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I. SUMMARY

On August 11, 1987, the National Institute for Occupational Safety and Health (NIOSH) received a request for a NIOSH Health Hazard Evaluation at the Keebler Company Bakery, Atlanta, Georgia. The Bakery, Confectionery, and Tobacco Workers (BCTW) Union, Local 42 wanted NIOSH to investigate a suspected excess of cancer among current and former workers at the bakery. Other concerns noted were the handling of raw materials in the mixing department, and various exposures to heated packaging products on the production lines.

On September 29-30, 1987, NIOSH investigators conducted an initial survey at the plant. NIOSH medical investigators abstracted personnel and medical records to evaluate a possible association between working at the bakery and the occurrence of cancer by means of a standardized morbidity ratio (SMR) study. During a walk- through survey of the bakery, workers expressed concern about the condition of the insulation on one of the baking ovens. Subsequent analysis of this material by both NIOSH and the company confirmed that the insulation contained asbestos. The company had the oven removed by an asbestos removal contractor during the first week of December 1987. Samples of hot-melt adhesives used to seal shipping cartons were also analyzed by NIOSH to identify volatile emissions released from these products when heated.

To address the remaining potential exposure concerns, a follow-up environmental survey was conducted on April 21-22, 1988. The follow-up survey involved: (1) airborne and settled dust sampling for asbestos in the Line No. 3 oven area and "old proofing room," (2) personal breathing zone, and area air sampling for acetaldehyde and formaldehyde near hot-melt glue vats, (3) personal and area air sampling to identify and quantitate shrink-wrap machine emissions, (4) air sampling to evaluate personal exposures to airborne dusts in the third floor mixing area, and (5) ammonia exposure monitoring during mixing and scaling operations on the second floor mixing area.

No asbestos fibers were detected in either settled dusts or airborne dusts in the two areas monitored. Trace levels of formaldehyde and acetaldehyde were detected in one of the heated hot-melt adhesives, but follow-up air monitoring detected only normal background levels (about 0.02 parts per million [ppm]) for these two compounds. Gas chromatograph/mass spectrometry (GC/MS) analysis of shrink-wrap film emissions detected trace amounts of toluene, limonene, and a mixture of other volatile organics including various C_9-C_{12} hydrocarbons, small amounts of acetone, methyl ethyl ketone (MEK), hexanes, isooctane, 1-methoxy-2- propanol, methyl isobutyl ketone (MIBK), propyl acetate, and

ethanol. Results from area and personal sampling of these emissions showed that the combined airborne concentrations of these volatile organic emissions were below the selected evaluation criterion of 5 milligrams per cubic meter (mg/m^3) for "polymeric fume" at the time of the survey. One worker dumping graham flour in the third floor mixing area was exposed, during a one-hour period, to 17.1 mg/m^3 of airborne flour dust. Three other exposures to flour dusts or other raw materials, sampled for up to four hours in this area, ranged from 0.9 to 4.2 mg/m^3. Ammonia exposures monitored by means of real-time direct reading instruments found 5-minute short-term exposures ranging from 15 to 39 ppm. The highest 15-minute exposure to ammonia was 32 ppm. These exposures were below the NIOSH recommended 5-minute exposure limit of 50 ppm, and also below the ACGIH 15-minute STEL of 35 ppm.

The medical investigation, using medical clinic records, and union- and management-provided lists, identified 24 cases of cancer occurring since January 1974. This is compared with 25.1 deaths expected (Standard Morbidity Ratio = 96), derived by applying the rate of the general population of metropolitan Atlanta (Surveillance, Epidemiology, and End Results [SEER] program data) to the person-years-at-risk experienced by the personnel of the plant. There was no statistically significant increase in the overall SMR for any age group, nor was there an elevated SMR for lung cancer (SMR = 56), which was of particular concern since one of the potential exposures at the plant was asbestos.

Based on exposure monitoring results, and an extensive review of the Material Safety Data Sheet (MSDS) files maintained by the Keebler Atlanta Bakery, no worker exposures to potential carcinogens were found during this survey. All other potential exposures monitored in response to worker concerns were below the NIOSH evaluation criteria. The potentially hazardous exposures to asbestos containing insulation from the oven on Line No. 3 were eliminated by Keebler's prompt action to have this oven dismantled and removed from the plant. There was no evidence of an increased incidence of lung cancer, or cancer in general, among Keebler employees. Recommendations for monitoring and controlling exposures in the Mixing Department, and for medical surveillance of workers who may have been previously exposed to asbestos are contained in Section VIII of this report.

KEYWORDS: SIC 2052 (Bakery products, dry), ammonia, formaldehyde, acetaldehyde, shrink-wrap emissions, flour dust, hot-melt adhesives, asbestos, cancer

II. INTRODUCTION

NIOSH conducted this health hazard evaluation in response to a request from an authorized representative of Local 42, Bakery, Confectionery, and Tobacco Workers (BCTW) Union. The requester had asked NIOSH to investigate cancer mortality and morbidity among current or former workers at Keebler's Atlanta Bakery. Other specific areas of concern included:

1. potential exposures to raw materials and chemicals handled and added to the product by workers assigned to the Mixing Department, and the potential for exposures to toxic substances from these materials or chemicals during baking;
2. the area previously used for the "proofing room" where pipe or ceiling insulation may have contained asbestos;
3. the potential for exposures to airborne contaminants or carcinogens through inhalation or through direct handling of the product; and
4. the potential for release of contaminants or carcinogens from heating of plastic film on over-wrap or shrink-wrap machines, and from heating of hot-melt adhesives.

On September 29-30, 1987, NIOSH investigators conducted an initial survey at the plant. An opening conference was held with management and employee representatives to discuss the purpose and scope of the NIOSH evaluation. Following the opening conference, the NIOSH investigators conducted a walk-through survey of the plant. Employee representatives accompanied the investigators to identify the production areas and processes of greatest concern to the employees. Bulk samples of insulation material from a baking oven, and two samples of hot-melt glue were collected for laboratory analysis. The NIOSH medical investigators reviewed personnel records to obtain demographic data on all terminated and current employees. An interim report summarizing the preliminary initial survey results was submitted to Keebler management and BCTW representatives on October 26, 1987. On November 16, 1987, NIOSH investigators notified Keebler and BCTW representatives that the insulation material collected by NIOSH during the initial survey had been analyzed and was found to contain asbestos, ranging from 20-95% amosite and 5-15% chrysotile. Concurrent sampling and analysis of bulk samples collected by Keebler had confirmed the NIOSH findings. The company took immediate action to have the oven removed from the plant by an asbestos removal contractor. The oven was removed during the first week of December 1987. On March 9, 1988, a NIOSH industrial hygiene investigator made another walk-through survey of the production lines to observe changes that had been made to the plant since the oven on Line No. 3 had been removed. A follow-up environmental survey was completed on April 21-22, 1988. No follow-up medical survey was required.

