canaan, Connecticut 06018

PROJECT NUMBER: P:84:12

SURVEY CONDUCTED BY:
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DATE OF SURVEY:
September 18-19, 1984

REPORT WRITTEN BY:
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Industrial Hygiene 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

DISCLAIMER

Mention of company names and products does not constitute endorsement by National Institute for Occupational Safety and Health (NIOSH).

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:	**Becton, Dickinson and Company, Incorporated** Anthony Piniat-Corp Program Manager; Safety and Health, (201) 967-3633 Andrew Rowjohn-Plant Manager, Canaan, Connecticut, (203) 824-5487 Bonnie Morrow-Manager, Human Resources Richard Crook-Manager, Microbiological and Sterilization Services Cynthia Cantele-Occupational Health Nurse
EMPLOYEE REPRESENTATIVES:	**None**
STANDARD INDUSTRIAL CLASSIFICATION:	3841 - Surgical and Medical Instruments and Apparatus

ABSTRACT

On September 18-19, 1984, a walk-through survey was conducted at Becton, Dickinson and Company, Incorporated (BD) in Canaan, Connecticut, to evaluate industrial hygiene and personnel records, production processes, and document historic use of ethylene oxide (ETO). This survey was conducted as part of an industrywide study of mortality associated with an occupational exposure to ETO.

BD began production of plastic disposable syringes with and without needles at its Canaan, Connecticut, site in 1961. BD installed its first two (2) sterilization vessels in 1963, however, they did not use the vessels until 1964. At that time, the company began sterilization with 100% ETO. Over the next several years, BD installed five (5) more vessels. In 1970, BD installed a cobalt irradiation unit. At the time of this walkthrough survey, BD still uses 100% ETO to sterilize the majority of its product and cobalt irradiation to sterilize the remainder.

BD has conducted industrial hygiene sampling for ETO since 1981. The first two years (1981-82), sampling was conducted with Quazi Ketchum (QK) tubes to establish baseline data (Time weighted averages and short term exposures). The next two years (1983-84), passive monitors (3M and Dupont) were used to evaluate time weighted exposures. At this time, NIOSH Industrywide Studies Branch has no plans to conduct industrial hygiene sampling at this facility.

This plant meets the three eligibility requirements as defined in the 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.

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] Inorder 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 facility is not part of the pilot study.

This walk-through survey was conducted to determine the suitability of including Becton, Dickinson and Company, Incorporated in the industrywide mortality and industrial hygiene study of workers potentially exposed to ETO in industrial sterilization processes. The suitability of including this facility was based on data gathered in 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.

DESCRIPTION OF FACILITY

Becton, Dickinson and Company, Incorporated (BD) began production of plastic disposable syringes with and without needles at its Canaan, Connecticut site in 1961. BD installed its first two (2) sterilizers in 1963 (vessels #1 and #2), however, sterilization with 100% ETO did not begin until 1964. In 1965, vessel #3 was installed. Vessel #4 was installed in April, 1967. Vessel #5 was installed in March, 1969. The last vessel (#6) was installed in June, 1981. Each vessel is 1,000 ft^3, and can accommodate 12 pallets. In 1970, BD installed a cobalt irradiation unit to sterilize some of its product. There is an on-site cafeteria where most of the employees eat. The remaining employees eat off-premises.

At the time of this survey, the company was using 100% ETO to sterilize 95 to 98% of the product. The remainder was sterilized with an on-site cobalt unit. This facility also sterilizes products made by other BD locations. BD does not do any contract sterilization. The company estimates that approximately 240-250,000 pounds of ETO are used annually. This use of ETO has remained fairly constant over the last several years. The company also has a small research and development sterilizer in the MicroBiology Quality Assurance labs. The annual use of ETO in this sterilizer is unknown, but it is assumed to be small.

