

PRELIMINARY SURVEY REPORT:
CONTROL TECHNOLOGY FOR ETHYLENE OXIDE STERILIZATION IN HOSPITALS

AT

BRONSON METHODIST HOSPITAL
KALAMAZOO, MICHIGAN

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Kalamazoo, Michigan 49007

SIC CODE: 8062 (General Medical and Surgical
Hospitals)

SURVEY DATE: July 31, 1984

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INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is the primary Federal agency engaged in occupational safety and health research. Located in the Department of Health and Human Services (formerly DHEW), it was established by the Occupational Safety and Health Act of 1970. This legislation mandated NIOSH to conduct a number of research and education programs separate from the standard setting and enforcement functions carried out by the Occupational Safety and Health Administration (OSHA) in the Department of Labor. An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards. The Engineering Control Technology Branch (ECTB) of the Division of Physical Sciences and Engineering has been given the lead within NIOSH to study the engineering aspects of health hazard prevention and control.

Since 1976, ECTB has conducted a number of assessments of health hazard control technology on the basis of industry, common industrial process, or specific control techniques. Examples of these completed studies include the foundry industry; various chemical manufacturing or processing operations; spray painting; and the recirculation of exhaust air. The objective of each of these studies has been to document and evaluate effective control techniques for potential health hazards in the industry or process of interest, and to create a more general awareness of the need for or availability of an effective system of hazard control measures.

These studies involve a number of steps or phases. Initially, a series of walk-through surveys is conducted to select plants or processes with effective and potentially transferable control concepts or techniques. Next, in-depth surveys are conducted to determine both the control parameters and the effectiveness of these controls. The reports from these in-depth surveys are then used as a basis for preparing technical reports and journal articles on effective hazard control measures. Ultimately, the information from these research activities builds the data base of publicly available information on hazard control techniques for use by health professionals who are responsible for preventing occupational illness and injury.

BACKGROUND FOR THIS STUDY

The present Control Technology Assessment of Ethylene Oxide Sterilization in Hospitals is the result of the research recommendations of the 1983 Feasibility Study of Engineering Controls in Hospitals. During the feasibility study, preliminary surveys were conducted at eight hospitals to assess the potential need for further research in the control of anesthetic gases, antineoplastic drug exposures, and ethylene oxide (EtO) sterilization operations. Based on the feasibility study, a need for the evaluation and documentation of effective engineering controls for EtO sterilization was identified.

The health effects of ethylene oxide have been under intense study for several years. EtO exposure may cause irritation of the eyes, nose, and

throat. Dermal exposure to aqueous solutions of EtO may cause burns and allergic sensitization. Animal toxicity studies have shown EtO to be a mutagen and a carcinogen. Studies of exposed workers have indicated increased mutagenic activity in human cells, an increase in the incidence of leukemia, and adverse reproductive effects. Many of these effects, both for exposed animals and humans, were observed at concentration levels lower than the former OSHA permissible exposure limit (PEL) of 50 parts EtO per million parts air (ppm), expressed as an 8 hour time-weighted average (TWA). As a result of these studies and the urgings of workers' groups, OSHA began the rulemaking process to issue a new standard in early 1983. On June 15, 1984 OSHA issued a new PEL of 1 ppm (8 hr. TWA) for ethylene oxide based on its determination that EtO is a potential human carcinogen.

In response to the hospitals' need to control worker exposure to EtO to levels below 1 ppm, the Engineering Control Technology Branch of NIOSH is studying the control of EtO emissions from sterilizers in the hospital setting. The goals of this study are to evaluate and document effective engineering controls which select hospitals have implemented, and then to disseminate useful information and practicable recommendations on effective methods for controlling occupational ethylene oxide exposure.

BACKGROUND FOR THIS SURVEY

To identify hospitals which meet the design criteria of the study, ECTB has worked closely with the American Hospital Association and the Ohio Hospital Association, who have publicized and promoted the study to their member hospitals. Bronson Methodist Hospital expressed an interest in participating in the study and supplied information about the Central Service (CS) Department to NIOSH. Based on this information, it was determined that the hospital might fulfill the requirements of the category specifying: a sterilizer using a 12:88 EtO and Freon 12 mixture, no extra evacuation phases at the end of the sterilizer cycle, vented evacuation drain controls, and local exhaust ventilation other than above the sterilizer door.