III. BACKGROUND

The Atlanta Bakery, formerly owned by Sunshine Bakeries, was built in 1954 to produce potato chips and roasted peanuts. The Keebler Company acquired the bakery in January 1974 to produce and distribute their cookie and cracker products, mostly for food service industries and vending services. When the NIOSH investigators conducted the first site visit, the bakery employed about 340 production workers. Forty employees were assigned to administrative or supervisory functions. The plant operated three shifts per day, five days a week, with weekends reserved for maintenance and sanitation activities.

At the time of the NIOSH survey the plant operated four production lines. There were two cracker lines (No. 2 and 3) and one cookie line (No. 1). Line No. 4 was running a new product being test marketed by the Kelloggs Company. The major production operations were receiving, mixing, machining, baking, packaging, and shipping.

In the receiving area, flour is off-loaded from trucks (4-5 trucks per day), and sugar is dispensed from rail cars. Four silos are used for storing flour, and one silo holds the sugar. Fats are off-loaded from rail cars and stored in the oil room located in the basement of the bakery building. Flour and sugar are pumped through the "green room", and from there to the Mixing Department.

In the Mixing Department, flour, sugar, fats, and other raw materials are mixed to form the dough. Four mixer machines (one for each baking line) are located on the second floor. Flour, sugar, and fats are dispensed directly into the mixer, but the Mixing Department workers must manually blend and dispense small amounts of other raw materials such as salt, baking soda (sodium bicarbonate), ammonium bicarbonate, leavenings (acid leavening blend containing disodium pyrophosphate), enzymes, sodium sulfite, and other flavorings and colorings. During the walk-through survey, a moderately strong odor of ammonia was noted in the second-floor mixing area. On the third floor of the Mixing Department, raw materials are reworked back into the product. Workers complained about dust in this area when performing some of these tasks.

After it is mixed, the dough is dumped from the mixer into a hopper that discharges the dough down to the first-floor "Machining Area." Here the dough is shaped, lapped, and rolled into a continuous sheet. Cookies or crackers are shaped and cut from the dough sheet by passing the sheet through a rotary cutter. Dough trimmings are removed from the conveyer, and the cookies or crackers pass through the ovens. After leaving the ovens, the products travel, via a cooling conveyor, to the packaging area where they are wrapped and heat-sealed in plastic film packaging. On lines running cream-filled cookies and crackers, the fillings are dispensed and sandwiched between the baked products just before packaging. The plastic wrapped products are then cased in cardboard boxes. In the "casing" area, the tops and bottoms of the cardboard boxes are glued together with hot-melt adhesives. The sealed boxes are then conveyed to the shipping warehouse, where they are stacked and stored to await shipment.

During the walk-through survey, several workers asked about the risks from breathing fumes and vapors released from the hot-melt glue vats, and from the machines used to heat and seal the plastic packaging films. Of particular interest to the workers was the newly installed shrink-wrap equipment on Line No. 2. Although the shrink-wrap oven was local exhaust ventilated, the unvented cutter bar emitted a small amount of visible plastic fume into the work area.

IV. EVALUATION DESIGN AND METHODS

A. Initial Survey

1. Environmental

As a first step in evaluating worker concerns about possible exposures to airborne contaminants or potential carcinogens, the NIOSH industrial hygienist extensively reviewed Keebler's Material Safety Data Sheet (MSDS) files that they had compiled to comply with the Occupational Safety and Health Administration (OSHA) "Hazard Communications Standard" (29 CFR 1910.1200). A listing was prepared of all the materials or chemicals used as raw materials for food products, or used during production of those products. A partial list of the more toxic materials used by maintenance personnel, or used by workers involved with sanitation jobs, was also prepared from the complete list of materials used for these tasks. A copy of the MSDS was obtained for all compounds believed to require additional review by the NIOSH industrial hygienist.

Because of employee concerns about the insulation on the No. 3 oven, bulk samples were collected and analyzed for asbestos by the NIOSH laboratory. The oven insulation consisted of an inner and outer layer of white plaster-like material, and a middle layer of loose fibrous material. A sample from each of the three layers of insulation material was analyzed. The NIOSH industrial hygienist also obtained a sample from a patch in the oven insulation where a viewing window had previously been located. Also sampled was a pile of loose fibrous material that had collected on a ledge running alongside the oven's outer wall.

Two samples of hot melt adhesive (Swifts 80625 and Instant-Lok 34-2887) were taken from their shipping cartons. In the NIOSH laboratory, the adhesive samples were melted to their normal-use temperature of 350° F and analyzed by gas chromatography-mass spectrometry (GC/MS) to identify any organic vapors released.

Photographs were taken of all production processes, which included receiving, mixing, machining, baking, packaging, and shipping. At the request of the employee representatives, specific attention was directed to the shrink-wrap machines on Line No. 2.

2. Medical

The NIOSH medical investigators interviewed management, medical personnel, and union representatives; and reviewed the OSHA 200 logs, personnel records, and selected medical records. The purpose of the medical interviews was to investigate more thoroughly the adverse health effects reported by employees and management, and to identify which substances, processes, and areas of the workplace were of concern.

To estimate the standardized morbidity ratio (SMR) for cancer experienced by the employees at Keebler's Atlanta Bakery, it was necessary to obtain estimates of both the numerator (number of cancer cases) and the denominator (number of person-years at risk for workers at this plant). The number of persons thought to have cancer was obtained from interviews with the medical clinic nurse, union, and management personnel. The individuals interviewed were confident that they had identified the majority, if not all, of former and current employees who had ever been diagnosed with cancer. Histologic confirmation was not sought for these cases; therefore, it is possible that some persons were misclassified as having cancer.