DESCRIPTION OF PROCESS

BD produces disposable plastic syringes with and without needles, (see Table I). The company sterilizes most of its product with 100% ETO, the rest of the product is sterilized with cobalt irradiation. The polypropylene plastic is received and sent to molding, where barrels or plungers are formed by injection molding. The barrels are sent to printing, where graduations and the company trade mark or name are printed on the barrel. The printed barrels and the plungers are sent to the assembly department, where they are assembled. Quality control (QC) inspectors examine the product for defects before it is sent to packaging.

Following the QC inspection, most of the product is packaged, palletized, and Biological Indicators (BI) are placed throughout the pallet before it is sent to a holding area for ETO sterilization. The rest of the product is sent to the cobalt irradiation unit for sterilization. When the product is released from the holding area, it must be pre-conditioned before it can be sterilized. Part of the product is sent to a pre-conditioning area, which is at an elevated temperature and humidity. The rest of the product is pre-conditioned inside the sterilizer.

Following pre-conditioning, the product is placed in the sterilizer, if it was not pre-conditioned there, and the vessel is placed under a vacuum. Steam is then introduced into the vessel, if the vessel was not used for pre-conditioning. ETO is then introduced into the vessel. Exposure time of the product to the ETO is dependent on the size of the syringe to be sterilized. The total cycle time, from load to unload, is 5.5 to 13.5 hours. At the end of the exposure time, air is injected into the vessel to return it to atmospheric pressure. The door is opened slightly by the operator, at the vessel, and the rear exhaust fan, which was installed in 1981, is automatically activated. The fans run for five (5) minutes before the door is fully opened, and the vessel is unloaded, which takes 20-30 minutes. There is a single, front entry to the vessel.

After the product is unloaded, it is transferred to the link area where it aerates, and the sterilizer operator removes the BIs and the QC samples. Product may stay in the link for as long as two (2) hours. The product is then sent to the quarantine area where, until 1979, it had to remain 14 days before it was available for final packaging (case pack) and shipping. Product is now available for case pack and shipping in four (4) days because of parametric release. The BIs are transferred to the Microbiology QC area where they are unwrapped and placed in nutrient media. There is a small (3 ft^3) sterilizer in this area also. This unit is used for research and development.

After the product is released from quarantine, it is sent to case pack and shipping.

DESCRIPTION OF MEDICAL, INDUSTRIAL HYGIENE AND SAFETY PROGRAMS

Medical

Prior to 1981, any minor first aid was handled by an employee, who was trained as an Emergency Medical Technician (EMT). Since that time, BD has had an in-house medical department, staffed by a nurse trained in occupational health and a physician on-call to handle any inplant injuries. All employees are given pre-employment physicals. Physicals have been given annually, since 1981, to all employees considered to be at risk due to exposure to ETO. These employees were identified by job description and verification of exposure to ETO by industrial hygiene measurements.

Industrial Hygiene and Safety

BD has an industrial hygiene and safety program at the corporate level, which oversees the activities at each individual plant. In 1981, BD began its monitoring program for ETO. The industrial hygiene sampling was conducted by an in-plant employee, who had been trained to collect samples by the corporate industrial hygienist. These samples, Quazi Ketchum (QK) tubes were collected to establish baseline time weighted average (TWA) exposures to ETO throughout the plant, as well as to document any short term high exposures. All samples were analyzed by the corporate lab. Copious, detailed notes were taken during the sampling period to document an employee's various job tasks and work practices. All pumps used were

calibrated on-site before and after each use. Respirator use or lack of use was also noted.

A review of the data indicated that ten (10) jobs were evaluated for an 8 hr TWA with QK tubes (see Table 2). In 1983, the use of QK tubes was discontinued, and Dupont and 3M passive monitoring badges were used to monitor an employee's TWA exposure to ETO (see Table 2). In 1984, 3M badges were used exclusively. Six of the ten employees and/or jobs monitored with the QK tubes were also monitored with the badges. In general, the charcoal tube data indicate that the ETO exposure for each job decreased over time. In general, the first time the badges (3M) were used the exposures appeared to increase and then decrease to a level at or below the lowest sample previously collected with the QK tubes. This initial rise may have been due to several factors such as: lack of experience with use of the badges, QK tubes gave false low results or the badges gave false high results.