A survey was conducted in the CS Department on July 31, 1984. This report documents the information gathered and the preliminary evaluation of the department.

HOSPITAL AND PROCESS DESCRIPTION

HOSPITAL DESCRIPTION

Bronson Methodist Hospital is a not-for-profit, acute care facility with 464 beds. Services which the hospital provides include: general surgery, oncology, eye surgery, cardiovascular catheterization, burn treatment, a trauma center, obstetrics, and neonatal care.

The CS Department is located on the fourth floor of the building. The department is near the labor and delivery department.

CENTRAL SERVICE DEPARTMENT DESCRIPTION

Ethylene oxide gas sterilization operations for the hospital are conducted in the Central Service Department and in the Surgery Department. The CS Department performs EtO sterilization for obstetrics, neonatal care, respiratory therapy, the catheterization laboratory, isolation cases, x-ray, and emergency. The Surgery Department sterilizes its own instruments and equipment.

The CS Department employs 15 persons distributed over 3 shifts. The number of employees working on the day shift varies from four to six depending on the product volume to be processed on a particular day. Typically, one person works in the decontamination room and three to five others work in the sterilization and packing room (hereafter referred to as the clean room). Only one person is assigned to operate the sterilizers and process the loads. The department manager, and secretary spend most of their time in offices or moving between the different areas of the department. During the evening shift, four persons are in the department. One or two persons are assigned to decontamination, and two or three persons work in the clean room. The night shift employs one or two persons as needed rotating between decontamination and the clean room.

The layout of the CS Department is diagrammed in Figure 1. Of particular interest in this study is the clean room which serves three functions. One end of the room is used to store clean supplies. Another part of the room serves as a processing area where cart loads are prepared for sterilization and where sterile loads cool before storage or distribution. A third area of the room is occupied by a bank of sterilizers (one steam, and one EtO) and two aerators that are recessed along one wall.

The sterilizers may be accessed for maintenance through a small recess room located behind the sterilizers. This room is entered through a doorway off the sterile storage room and is marked as a hazard area and restricted to authorized personnel only. The backs of the sterilizers and aerators are open to the room. Steam and water from the sterilizers are emptied into closed drains.

The EtO sterilizer is supplied with gas from a cylinder. The cylinder is located beside the EtO sterilizer in the recess room. A cylinder emptying during a sterilization cycle necessitates abortion of the load.