To estimate the number of person-years, company employment records were reviewed. Employment records used were provided in two forms: (1) a computer listing of all current hourly and salaried employees, and (2) a summary employment history card. Abstracted from these two sources were the employees' name, social security number, gender, date of birth, date of hire, date of termination, and race. Date of termination for current employees was recorded as 9/21/87, the end date of the study. These data were entered into the NIOSH Life Table Analysis System for tabulation of the number of person-years experienced at the Atlanta facility.

Although all person-years beginning with the acquisition of the plant in December 1974 were considered, only person-years accrued after 5 years of employment were counted in the final number. This was done because it usually takes at least 5 years for cancer to develop after exposure has first occurred. The resulting person-years were then stratified by 5-year age groups.

The comparison incidence rate of cancer in a general (non-exposed) population was obtained from the Surveillance, Epidemiology, and End Results (SEER) Program. This program is a continuing project of the National Cancer Institute (NCI). Data on demographic characteristics of the patient, anatomic site, histologic cell type, and extent of disease at the time of diagnosis are collected. These data are collected based on the general population for ten areas in the United States, including metropolitan Atlanta, Georgia. The metropolitan Atlanta annual incidence rates based on the years 1978-1981 rather than 1971-1974 were used to calculate the expected number of cases in this study population, since 1978-1981 falls in the middle of the study period.

Ideally, the age of an individual at the onset of his/her disease is used to determine the number of years-at-risk and incidence rates by age-group. However, this information was not available for the Keebler employees who were suspected of having cancer. Therefore, individuals were categorized into age-groups based upon their age at the time the study was conducted, unless the date of death or year of onset of disease was known.

B. Follow-up Environmental Survey Design

To assist with the development of a follow-up environmental protocol, a NIOSH industrial hygienist returned to the plant on March 9, 1988. Actions taken during this visit included: (1) a walk-through of the mixing, baking, and packaging operations; (2) measurements of ammonia concentrations in the Mixing Department using direct-reading detector tubes; (3) verification of the locations for all hot-melt glue vats on all production lines; and (4) examination of the new oven that had been installed on Line No. 3.

The bulk samples of hot-melt adhesives that had been analyzed by GC/MS to screen for potential carcinogenic components revealed that only one of the two brands of adhesives found in the plant during the initial NIOSH survey (Swifts 80625) contained aldehydes, with a formaldehyde and an acetaldehyde derivative being the largest single components identified. The other adhesive (National Instant-Loc), used only on Line No 4, contained only trace amounts of aldehydes. No other potential carcinogens were identified in either of the samples.

Detector tube readings taken in the 2nd-floor mixing area showed that ammonia concentrations were about 5 ppm, even when workers were not involved with scaling or mixer loading operations.

With the removal of the old oven from Line No. 3, the risk of exposure to asbestos insulation had been greatly reduced or eliminated. Workers who had worked on or near the old oven had been given "asbestos monitoring physicals" by a local occupational health clinic. Twenty-one workers, including mechanics, maintenance managers, and oven operators, were given baseline spirometry exams and chest x-rays. One worker, who was a smoker, had a restrictive pulmonary function pattern. Several of those tested were recommended for a follow-up examination in five years.

During the second walk-through survey, the new shrink-wrap machines gave off less visible emissions than during the initial NIOSH survey. According to the company safety officer, "operation procedures had been improved."

To address the remaining health concerns of the workers, a follow-up industrial hygiene survey was scheduled for April 21-22, 1988. With consideration given to changes that Keebler had made in production operations since the initial NIOSH visit, and based partly on preliminary sampling data that had been obtained or reviewed by the NIOSH investigators, the industrial hygiene evaluation involved:

(1) airborne and settled dust sampling for asbestos in the Line No. 3 oven area and in the "old proofing" room area where asbestos pipe lagging had been removed during an earlier asbestos removal project;

(2) personal and area air sampling for acetaldehyde and formaldehyde near hot-melt glue vats containing Swifts adhesive;

(3) personal and area air sampling to identify and quantitate shrink-wrap machine emissions;

(4) air sampling to evaluate personal exposures to airborne dusts on the 3rd floor of the Mixing Department; and

(5) ammonia exposure monitoring during mixing and scaling operations on the 2nd floor of the Mixing Department.

C. Air sampling and monitoring methods.

1. Asbestos

Both general area air samples and settled dust samples were collected in the oven area of Line No. 3, and in the area of the "old proofing room." Five air samples were collected using battery powered air sampling pumps operated at a flow rate of 4 liters of air per minute (Lpm). The samples were collected on 0.8 micron pore size, cellulose ester membrane filters, housed in 25 millimeter diameter open-face plastic cassettes. To collect each sample, a filter cassette was attached to a pump via plastic tubing, and a known volume of air was pulled through the filter.

Sampling times ranged from two to six hours. Settled dusts from these two areas were also collected by vacuuming several surfaces where dusts were likely to accumulate. The samples were vacuumed by attaching a filter cassette to a pump operated at maximum flow (about 5 Lpm). The open face of the filter cassette was moved back and fourth over a surface until dust accumulations on the filter could be observed.

The filters were analyzed for fiber content according to NIOSH Method 7400, Set A, utilizing phase contrast microscopy.[1] The NIOSH contract laboratory estimates a limit of detection for this method of 3000 fibers per filter. In addition to the standard fiber count, the laboratory also provided qualitative comments about the fibers observed on the filter samples.

2. Aldehydes from Hot-melt Adhesives

Three different methods were used to sample aldehydes near the hot-melt adhesive vats.

Personal sampling for formaldehyde was accomplished using the procedures described in NIOSH Method 2502.[1] The workers monitored included the Box Maker Operator and the Case Maker Operator on Line No. 1, and the Line No. 3 Oven Operator. Although no aldehyde exposures were likely for the No. 3 Oven Operator, this worker was sampled because the BCTW had previously expressed concerns about possible aldehyde exposures from products exiting the ovens. Personal samples for formaldehyde were collected on ORBO™ 22 solid sorbent tubes that were mounted in special tube holders which were clipped to the workers' shirt collar. The holders were connected, via plastic tubing, to battery powered air sampling pumps operated at a flow rate of 80 cubic centimeters (cc) per minute. The samples were analyzed by gas chromatography (GC) according to NIOSH Method 2502.[1] The detection limit for formaldehyde was 2 micrograms (ug) per sample.