The use of hearing protection is required in all areas where noise presents a hazard. There is no routine use of respirators any where in the plant. Safety glasses are required to be used in certain jobs (eg, maintenance-grinding). Safety shoes are not required. There is an in-plant safety committee which is chaired by the Manager of Human Resources.

DESCRIPTION OF PERSONNEL RECORDS

The personnel office maintains files for all active workers, and for all workers that have terminated employment since 1980. These files contain the following documents which could be potentially useful for the mortality study; an employee record card, an employee seniority card and employee status notices. The employee record card contains the following useful information: name, social security number, date of birth, sex, current address and a detailed job history. The seniority card contains the worker's name and a detailed work history. An employee status notice form is placed in the file each time a change in position or salary is made. These notices could be used for constructing detailed job histories; however, it would be far easier to do so using either the employee record card, or the employee seniority card.

Personnel files for active and workers who terminated employment since 1980 are filed separately. For inactive workers, exempt (exempt from overtime compensation) salaried personnel records are filed separately from hourly and non-exempt salaried personnel records. There are a total of 42 records in the former category, and 336 in the latter category. For active workers separate filing systems exist for exempt salaried, non-exempt salaried, and hourly workers. There are 51 exempt salaried, 50 salaried non-exempt, and 280 hourly records on file.

Personnel files for workers who terminated employment between 1961 and 1980 have been microfilmed. Records for hourly and salaried (exempt and non-exempt) workers have been merged together on this film. These records appear to contain the same forms as the hard copy records described above.

An index of these films indicates that there are 2,657 individual records on these films.

Additional records were located, which could be used for verification of the completeness of the personnel files. The Payroll department has maintained registers which date back to 1973. These records list individual names by department number. Finally, the personnel office has an index card system with employee's name and address for all current and former employees.

Identification of Exposed Workers

After a careful review of processes using ETO and discussions with plant personnel a tentative list of potentially ETO exposed department titles were prepared. Any workers that have been employed for at least 3 months in any of the following areas would be included in the mortality study; sterilization department, shipping department, quality control department, case pack department, maintenance department, and the facility engineer from the engineering department.

Sampling and Review of the Records

A random sample of approximately 5% of the personnel records was selected and reviewed. The primary objective of this review was to determine whether workers potentially exposed to ETO, according to the definition in the previous section, could be identified from the record system. In addition information on sex, year of birth, first year of exposure, and duration of exposure was recorded for workers judged to be potentially exposed to ETO.

In every record reviewed it was possible to determine whether the individual was potentially exposed according to the previously described criteria. A summary of the data obtained from the review is presented in Table 3. Overall, 1,693 out of 3,038 (56%) of the individuals were estimated to be potentially exposed to ETO. Forty-eight percent of the potentially exposed workers were males. The mean year of birth was 1938, the mean year of first exposure was 1969, and the mean duration of exposure was 3.3 years.

Assuming follow-up from the average first year of exposure (1969) to 1983, it is estimated that this group would contribute 24,499 (14 years x 1,693 persons) person-years to the mortality study.

DESCRIPTION OF WORKFORCE

According to company management, the workforce at this plant is predominately white, and about 62% female. They also indicated that turnover at this plant is very low.

DESCRIPTION OF PAST EXPOSURES

There have been many modifications in the plant over the last several years that would have effected employee exposure to ETO. The changes have occurred in work practices, sterilization procedures, physical location of departments, modifications to the sterilizing vessels and ventilation.

Work Practices

The employees have always been instructed to use caution when working with ETO, primarily due to its explosiveness. It was always a common work practice to open a vessel and wait several minutes before entering it. In 1981, a rear exhaust fan was installed in each sterilizer. At this time, the employees were instructed to wait five (5) minutes before unloading the vessel to allow the fan sufficient time to exhaust the vessel. There are also written work guidelines instructing the employees to pull instead of push the pallets of sterilized goods.