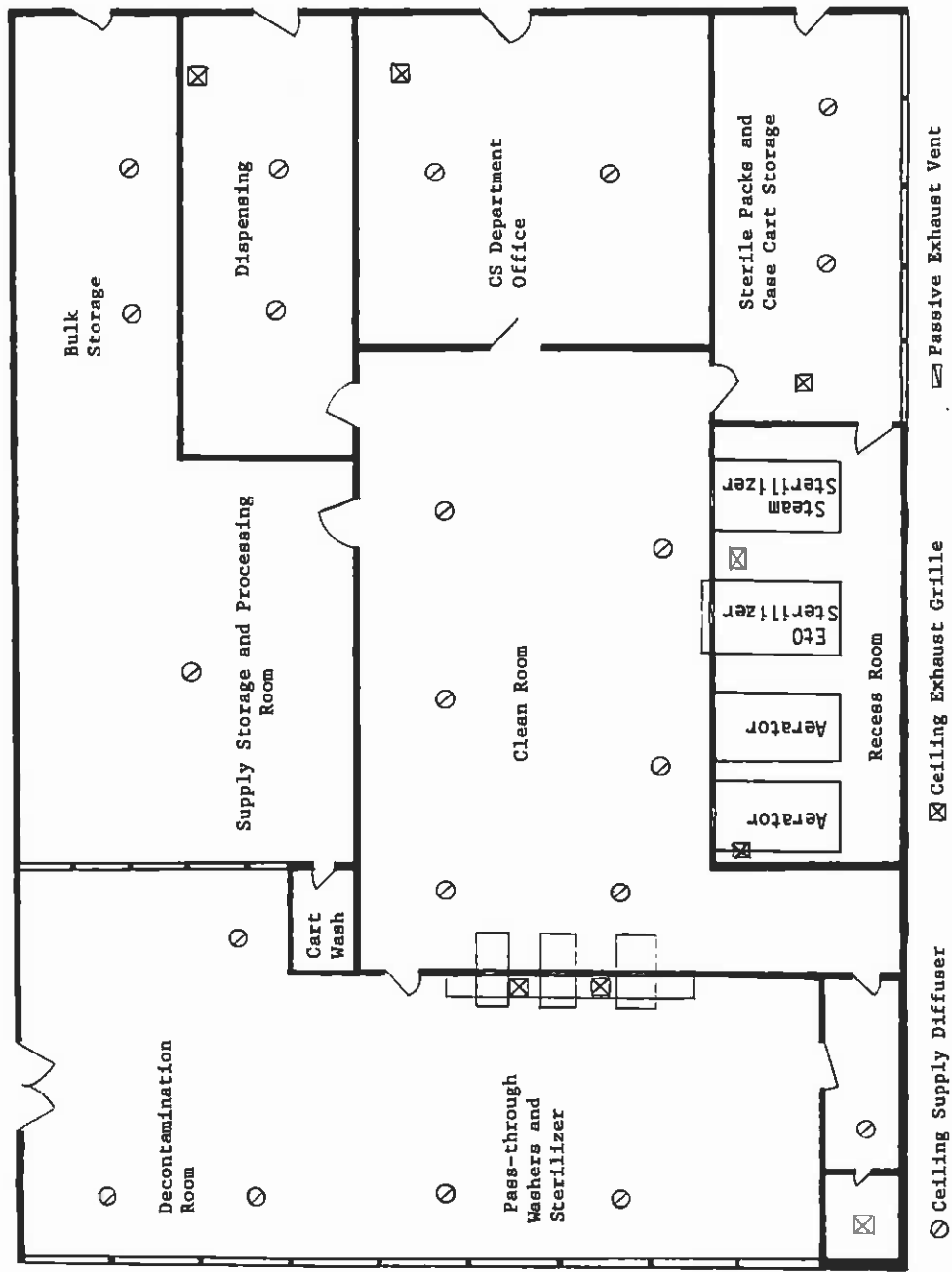


Figure 1. Central Service Department, Bronson Methodist Hospital.

PROCESS DESCRIPTION

The CS Department sterilizes medical supplies, some surgical instruments and other equipment. Metal instruments and other items which can be steam sterilized are delivered to the decontamination room in covered or enclosed carts. These items are washed and enter the preparation/packaging area of the clean room by cart through a doorway between the rooms or through a pass-through washer. The items are dried, wrapped and packaged for terminal sterilization. Wrapped items are loaded onto carts in the processing area of the clean room and steam sterilized. The sterile items are either stored or delivered to the using department.

Heat- or moisture-sensitive items must be sterilized with EtO gas. These items arrive in decontamination in enclosed carts delivered to the door by the using department, or picked up in the using department by CS personnel. The items are washed, dried, and either carted or carried into the preparation/packaging area of the clean room. Very small items are hand cleaned and treated with ultrasonics before passing into the clean room. The items may then be wrapped or heat-sealed in a peel-pak and carried to a table in front of the sterilizer bank. The sterilizer operator prepares the load for sterilization by arranging the items on a cart-rack, placing a biological indicator in the load, and completing the necessary record forms. The cart-rack is placed in the sterilizer, and the cycle is started at approximately 1700 daily. If there are only a few items for EtO sterilization or in the event of an equipment malfunction (in either CS or Surgery), the CS Department may consolidate its load with Surgery's load, and only one load is run between the two departments.

The EtO gas sterilizer is an AMSCO (American Sterilizer Company) Medallion, Cryotherm. Its internal chamber size is 24 inches by 36 inches by 60 inches, a volume of approximately 30 cubic feet. The cycle is 2 1/2 hours duration, and consists of several phases: initial vacuum and humidification, EtO charging of the chamber, dwell period, and two chamber evacuations.