The formaldehyde area samples were collected using midget impingers containing 20 mL of 1.0% sodium bisulfite solution. Battery powered air sampling pumps were used to bubble air through the impingers at a flow rate of 500 cc/minute. Two impingers connected in series were attached to the pump using plastic tubing. Sampling pumps and impingers were located on Line No 1. above the box making machine's hot-melt adhesive applicator, outside the box making machine enclosure, and on the back side of the case sealer machine enclosure opposite a control panel. After a known volume of air was pulled through the impingers, the solutions were transferred to Nalgene™ plastic bottles and sent to the laboratory for analysis by visible adsorption spectrophotometry according to NIOSH Method 3500.[1] The NIOSH contract laboratory estimated the limit of detection to be 0.03 ug per sample.

Personal and area air samples for acetaldehyde were collected on ORBO™-24 solid sorbent tubes (Lot 637-26). The samples were collected at the formaldehyde sampling locations described above. The holders containing the sorbent tubes were attached via plastic tubing to battery powered pumps operated at a flow rate of 50 cc/min. After pulling a known volume of air through the sampling tubes, they were capped and sent to the NIOSH laboratory for analysis. Using a method developed by the NIOSH laboratory, the tubes were desorbed with toluene and analyzed for acetaldehyde by GC using a 30-meter SPB-1 fused silica capillary column and a nitrogen-phosphorous detector. The limit of detection for this method was reported as 0.5 ug/sample.

3. Shrink-Wrap Machines Emissions

At the end of Line No. 2, individual boxes of Town House™ crackers were being shrink-wrapped in groups of six with polyethylene film. The process was fully automated. Both of the two shrink-wrap units were operating at the time of the survey.

Each unit consisted of a film wrapping machine and oven. The wrapping machine guided a sheet of plastic around the boxes, after which the film was heat sealed end-to-end, and cut from the supply roll. The loosely wrapped package of six boxes was then sent through an exhaust vented oven where the plastic wrap would shrink tightly around the package. Since the heat sealer equipment was the only source of visible fumes, air sampling devices were mounted directly over the heat sealer/cutter bar on each unit. The samples were collected on organic vapor-adsorbing activated charcoal tubes. The tube holders were attached via plastic tubing to battery powered air sampling pumps operated at a flow rate of 200 cc/min. To collect a personal sample, another air sampling device was also worn by the shrink-wrap machine operator.

After sampling was completed, the charcoal tubes were capped and sent to the NIOSH laboratory in Cincinnati for qualitative and quantitative analyses of organic compounds. The charcoal tubes were desorbed with carbon disulfide and screened by GC using a flame ionization detector. Since the chromatograms from each sample were similar, only one sample was further analyzed by GC/MS to identify individual organic compounds. Based on the GC/MS results, the largest individual components of the air samples were quantitated. The other air sample components were combined and quantitated (reported as total hydrocarbons) using decane as a standard. Thirty-meter DB-1 fused silica capillary columns were used for all GC analyses.

4. Dust Exposures in Third Floor Mixing Area

Four personal air samples were collected in the third floor mixing area to evaluate exposures to airborne dusts generated from manually dumping of raw materials into dough mixers. Although flour was normally dispensed into mixers from bulk delivery systems, certain products, such as the Old Fashion[tm] cookie mix, used a special graham flour which was being dumped by hand from 50 lb. sacks into chutes leading to the mixers on the floor below.

Another raw materials handling task taking place during the survey was the dumping of 50 lb. sacks of spray-dried pasteurized whey. The sacks were dumped into a bin from which whey was later scooped out and put in paper sacks. The whey was then dumped from the sacks into the mixer.

The air samples were collected on pre-weighed polyvinyl chloride filters having a pore size of five microns. The filters were mounted in 37 mm plastic cassettes attached with plastic tubing to battery powered air sampling pumps operated at a flow rate of 2 Lpm. The sampling equipment was worn by the workers dumping and scooping the raw materials. A filter cassette was placed in a worker's breathing zone by attaching the cassette to the shirt collar. The samples were later analyzed gravimetrically by the NIOSH contract laboratory for total dust by weighing the samples plus the filter on an electrobalance and subtracting the previously determined tare weights of the filters. Tare and gross weighings were done in duplicate. Based on the sensitivity of the electrobalance, the limit of detection for this procedure was about 0.01 mg/sample.

5. Ammonia Monitoring, Second Floor Mixing Department

To add volume to the products, granular ammonium bicarbonate was routinely added to each batch of dough being formulated and mixed. As a result, workers on the 2nd floor were normally exposed to ammonia. Instantaneous readings were made using Drager[tm] short-term detector tubes, and both personal and area monitoring were done using Drager[tm] long-term detector tubes to determine average ammonia levels during the work shift. The detector tubes contained a chemical which changed color in the presence of ammonia. As air was pulled through the tubes the length of the color change indicated the approximate concentration of ammonia. The air samples were drawn through the short-term tubes using a hand-operated bellows pump, and air was pulled through the long-term tubes using battery powered air sampling pumps operated at a flow rate of 20 cc/minute.

To determine if workers were exposed to ammonia above the NIOSH recommended exposure limit, "real-time" air monitoring was accomplished using a Foxboro Miran Model 103 Specific Vapor Analyzer equipped with a 10.4 micrometer interference filter, and a meter scale for measuring ammonia concentrations ranging from zero to 30 ppm. Both before and after sampling, the instrument was calibrated using a closed-loop calibration system. Known concentrations of ammonia gas were injected into the loop and meter responses were recorded. For continuous monitoring of ammonia levels, the analyzer was connected to a Metrosonics Model 332 data logger. Voltages produced by the analyzer (zero to one volt DC representing zero to full scale deflection of the meter) were recorded and stored by the data logger once each second. The data logger was programmed to store and report the minimum, average, and maximum readings detected by the analyzer during each five minute interval of the monitoring process.