Sterilization Procedures

BD first used 100% ETO to sterilize their product (plastic disposable syringes) in 1964. In 1970, BD installed a cobalt irradiation unit, which is used to sterilize some of the product. It is the intent of BD to move toward greater utilization of the cobalt unit, thus decreasing the amount of product sterilized with ETO.

In 1979, BD began parametric release of its product. This allows release of product for case pack and shipping in four (4) days instead of 10-14 days. Parametric release of a product means that previously defined vessel operating parameters were followed during the sterilization of the product, and that these operating parameters were selected, after repeated experimentation, to ensure desired bacterial kill ratios were met. The product is still held in quarantine for the four days, however, this shorter quarantine time would decrease the length of aeration time of the product before it is shipped.

Physical Location of Departments

Production began at this facility in 1961. At that time, most of the processes were located in one (1) large area. Manufacturing covered most of this area, with casepack and shipping located in the remaining space at the north end of the building. At some point in time between 1963 and 1964 a wall was installed at the north end of the manufacturing area so that case pack and shipping were physically separated from manufacturing. The warehouse, which shared a common south wall with the manufacturing area, contained the quarantine area. The sterilization area has always been located in a separate wing (north east of the manufacturing area). The doorway to this wing, which is always open, leads directly to the manufacturing area. The wing is under negative pressure relative to the manufacturing area. Molding has always been separated from the rest of the manufacturing area by a solid floor-to-roof wall. Molding also has an unique ventilation system.

In 1974, case pack was moved to the opposite (southern) end of the building.

There has been some movement of departments within the facility. The most important department relocation, relative to ETO exposure, was the transfer of the quarantine area in 1982 from the warehouse to a physically separate area. The quarantine area now only has access through the link area, which is adjacent to the sterilizer wing, or through the case pack area which are always kept closed.

In 1982, the physical QC area was moved from the manufacturing floor to a separate room near the sterilizer wing. Microbiology QC has always been located in the same area. Microbiology QC is separated from the rest of the facility by floor to roof walls and a separate ventilation system.

In June, 1982 the link area was built. This area serves as a transition area, between the sterilization wing and the quarantine area, where the BIs are removed, and the product is allowed to aerate. Product may stay in the link area for up to two (2) hours before it is placed in quarantine.

Sterilization Vessel Modifications

The most important modification to the sterilizing vessels was the installation of rear exhaust fans in 1981. These fans, which are activated automatically when the vessel door is opened slightly, are vented through the roof. There have also been some modifications and/or additions to the ventilation system around the sterilizers. These changes are described in the ventilation section.

Ventilation

Manufacturing, molding, offices and labs have separate dedicated recirculating heating, ventilation, and air conditioning (HVAC) systems. HVAC drawings indicate that in 1962 a common system served case pack and the north end of manufacturing. This system probably served the two areas until case pack was relocated in 1974. The degree of recirculation of air between case pack where ETO sterilized product was handled and the manufacturing area which did not have any sterilized product is unknown. The manufacturing area probably did some exposure to ETO, however the degree of exposure was probably minimal and does not warrant inclusion in the study. The intake for these systems are on the roof, down wind from the sterilizer exhaust stacks. The top of the sterilizer exhaust stacks are approximately 10-12 feet above these intakes, however, reintrainment of ETO may occur. The concentration of the reentrained ETO probably is low, however.