At the end of the second evacuation, a buzzer sounds alerting the operator that the cycle is complete and the door may be opened. The operator turns the door handle so that the door will swing open when the pressure is released. Next the aerator door is opened, and the operator uses a heavy towel to protect the hand during contact with the cart. The sterilizer door is swung fully open, and the operator pushes the cart into the chamber, engages the cart-rack, and withdraws the cart-rack and cart. The sterilizer door is closed as the cart is pulled to the aerator. The operator then removes the biological indicator from the load, and pushes the cart inside the aerator chamber. The cart-rack is disengaged and the cart withdrawn. The aerator door is closed and aeration times are taped to the outside of the door. The biological indicators are opened at the work table, then taken to the microbiology laboratory for incubation and analysis.

The two aerators are AMSCO models with internal dimensions 2 feet by 3 feet by 5 feet, a volume of approximately 30 cubic feet. All items are aerated at 120° F for a minimum 12 hours. Certain items may require up to 72 hours aeration time and are treated as specified by the manufacturer. In loading the aerators, the aerator adjacent to the sterilizer is filled first and the second aerator is used for overflow and for items requiring longer than 12 hours aeration time.

The EtO sterilizer is supplied with gas from a compressed gas cylinder. If a cylinder empties during a cycle and an insufficient amount of EtO is supplied to the sterilizer, the cycle is interrupted. A new cylinder is needed about every 3 weeks. When a new cylinder is needed, the Central Distribution delivers one to the department, and a person from maintenance connects the new cylinder.

POTENTIAL HAZARDS, EXPOSURE GUIDELINES, AND EXPOSURE SOURCES

Workers exposed to EtO may experience both acute and long-term health effects. EtO is a central nervous system depressant, and in air can cause acute irritation to the eyes, upper respiratory tract, and skin at concentrations of several hundred to 1,000 ppm. Exposure to high concentrations may also cause headache, dizziness, nausea, and vomiting. Dilute (1 percent) aqueous solutions can cause blistering of human skin after prolonged contact, and allergic sensitization can also occur in some individuals.

NIOSH has conducted animal toxicity studies to determine the possible long-term health effects of EtO exposure. The results of the NIOSH studies support the conclusions of other researchers that EtO is a mutagen and a carcinogen in animals. The studies showed an increase in sister chromatid exchanges and in chromosomal aberrations, evidence of mutagenic activity. The studies also showed an increase in the frequency of leukemia, peritoneal mesotheliomas, and cerebral gliomas. Adverse reproductive effects were also observed.

The potential of EtO to cause mutagenic activity in humans has been examined by a number of investigators. The studies were conducted by examining blood lymphocyte cultures obtained from workers exposed to EtO in a variety of occupational settings. The results clearly demonstrate that EtO adversely affects human genetic material.

Epidemiologic studies of humans occupationally exposed to EtO, show an increase in the frequency of leukemia and other malignant tumors. Taken along with the results of the animal studies, EtO must be considered a potential human carcinogen.

In addition to the OSHA PEL of 1 ppm, the standard mentions an action level of 0.5 ppm, above which semi-annual monitoring is required. The American Conference of Governmental Industrial Hygienists has also adopted 1 ppm as an 8-hour time-weighted average Threshold Limit Value (TLV); however, they have allowed for an excursion limit such that short-term exposures should exceed 3 ppm no more than 30 minutes during a workshift and should never

exceed 5 ppm. In its testimony to OSHA on the new standard, NIOSH recommended that a ceiling limit of 5 ppm not be achieved for more than 10 minutes in a workday, and that the 8-hr PEL be set lower than 0.1 ppm to reduce the risk of occupational mortality to the greatest extent possible.

PRIMARY EXPOSURE SOURCES

Hospital central service personnel may be exposed to EtO from several sources. Each source contributes to the ambient concentration of EtO but three may be directly responsible for most of the exposure on a daily basis.

Uncontrolled Drain

During the evacuation phase of the sterilization cycle, most of the EtO in the sterilization chamber is removed through the vacuum pump and drain. For sterilizers which evacuate to an uncontrolled drain, much of the EtO used in sterilization may be released into the recess room and/or perhaps to the workroom atmosphere.

Opening of the Sterilizer Door

In some situations, the most significant EtO emission source on a daily basis is the opening of the sterilizer door at the end of the sterilization cycle. In an uncontrolled system, warm, moist, EtO-laden air escapes from the sterilizer when the door is opened and may diffuse throughout the room. This source of EtO may release a significant quantity of EtO into the workroom air as a background concentration, and, depending on the work practices, may or may not provide a peak exposure for the sterilizer operator.