Since the greatest risk for ammonia exposures were for the Mixer Operators during "scaling" operations (filling and weighing paper sacks with ammonium bicarbonate scooped from a supply bin), the probe of the Miran analyzer was placed as close as possible to the operator's breathing zone during scaling. For the operator running the Line No. 2 mixer, the probe was placed above the scale. During the 15-minute monitoring period, the operator scaled 29 batches (one 2 lb. sack per batch) which were to be added to the mixer during the next shift. For the No. 3 Mixer Operator the analyzer probe was clipped to the operator's shirt collar. The No. 3 Mixer Operator scaled one batch at a time (14 lbs. per batch). On the day of the survey the operator mixed about three batches per hour during the two-hour monitoring period.

V. EVALUATION CRITERIA

A. Environmental Criteria

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

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

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH criteria documents and recommendations, (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[2] and (3) the U.S. Department of Labor (OSHA) occupational safety and health standards.[3] Often, the NIOSH recommendations and ACGIH TLVs are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLVs usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended exposure limits (RELs), by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, employers should note that they are legally required to meet those levels specified by an OSHA standard.

For those compounds with established occupational exposure limits, the various criteria proposed by OSHA, ACGIH, and NIOSH for airborne concentrations of the chemical substances measured in this evaluation are listed in Table 1. A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

For the purposes of this evaluation, NIOSH has selected the most stringent exposure limits as our evaluation criteria. The major health effects anticipated for workers exposed above these evaluation criteria are summarized Table 1. A brief discussion of the toxicity for several of the substances evaluated during this survey is provided below.

1. Asbestos

Asbestos is a generic term applied to a group of hydrated mineral silicates including chrysotile, amosite, crocidolite, tremolite, anthophylite, and actinolite. It was used extensively for thermal and electrical insulation, for fireproofing, and in cement products. Excessive inhalation of asbestos dust was initially associated with asbestosis, a chronic lung disease characterized by a diffuse interstitial pulmonary fibrosis.[4] As a result of the fibrosis, the lungs are not able to adequately oxygenate the blood. The fibrosis also makes the lungs less compliant, requiring increased energy for breathing. Chest x-rays reveal a granular change usually beginning in the lower lung fields. Typically, there is a restrictive pulmonary function pattern.[5] Asbestos exposure has been shown to induce bronchogenic carcinoma and mesothelioma of the pleura and peritoneum. Excess cancer of the stomach, colon, and rectum have also been observed in exposure populations. These cancers usually appear many years after the initial contact with asbestos. The risk of cancer indicates that there may not be a "safe" level of exposure to asbestos. Mesothelioma is a relatively rare and rapidly fatal neoplasm seen chiefly in crocidolite workers. Mesothelioma can occur even after a short intensive exposure, and has been found in patients younger than 19 years of age.[4] Not all mesotheliomas result from asbestos exposure. The background level for naturally occurring mesotheliomas in persons 45 years and older has been estimated to be about ten in 1 million for males and about four in one million for females.[5] Cigarette smoking in combination with asbestos exposure greatly increases the risk of developing lung cancer. It has been estimated that cigarette-smoking asbestos workers have approximately 15 times the risk of getting lung cancer than non-smoking asbestos workers.[4]

2. Formaldehyde

Formaldehyde has a pungent odor that is usually noticeable at around 1 ppm, but may be detected by some individuals at concentrations as low as 0.05 ppm.[6] The most common symptoms of acute exposure are tingling, irritation, or burning of the eyes, nose, and throat. Different references cite various levels at which these irritant effects occur, ranging from 0.01 or 0.10 ppm up to 3 ppm.[6,7] Marked discomfort and lacrimation (watering eyes) occur at 4 to 5 ppm. At concentrations of 10-20 ppm, difficulty in breathing, severe burning of the nose, throat, and trachea, and coughing occur. At higher concentrations (the exact levels not known) heart palpitations, severe irritation of the bronchi and lower respiratory tract, pulmonary edema, pneumonitis, and death may result. Splashes of liquid may produce skin irritation and severe eye injury. Asthmatic symptoms such as wheezing may occur in persons with allergic sensitivity to formaldehyde gas.[8]

Most workers repeatedly exposed to low concentrations of formaldehyde during normal work periods seem to develop a physical tolerance to some of its irritant effects, and can work in concentrations that are intolerable to many outsiders.[4]

The chronic symptoms associated with repeated low-level exposures include itching eyes, dry or sore throat, disturbed sleep, and unusual thirst upon awakening. Dermatitis is a common chronic effect.[4] Primary skin irritation can result from exposure to liquid solutions on the skin and from airborne vapor exposure. Chronic exposure to formaldehyde solutions or to formaldehyde-containing resins may lead to allergic contact dermatitis. Exposure of the hands to formaldehyde may turn the fingernails soft and brownish. In experimental studies, formaldehyde exposure has produced nasal cancer in rats and mice.[9,10] Several studies of worker populations suggest that formaldehyde exposure may be associated with increased risk of cancer in humans.[10] These findings have prompted NIOSH to recommend that formaldehyde be considered a potential occupational carcinogen, and that occupational exposure be controlled to the lowest feasible concentration. Currently, NIOSH considers the lowest reliably quantifiable concentrations are (sampled and analyzed using the NIOSH designated analytical method) 0.016 ppm for an 8-hour sample, or 0.1 ppm for a 15-minute sample.[10]

3. Acetaldehyde

Acetaldehyde is an irritant of the eyes and mucous membranes. Human volunteers exposed to 50 ppm for 15 minutes experienced mild eye irritation. Sensitive subjects complained of mild upper respiratory irritation even after 15 minutes exposure at 25 ppm. The irritant effects of the vapor, such as cough or a burning sensation in the nose or throat, usually prevent exposures sufficient to cause central nervous system depression.[4] In 1985 the International Agency for Research on Cancer (IARC) concluded that "there is sufficient evidence for the carcinogenicity of acetaldehyde to experimental animals" and "inadequate evidence for the carcinogenicity of acetaldehyde in humans," which for the purpose of the OSHA Hazard Communications Standard would classify acetaldehyde as category 2B carcinogen.[11] The Environmental Protection Agency (EPA) considers acetaldehyde to be a probable human carcinogen.[12] NIOSH is currently considering developing a criteria document for acetaldehyde. The ACGIH TLV committee is currently reviewing data on acetaldehyde and its potential as an occupational carcinogen.[13]