Sterilization Wing

The sterilization wing, which is on its own ventilation system, is under negative pressure in reference to the rest of the building. When the wing was built in 1964, each vault except #2 and #3, which contained one (1) sterilizer, had a separate low point exhaust ventilation system. Vaults 2 and 3, which shared ventilation ducts, now have separate systems. The wing has also always had large exhaust fans located near the entrance to the wing. The vacuum pumps, which are water sealed, have always been located in one of the two (2) ETO drum rooms (except the pump for vessel 6 which is located behind the vessel). These rooms contain the ETO cylinders which supply the vessels. In the late 1970's, rigid duct work ran from the ceiling, with the intake located between 2 drums near the top. In July, 1984, flexible duct with a hood at the end was installed for each drum. This hood covers the entire top of the drum.

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are removed, and the product is allowed to aerate. Product may stay in the link area for up to two (2) hours before it placed in quarantine.

The link has its own dedicated exhaust ventilation system. In addition, there are ducts that were installed in 1983 that run down the wall with the end of the duct about 2 feet from the floor. This ventilation system is designed to pull air from the center of the room toward the sides where it is captured by these ducts. The system may be ineffective, however, because when the area is full of pallets containing the freshly sterilized product, the pallets may be pushed almost flush with the ducts therefore, partially or completely blocking them.

Quarantine

In the old quarantine area, which was located in the warehouse, the ventilation system consisted of passive air flow through vents that were located at the ceiling/wall interface. When the new quarantine area was built in the early 1970's, four (4) exhaust fans were mounted in the roof. The make-up air was supplied by a heating/cooling system which was devoted to the area.

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 nonexposed 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 area 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 Benz 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.

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.

CONCLUSIONS AND RECOMMENDATIONS

BD began production of plastic disposable syringes with and without needles at its Canaan, Connecticut, site in 1961. BD installed its first two (2) sterilization vessels in 1963, however they did not use the vessels until 1964. At that time, the company began sterilization with 100% ETO. Over the next several years, BD installed five (5) more vessels. In 1970, BD installed a cobalt irradition unit which is used to sterilize some of the product. At the time of this walkthrough survey, BD still uses 100% ETO to sterilize most of its product and cobalt irradition to sterilize the remainder.

BD has conducted industrial hygiene sampling for ETO since 1981. The first two years, sampling was conducted with QK tubes to establish baseline data (Time weighted averages and short term exposures). The next two years, passive monitors were used to evaluate time weighted exposures. At this time, NIOSH Industrywide Studies Branch has no plans to conduct industrial hygiene sampling at this facility.

There are a few recommendations which can be made in this report. These recommendations are:

1. The company should consider conducting industrial hygiene sampling, in those areas where data does not exist or the data is inconclusive, to determine exposure or nonexposure to ETO. Sampling should also be conducted in the office areas to document that reentrainment of ETO from the sterilizer exhaust stacks does not occur.

2. Ventilation in the link area should be evaluated when this area is filled with pallets of freshly sterilized material. There may not be adequate movement of air to reduce the ambient ETO to desired levels.

3. The company should consider installing curbs or guards, on the floor in front of the ducts, in the link area to prevent pallets from being shoved against these ducts.

4. The company should maintain the same level of excellence in its industrial monitoring that it has exhibited to date.

This plant meets the three eligibility requirements as defined in the 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.