Transferring the Sterilized Load

Some of the EtO used in sterilization remains on the sterile items and wrapping material and inside the package after the sterilization cycle is complete. This EtO will be given off exponentially until equilibrium is reached with the surrounding air; and, depending on the composition of the items and their packaging, these off-gassing items can provide a significant EtO exposure source for the operator transferring the load to the aerator and contribute to the background levels of EtO in the workplace.

SECONDARY EXPOSURE SOURCES

Other exposure sources may not be as readily apparent, but may also provide important contributions to the background levels of EtO in the workroom air. Some of these sources may only intermittently release EtO.

Aeration

Post-sterilization aeration is essential for protection of the patients who will use the items and for controlling occupational exposure to EtO. While in the aerator the sterile items continue to off-gas. If the aerator cabinet is not vented out of the building or to a dedicated exhaust, it can become a major contributor to the background EtO levels.

Replacement of EtO Gas Cylinders

Ethylene oxide gas is supplied to many sterilizers from pressurized gas cylinders. When replacing empty EtO cylinders, the worker may be exposed to EtO vapors from residual liquid or gaseous EtO in the supply lines. This may permit worker exposure to the EtO and may contribute to background EtO concentration levels; however, cylinder changes are not usually performed on a daily basis.

Pressure Relief Valve

Another possible source of EtO is the sterilizer safety valve. If the sterilizer becomes overpressurized during the cycle, this emergency relief valve releases EtO gas. If not controlled or remotely vented, this release may contribute a significant quantity of EtO to the workplace atmosphere.

Maintenance

Sterilizer part failures, maintenance operations, and repair work can also result in significant exposures to personnel. Of particular concern are plastic and rubber components which will absorb EtO and may even react with the gas; these parts can deteriorate over time. Valves, connections, and the front door gasket are potential sources of leaks, and occasional exposure. Maintenance personnel may be exposed by unknowingly entering the recess room to work on equipment when EtO concentrations are high during or following a purge cycle.

CONTROLS

PRINCIPLES OF CONTROL

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, work practices, personal protection, and monitoring. These principles may be applied at or near the hazard source, to the general workplace environment, or at the point of occupational exposure to individuals. Controls applied at the source of the hazard, including engineering measures (material substitution, process and equipment modification, isolation or automation, local ventilation) and work practices, are generally the preferred and most effective means of control in terms of both occupational and environmental concerns. Controls which may be applied to hazards that have escaped into the workplace environment include dilution ventilation, dust suppression, and housekeeping. Control measures may also be applied near individual workers, including the use of remote control rooms, isolation booths, supplied-air cabs, work practices, and personal protective equipment.

In general, a system comprised of more than one of the above control measures may be required to provide worker protection under normal operating conditions and also under conditions of process upset, failure and/or maintenance. Process and workplace monitoring, personal exposure monitoring, and medical monitoring may be used to provide feedback concerning the effectiveness of the controls in use. The maintenance of equipment and controls to insure proper operating conditions and the education of and the commitment from both workers and management concerning occupational health are also important ingredients of a complete, effective, and durable control system.

Not all principles apply to all situations, and their optimal application varies from case to case. The application of these principles are discussed below.

ENGINEERING CONTROLS

Isolation

Isolating workers from potential exposure sources can be a very effective method of control. Workers may be isolated by distance, physical barriers, and time. The CS Department workers are isolated from the sterilizer by a physical barrier, and to a lesser degree, by time.

The EtO sterilizer is recessed into a room and the drain and mechanical components of the sterilizer are separated from the clean room by a concrete wall. Only the door and control panel of the sterilizer are in the clean room. The recess room is under negative pressure with respect to the clean room and acts as an exhaust plenum for gases and vapors escaping at the drain and any release of EtO from the sterilizer safety valve. A sign on the door of the recess room alerts workers of the presence of EtO and labels it "hazardous" and a "potential carcinogen." Only persons authorized by the CS manager or maintenance may enter. Maintenance policy requires that the recess room may not be entered if the sterilizer cycle is in the exhaust

phase, and that exhaust systems for the recess room and local exhaust systems for the sterilizer should be verified operational before entering. Workers on the day and night shifts do not routinely process an EtO load. These time constraints serve to isolate some of the workers from potential EtO exposure.