4. VOCs from Heated Polyethylene Film

Low-density polyethylene films are commonly used for packaging. Heated or burning polyethylene may release toxic and irritating decomposition products. The principal decomposition products are carbon monoxide, acrolein, and formaldehyde. Many other products may be formed in small amounts. The fumes may cause lung irritation and, at very high levels, death. Pure polyethylene seems to be biologically inert and does not affect the body during normal exposure. Solid polyethylene (films, prosthetic devices, contraceptive devices) may have non-specific "irritating" effects when implanted into the body for prolonged periods. Some cases of dermatitis among workers heat-sealing polyethylene bags may be due to acrolein, formaldehyde and other chemicals released during the operation. Some additives in the polymer may creep to the surface of the plastic and cause irritant dermatitis following prolonged or repeated skin contact.[14] Polyethylene fumes are not considered carcinogenic by inhalation or ingestion.[15] Evolution of acrolein or formaldehyde from decomposition of polyethylene would not occur at temperatures below 250° C (482° F).[16] There is no established occupational exposure limit for polyethylene fumes or vapors, but a Material Safety Data Sheet (MSDS) from one of Keebler's suppliers of polyethylene film (Exxon Chemicals) recommended controlling exposures to "polymeric fume" emissions to less that 5 mg/m^3. The MSDS defined polymeric fumes as C_8-C_{20} paraffinic and olefinic hydrocarbons.

5. Flour Dust

Studies have shown that long-term exposures to airborne flour dust can increase the risk of developing pulmonary disorders. Results from a study of 520 bakers and millers who underwent a series of x-rays, allergic skin tests, and bronchial provocation tests showed that 45% had cough, 42% had sputum abnormalities, and 16% had shortness of breath. Wheezing and dyspnea were three times greater in persons with long occupational exposures. A bronchial provocation test on 47 asthmatics revealed an elevated reactivity to allergens in flour. Allergic skin testing revealed serum IgE antibodies to allergens of flour in 59% of the 54 workers with asthma or bronchitis.[17] In 1986, NIOSH evaluated a baking supply facility where two workers who weighed and loaded a large variety of fragances, flavorings, starch and 50 to 100 pound bags of flour into one of three mixers, had developed "catastrophic fixed airways disease" suggestive of bronchiolitis or emphysema. Their symptoms started within five to six months of starting work at the facility. Dust exposures previously measured were up to 20 mg/m^3.

The authors concluded that the workers' pulmonary problems may have been caused by a single short term exposure to a specific mix which they were unable to identify.[18] The term "Baker's Asthma" has been used to describe a form of industrial asthma arising from occupational exposure to flour dust. It is a reversible airway disease with prominent symptoms being wheezing, accompanied by cough and sputum.[19] There are no established exposure criteria for flour dust. However, in view of the potential for respiratory sensitization, it seems inappropriate to consider flour dust a nuisance particulate.

6. Ammonia

Ammonia is a colorless gas with a sharp, intensely irritating odor, perceptible at about 1 to 5 ppm. Complaints of respiratory tract irritation and discomfort begin at 20-25 ppm. Exposures for 5 minutes at 133 ppm causes nose and throat irritation, and symptoms of cornea irritation and tearing have been noted after 5 minutes of exposure at 134 ppm. At 700 ppm the vapor is immediately irritating. Tolerance to usually irritating concentrations of ammonia may be acquired for some workers after several weeks of exposure.[14] NIOSH has concluded that the irritating effects of ammonia are more dependent on the concentration than on the length of exposure. Therefore, NIOSH considers a TWA exposure limit for ammonia inappropriate, and recommends a 50 ppm exposure ceiling limit, measured over a 5-minute sampling period.[20] The ACGIH has judged that a TWA exposure limit should be maintained, but at a lower level. They have recommended an 8-hour TWA of 25 ppm to protect against irritation to eyes and respiratory tract and to minimize discomfort to workers infrequently exposed.[5] In a revision to the OSHA General Industry Standards, Subpart Z, which became effective March 1, 1989, OSHA has rejected the use of an 8-hour TWA exposure limit for ammonia, preferring to specify a 15-minute STEL for ammonia of 35 ppm. A STEL, by OSHA definition, is the employee's "15-minute time-weighted average exposure which shall not be exceeded at any time during a work day."[21]

VI. RESULTS AND DISCUSSION

A. Environmental

1. Asbestos

Using phase contrast microscopy (PCM) no fibers of any type were found in air samples collected in the Line No. 3 oven area. Airborne fibers, most likely cellulose, were detected at concentrations of less than 0.005 fibers per cubic centimeter of air in the area of the old proofing room. No fibers were found in any of the vacuumed settled dust samples. The sample locations and results are summarized in Table 2.

The EPA considers cleanup complete when clearance sampling, collected by PCM under aggressive air movement conditions, shows airborne fiber concentrations in the asbestos removal work area are below 0.01 fibers/cc.[22] The OSHA Construction Industry Standards, which apply to asbestos removal operations, permit release of the removal contractor if PCM sampling results for at least 4 samples for each 5000 square feet of enclosed area show asbestos concentrations are below 0.1 f/cc.[23]

2. Aldehydes from Hot Melt Adhesives

Although GC/MS analysis of a bulk sample of the Swifts 80625 adhesive confirmed the presence of formaldehyde and acetaldehyde, air sampling results showed that personal exposures to these aldehydes were either not-detectable or negligible for persons working near the hot-melt adhesive vats. Even air samples collected near or directly above the vats showed concentrations were barely above normal background levels (0.01-0.02 ppm).[24-26] No airborne formaldehyde exposure was detected for the Line No. 3 Oven Operator. Full results of the aldehyde sampling are presented in Table 3.

3. Shrink-Wrap Machine Emissions

The chromatogram obtained from the GC/MS analysis of the area air sample collected above the cutter bar on the north unit shrink-wrap machine is shown in Figure 1. The major component identified in all three samples collected was 1,1,1-trichloroethane (111T). Toluene, limonene, various C_9-C_{12} hydrocarbons similar to those found in mineral spirits were also present. Also found were small amounts of acetone, methyl ethyl ketone (MEK), hexanes, isooctane, 1-methoxy-2-propanol, methyl isobutyl ketone (MIBK), propyl acetate, and ethanol. The quantitative results for the larger components of the samples are presented in Table 4. The column in Table 4 identified as "Other VOCs" would include all the compounds identified in the samples generally falling in the MSDS's catagory of "polymeric fumes", that is, C_8-C_{20} paraffinic and olefinic hydrocarbons plus other specific additives. None of the measured air concentrations exceeded the NIOSH evaluation criteria for either individual components or for total polymeric fume as defined by the MSDS. Because 111T concentrations were not appreciably higher for the two area samples when compared to the personal sample, NIOSH investigators assumed the source of 111T was not the heated polyethylene film; therefore, the 111T levels were not included in the results shown in Table 4 as "Other VOCs."