TABLE 1

PROCESS FLOW DIAGRAM
BECTON, DICKINSON AND COMPANY
CANAAN, CONNECTICUT
SEPTEMBER 18-19, 1984

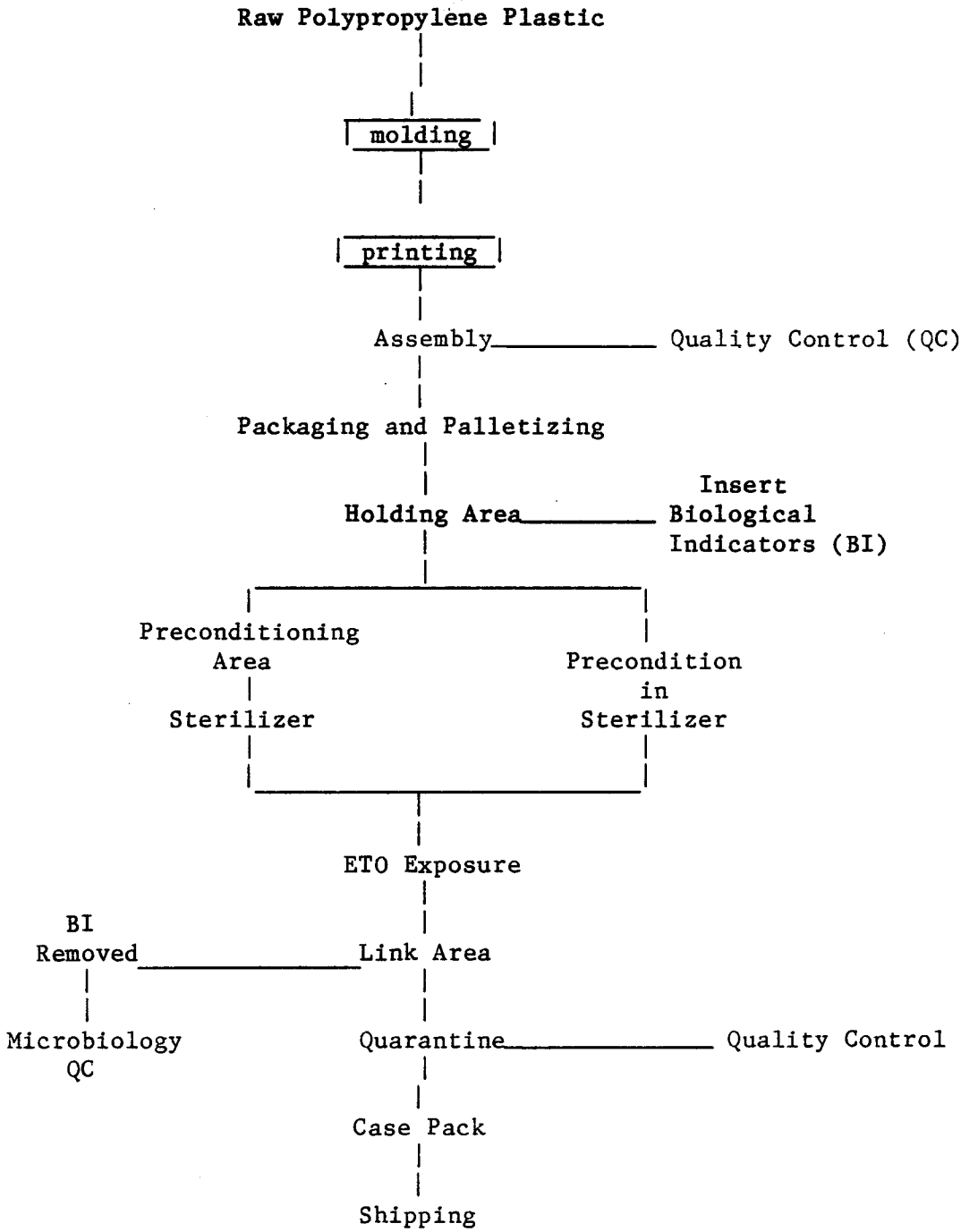

TABLE 2
INDUSTRIAL HYGIENE DATA, 8 HOUR TWA
BECTON, DICKINSON AND COMPANY
CANAAN, CONNECTICUT
SEPTEMBER 18-19, 1984

JOB	DATE	MEAN ± S.D. PPM	RANGE PPM	OBSERVATIONS	TYPE
Sterilizer Operator	10-81	1.7 ± 0.4	1.4-2.2	3	QK[O]
	4-82	3.8 ± 3.4	1.1-7.6	3	QK
	6-82	2.9 ± 1.0	1.8-3.7	3	QK
	6-83	6.7 ± 3.7	0.4-11.0	7	3M[+]
	12-83	2.4 ± 1.1	1.4- 4.0	6	3M
	6-84	2.3 ± 1.8	0.6- 5.5	7	3M
	7-84	1.4 ± 0.8	0.6- 2.5	4	3M
Assist Sterilizer Operator	11-81	2.4 ± 0.6	3.1-4.0	3	QK
	4-82	2.1 ± 1.1	1.8-3.0	3	QK
	6-82	3.6 ± 0.5	1.3-3.3	3	QK
	6-83	7.1 ± 3.9	2.8-11.0	4	3M
Material Handler	10-81	3.6 ± 1.1	2.1-5.1	6	QK
	4-82	2.7 ± 0.8	1.5-3.6	6	QK
	6-82	3.4 ± 2.6	1.0-5.5	3	QK
Material Handler Forklift Operator*	10-81	3.2 ± 0.8	2.3-3.9	3	QK
Sterilizer Technician-Cobalt	11-81	2.4 ± 1.4	0.8-3.4	3	QK
	6-82	1.3 ± 2.1	0.4-5.6	6	QK
Forklift Operator	10-81	3.8 ± 2.5	0.5-6.6	6	QK
	5-82	1.6 ± 0.5	1.1-2.1	3	QK
	6-82	2.9 ± 1.5	1.3-4.3	3	QK
	7-82	1.6 ± 0.6	0.8-2.6	6	QK
	6-83	10.5 ± 1.3	8.9-12	4	3M
	12-83	3.0 ± 1.4	1.7- 4.9	4	3M
	6-84	3.1 ± 1.1	2.1- 4.2	3	3M
	7-84	2.1 ± 0.8	1.4- 3.3	5	3M
Assist Supervisor	6-82	1.3		1	QK

TABLE 2 (continued)
INDUSTRIAL HYGIENE DATA, 8 HOUR TWA
BECTON, DICKINSON AND COMPANY
CANAAN, CONNECTICUT
SEPTEMBER 18-19, 1984