Local Exhaust Ventilation

Local exhaust ventilation (LEV) controls EtO emissions at their sources. This system includes an exhaust hood above the sterilizer, exhaust vents over the bank of sterilizers, and exhaust hoods at the drain, at the safety relief valve, at the aerator, and near the EtO cylinders.

An engineering firm designed and installed an exhaust hood over the EtO sterilizer in 1981. This hood is constructed of sheet metal and measures 14 inches by 40 inches by 14 inches. Exhaust is provided by a rectangular vent in the wall, located inside the hood and measuring 6 1/2 inches by 22 inches. The vent is connected to the dedicated system which exhausts the recess room. The hood is located about 18 inches above the sterilizer door. The hood is designed to capture EtO laden air rising as the sterilizer door is opened after the completion of the cycle. Hood face velocity is estimated to be 250 ft/min.

Additional local exhaust is provided by two, 6 1/2 inch by 22 inch, louvered vents located about 14 inches above the tops of the steam sterilizer and aerator along the wall. These vents are passive and open to the recess room. Air flows from above the sterilizers into the recess room are due to the negative pressure developed in the recess room by exhaust ventilation. One vent is located over the steam sterilizer and one vent is over the second aerator. These vents serve to exhaust EtO and very hot air from the steam sterilizer into the recess room.

Local exhaust ventilation is also provided for the sterilizer drain. When the sterilizer chamber is evacuated, a mixture of water and EtO passes through the vacuum pump and into a drain. There the water and gas may separate, and if uncontrolled, the gases escape to the recess room atmosphere. The hospital designed and installed a drain enclosure and connected the enclosure to the dedicated exhaust system to control emissions from this source. The sterilizer safety relief valve is also exhausted through a duct connected to the same dedicated system.

Both aerators are vented to the dedicated exhaust system. This control provides exhaust for the EtO off-gassing from the sterilized goods in the aerator.

EtO supply cylinders are chained to the wall alongside the sterilizer in the recess room. Local exhaust ventilation provided at this location is designed to exhaust any EtO which might escape during a cylinder change operation or in the event of a leaky cylinder connection. The exhaust is part of an auxiliary dedicated system which can be manually activated during a cylinder change operation.

During the exhaust phase of the sterilizer cycle, EtO levels in the recess room may become elevated. An auxiliary dedicated exhaust system (installed in 1984) is activated by an EtO sensor when the concentration exceeds 20 ppm. Intakes for this exhaust system are located at the floor, near the sterilizer drain and near the EtO supply cylinders.

General Exhaust Ventilation

The decontamination room is supplied by five air diffusers. Exhaust grilles are located over the pass-through washers, inside a canopy hood. Passive exhaust vents in the wall between the decontamination room and the clean room are also located over the pass-through washers. The decontamination room is under positive pressure with respect to the hallways and the clean room. Doors between the decontamination room and the preparation/packaging area of the clean room are closed at all times.

The clean room has six supply air diffusers. Exhaust is provided by the louvered vents over the steam sterilizer and aerator and the local exhaust ventilation for the EtO sterilizer. The room is under positive pressure relative to the recess room and the surrounding hallways. Air movement patterns defined using smoke tubes, indicated little air exchange through the two open doorways between the dispensing and storage rooms and the clean room. Lack of apparent air movement would not affect the diffusion of EtO from the sterilizer area to these rooms.

The recess room is exhausted by a dedicated system and is under strongly negative pressure with respect to the clean room and adjacent hallways. The dedicated system was installed in 1976, and reportedly provides 18 to 20 room air changes per hour.

Preventative Maintenance

The CS Department has a preventive maintenance contract with MidWest Medical Company for routine quarterly evaluations. The maintenance protocol specifies the evaluation of the EtO sterilizer and aerators for mechanical function and leak testing. The service person also inspects the sterilizer door gasket and replaces it as needed. The EtO cylinders, supply lines, drain pipes, and floor drain are regularly leak-tested. Any necessary repairs are made immediately. Hospital maintenance personnel are also trained to provide some service functions for the sterilizer and are the first ones notified if the equipment malfunctions or leaks are suspected.

WORK PRACTICES

Work practices may have an important effect on the potential exposure an employee may receive. Work practices for EtO handling and sterilizer operation are specified in a procedure/policy manual. Hazard information and sterilizer operation instructions are posted beside the sterilizer.