Although aldehyde emissions such as formaldehyde or acrolein were not specifically evaluated, thermal sealing and cutting temperatures were maintained below 400° F. Aldehyde emissions would not be expected unless temperatures exceeded 480° F.[16]

4. Dust Exposures in Third Floor Mixing Area

Table 5 shows the monitoring results from personal sampling for raw materials dusts on the third floor of the Mixing Department. Although not a full shift exposure, one worker's one-hour average exposure to flour dust was 17.1 mg/m^3. Work practices were not continuously observed when this sample was taken, but this same worker's exposure on the following day during a four-hour sampling period was only 4.2 mg/m^3. Disposable dust masks were available, but the workers observed during the NIOSH survey chose not to wear them. Furthermore, Keebler did not require their use in the Mixing Department.

Several of the workers complained of the "suffocating odor" expelled from the third floor feed chute on Mixer No. 1. A cover lid was available for the chute, but it was often left open even when materials were not being added.

5. Ammonia Monitoring, Second Floor Mixing Department

Long-term and short-term detector tube readings obtained for ammonia on the second floor mixing area are shown in Table 6. All results were below the ACGIH 8-hour TWA TLV of 25 ppm. The highest personal exposure was 10 ppm, for the No. 3 Mixer Operator.

Continuous monitoring results of ammonia exposures for the Line No. 2 and Line No. 3 Mixer Operators are graphically displayed in Figure 2 and Figure 3, respectively. The source data for these charts was obtained from a time history report recorded and stored by the Metrosonics data logger that was connected to the Miran 103. The full data logger record is provided as an attachment to this report. Some notations to this record were added later for clarification. As shown in Figures 2 and 3, the vertical lines represent the minimum and maximum reading for each 5-minute interval of the sampling period. The average for each 5-minute exposure is represented by the horizontal intersecting line. For the No. 2 mixer operator, the highest 5-minute TWA reading obtained during scaling was 20.8 ppm. The No. 3 Mixer Operator, who was actually wearing the Miran probe, received his highest 5-minute TWA exposure, 38.7 ppm, at about 10:00 A.M. The results show that at no time was the NIOSH REL of 50 ppm (5-minute TWA) exceeded.

Furthermore, at no time was the ACGIH 15-minute STEL (35 ppm) for ammonia exceeded. The highest 15-minute exposure average recorded by the data logger was 32 ppm.

B. Medical/Epidemiological

Of the 24 cases of cancer identified through medical clinic records and union- and management-provided lists, there were 2 cancers of the lung, 3 breast, 5 digestive system, 2 prostate, 6 reproductive system, 2 skin, 1 leukemia, and 3 unknown sites. The mean age of cases was 48.5 (range = 32 to 64). Eighteen (57%) of the cases were women. Twelve cases (50%) were white and 12 were black or other races. Personnel files were available on all these employees. Complete information was available on 1389 of 1392 employees, with a total of 13,852.32 person-years experienced between January 1974 and September 1987. There were 719 (52%) women and 673 (48%) men in the study group; 664 (48%) were white and 728 (52%) were black or other races.

There were 24 observed cancer cases for the entire group, with an expected number of 25.1, resulting in a standardized morbidity ratio (SMR) of 96. Not only was there no increased risk of cancer overall, there was no statistically significant increase in the SMR for any age group (Table 7). Although the SMR in the 50-54 years age group appeared high, it should be noted that two of these cases were age 50, and one was age 51, at the time of the study. Classification by age of onset of disease would most likely have resulted in these individuals being placed into the 45-49 years category.

Since one of the exposures of concern was asbestos, the SMR for lung cancer was analyzed. Two cases of lung cancer were reported, but 3.59 cases were expected, resulting in a SMR of 56 (confidence interval 0.06-2.01). Therefore, there is no indication of an increased risk of lung cancer for this population.

There are two noteworthy potential sources of error in this study. Reported cancer cases were not confirmed, and it is possible that some employees who were reported as having cancer were not actually cases. It is also possible that additional cases of cancer among Atlanta Keebler employees were missed, since active case-finding through local hospitals and tumor registries was not conducted. Although this study does not determine the actual incidence of cancer among Keebler employees, the information provided allowed us to answer the question of whether or not the known number of cancers among these employees represented an elevation of cancer incidence above the non-exposed population. It did not. The second source of error is the use of the study date as a substitution for the date of diagnosis. This may over-estimate the number of years-at-risk, which would underestimate the risk of disease. Also, this method most likely resulted in misclassifying some individuals into an older age group. However, the effect should not be severe, since age groups are in 5-year increments and rates generally do not vary drastically between age groups.

VII. CONCLUSIONS

Based on exposure monitoring results, and an extensive review Keebler's MSDS files, the investigators concluded that no worker were exposed to potential carcinogens during this survey. All other potential exposures monitored in response to worker concerns were below NIOSH or other relevant evaluation criteria. The potentially hazardous exposures to asbestos containing insulation from the oven on Line No. 3 were eliminated by Keebler's prompt action to have this oven dismantled and removed from the plant.

This evaluation did not show an increased risk for lung cancer or cancer in general among Keebler Company's Atlanta Bakery employees.

VIII. RECOMMENDATIONS

1. Ammonia levels in the second floor mixing area should be periodically monitored. Short-term exposures might occasionally exceed either the ACGIH STEL or the NIOSH REL, especially for the No. 3 Mixer Operator. If under certain conditions exposures are excessive, storage bins should be exhaust-vented, and paper batching sacks should be replaced with vapor proof plastic bags or some other type of vapor-proof container.

2. Where manual handling of raw materials in the third floor mixing area might result in excessive dust exposure, disposable dust masks should be worn. Work practices and the effectiveness of existing ventilation systems for these manual operations should be further evaluated to reduce the risks of respiratory sensitization from the inhalation of flour or other raw materials.