JOB	DATE	MEAN ± S.D. PPM	RANGE PPM	OBSERVATIONS	TYPE
Spore Control Operator	11-81	3.3 ± 0.8	2.4-3.9	3	QK
	12-83	2.8		1	3M
	6-84	1.6		1	3M
	7-84	0.9		1	3M
Sterilization Lab Technician	11-81	0.7 ± 0.4	0.4-0.9	2	QK
	12-81	0.5 ± 0.1	0.4-0.6	4	QK
	8-83	0.9 ± 0.1	0.8-0.9	2	Dupont@
Sterilizer Technician-ETO	6-82	2.3 ± 0.9	0.6-3.2	6	QK
	8-83	0.6 ± 0.4	0.3- 0.9	2	Dupont@
	12-83	0.7 ± 0.3	0.5- 0.9	2	3M
	7-84	0.8		1	3M

* Spent 50% of time in sterilizer wing and 50% of time in quarantine.

°QK = Quasi Ketchum tube
+3M = 3M passive monitors
@Dupont = Dupont passive monitors

TABLE 3

SUMMARY OF PERSONNEL RECORDS REVIEW[a,b]
BECTON, DICKINSON AND COMPANY
CANAAN, CONNECTICUT
SEPTEMBER 18-19, 1984

RECORD SYSTEM	RECORDS (# SAMPLED)	EST % EXP	EST # EXP	% MALE	YR BIRTH	YR 1ST EXP	DUR EXP	EST[c] P-YRS
Inactive Salaried	101 (6)	17%	17	—	—	1964	20.0	323
Active Hourly	280 (14)	86%	241	58%	1941	1972	5.8	2,651
Inactive Hourly and Salaried	2657 (95)	54%	1435	45%	1938	1968	2.4	21,525
Overall	3038 (115)	56%	1693	48%	1938	1969	3.3	24,499

a) The following abbreviations were used in this table; EST for estimated, YR for year, EXP for exposed, DUR for duration, and P YRS for person-years.

b) Statistics presented are based on data abstracted from the workers classified as being potentially exposed to ETO 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.

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