An important work practice which may limit the operator's exposure to EtO, is the immediate removal of the load from the sterilizer upon completion of the cycle. Any delay in opening the door and transferring the load allows the

items to off-gas and EtO concentration levels to build up in the chamber. If the load transfer is delayed, the operator opens the door six inches and all employees leave the room for 20 minutes to allow EtO in the chamber to escape and be exhausted by the hood above the sterilizer before transferring the load. The sterilizer operator is instructed not to breathe deeply or unnecessarily when transferring the load from the sterilizer to the aerator.

Employee education on the hazards of EtO exposure and its proper handling is an important part of the department's control program. New employees are given on the job training. The CS manager provides an in-service program every 3 months. The maintenance personnel on both evening and the night shift are trained to change EtO cylinders for the department and are also provided with instruction on EtO hazards and safe handling.

PERSONAL PROTECTIVE EQUIPMENT

Employees are encouraged to wear protective cotton gloves or use a towel to prevent contact with the items when transferring a load from the sterilizer to the aerator. After being used for one transfer procedure, the gloves or towel are also placed in the aerator with the load.

Maintenance personnel have special protective clothing and air supplied respirators for use during an emergency spill or leak situation.

MONITORING

The CS monitoring program has three components: continuous monitoring with an alarm system, environmental area monitoring performed by maintenance, and personal monitoring.

In 1984, three monitoring sensors were installed in the department: one in the recess room near the sterilizer, one on the wall over the sterilizer door, and one over the work table in front of the sterilizers. The sensors and alarm system are manufactured by Gas Tech (model 1565-6). The alarm station is mounted on the wall at the end of the bank of sterilizers, about 10 feet from the EtO unit. When EtO concentration levels reach 20 ppm an audible and visual alarm is triggered. If levels reach 50 ppm the audible alarm becomes continuous. Each of the sensors is on a separate alarm indicator so that the worker can identify which location has triggered the alarm. During the exhaust phase of the sterilizer cycle, the sensor in the recess room is routinely triggered at the 20 ppm level. Workers have been instructed to evacuate the area and to notify maintenance if the sensor in the employee work area is activated and no causitive agent (such as alcohol or cleaning agents) is in use in the area. The department policy manual instructs workers to leave the department if the alarms remain activated for an "unreasonable" length of time.

Environmental area monitoring was performed by the CS manager initially in 1981. Maintenance personnel have been trained and now perform monitoring for the department every six months. Monitoring is also performed whenever there is a change in the system or if any leaks are suspected. Monitoring is performed with an infrared analyzer.

Personal monitoring is performed for the sterilizer operator quarterly using passive diffusion badges. Monitoring conducted in May 1984 indicated the operator's 8-hour TWA exposure was less than 0.1 ppm.

RECOMMENDATIONS AND CONCLUSIONS

Findings of this preliminary survey indicate the Central Service Department has instituted engineering control technology for minimizing employee exposure to EtO and has developed a comprehensive program to protect its employees. Local exhaust ventilation has been provided in critical areas. The auxiliary exhaust system activated by the EtO sensors is especially interesting. However, without sampling results and ventilation measurements, no estimation of the effectiveness of these controls can be made.

Proper work practices for employees are outlined in a procedure and policy manual, and, based on observation of the transfer of a load from the sterilizer to the aerator, the operator follows those procedures. The department manager provides education and training on proper work practices and the hazards of exposure to EtO.

The use of the continuous EtO monitor and alarm system can provide a valuable warning for the workers if a severe leak or emergency situation should arise. At the present time, the OSHA standard does not include a short term exposure limit (STEL). The agency is considering adding that provision to the standard sometime in the future. In that case, a sensor located over the sterilizer should respond to EtO levels appropriate for the STEL. This sensor would then provide an immediate indication if the STEL for the sterilizer operator is exceeded. NIOSH and ACGIH recommend a ceiling limit of 5 ppm, and ACGIH also recommends an excursion limit of 3 ppm.

Based on the preliminary survey, the CS Department appears to have a sound program for EtO control. Bronson Methodist Hospital is a candidate for an in-depth survey in NIOSH's study of control technology for ethylene oxide sterilization in hospitals.