3. Periodic medical evaluations, consistent with the medical surveillance provisions of the OSHA Asbestos Standard (29 CFR 1910.1001, Sub Paragraph [l]) should be provided to all workers who may have been previously exposed to asbestos containing insulation material from the old oven on Line No. 3. This is necessary because of the prolonged latency period of most asbestos-related disease, and the uncertainty surrounding the cumulative dose needed to initiate the disease process.

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XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati, Ohio address. Copies of this report have been sent to:

1. Keebler Company, Atlanta Bakery
2. Keebler Company, Risk Management, Elmhurst, IL
3. Bakery, Confectionery, and Tobacco Workers Union Local 42
4. Bakery, Confectionery, and Tobacco Workers Intl.
5. NIOSH Atlanta Regional Office
6. OSHA Region IV
7. Appropriate health and safety agencies of the State of Georgia

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

TABLE 1
EVALUATION CRITERIA

HETA 87-379
KEEBLER COMPANY, ATLANTA BAKERY
ATLANTA, GEORGIA

April 21-23, 1988

RECOMMENDED EXPOSURE LIMITS
(as 8-hour TWA limits unless otherwise noted)

SUBSTANCE	NIOSH	ACGIH	OSHA	HEALTH EFFECTS
Asbestos	0.1 f/cc*	2 f/cc, crysotile 0.5 f/cc, amosite	0.2 f/cc	Lung cancer, mesothelioma, asbestosis
Formaldehyde	0.016 ppm* 0.1 ppm (15-min)*	1 ppm 2 ppm (15-min)	1 ppm 2 ppm (15-min)	Nasal cancer, upper respiratory irritation, dermatitis
Acetaldehyde	--	100 ppm** 150 ppm (15-min)**	200 ppm	Upper respiratory irritation, possible carcinogenic effects
Flour dust	--	10 mg/m^3**	15 mg/m^3	As nuisance dust (these limits may not protect some workers from respiratory sensitization effects)
Ammonia	50 ppm (5-min)	25 ppm 35 ppm (15-min)**	50 ppm	Respiratory and eye irritation

* These limits represent the lowest reliably quantifiable concentrations
** Where noted these limits will become the new OSHA standard effective Sept 1, 1989

TWA = Time-Weighted Average - The levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects.

mg/m^3 = milligrams of substance per cubic meter of air

ppm = parts of substance per million parts of air

TABLE 2
FIBER SAMPLING RESULTS
(Phase Contrast Microscopy)

HETA 87-379
KEEBLER COMPANY, ATLANTA BAKERY
ATLANTA, GEORGIA
April 22, 1988

Air Samples

SAMPLE NO.	SAMPLING TIME	FIBERS/CC	FIBER TYPE	SAMPLE LOCATION
A1	0930-1348	ND	none	north side of line 3 oven, zone 1, 95 feet from oven entrance
A2	0930-1119	ND	none	north side of line 3 oven, zone 2, 195 feet from oven entrance
A3	0933-1535	ND	none	line 3 oven operator's desk
A4	0935-1535	0.004	cellulose	southeast end of old proofing room, on column (contractor in area loading shipping crates)
A5	0937-1150	0.005	cellulose	north wall of old proofing room (contractor in area loading shipping crates)

Settled Dust Samples

SAMPLE NO.	FIBERS DETECTED	SURFACE SAMPLE LOCATION
ASB1	none observed	top of electrical box on north wall of old proofing room, near sample A5
ASB2	none observed	above thermostat on column in center of old proofing room
ASB3	none observed*	east (cinder block) wall of old proofing room, on 45° ledge
ASB4	none observed	top of line 3 oven, near sample A1
ASB5	none observed	top of line 3 oven, near center
ASB6	none observed	top of line 3 oven, near sample A2
ASB7	none observed	top of line 3 oven temp. gauge panel
ASB8	none observed	top of hood at exit end of line 3 oven

* Filter overload - loose dust on filter, unable to see or count fibers

TABLE 3
ALDEHYDE SAMPLING RESULTS

HETA 87-379
KEEBLER COMPANY, ATLANTA BAKERY
ATLANTA, GEORGIA
April 22, 1988

TYPE SAMPLE	SAMPLING TIME	FORMALDEHYDE (ppm)*	ACETALDEHYDE (ppm)*	SAMPLE LOCATION
Personal	0807-1425	ND	(0.02)	Line 3 Oven Operator
Personal	0814-1440	ND	(0.03)	Line 1 Box Maker Opr.
Personal	0900-1458	ND	(0.02)	Line 1 Case Maker Opr.
Area	0835-1456	0.02	(0.02)	Line 1 Box Maker (above hot melt glue applicator)
Area	0855-1457	0.02	(0.03)	Line 1 Case Sealer (back side of enclosure, opposite control panel)
Area	0903-1458	0.03	(0.03)	Line 1 Box Maker (outside enclosure)
Evaluation Criteria		0.016 (1)	100 (2)	

1. This limit represents the lowest reliably quantifiable concentration

2. Current ACGIH 8-hour Threshold Limit Value
(NIOSH considers acetaldehyde a potential workplace carcinogen.)

LOD = limit of detection LOQ = limit of quantitation
Results falling between the LOD and LOQ are estimated values.
* Results given in parentheses fell between the LOD and LOQ.
Results reported as none detected (ND) were below the LOD.

Laboratory analytical limits for formaldehyde:
-- solid sorbent tubes LOD = 2 µg/sample, LOQ = 7 µg/sample
-- impinger collection LOD = 0.03 µg/sample, LOQ = 0.095 µg/sample

Laboratory analytical limits for acetaldehyde:
-- solid sorbent tubes LOD = 0.5 µg/sample, LOQ = 1.5 µg/sample

µg/sample = micrograms per sample
ppm = parts of analyte per million parts of air

TABLE 4

VOLATILE ORGANIC COMPOUNDS
FROM SHRINK WRAP MACHINES ON TOWN HOUSE CRACKER LINE (Line No. 2)

HETA 87-379
KEEBLER COMPANY, ATLANTA BAKERY
ATLANTA, GEORGIA
April 21-22, 1988

TYPE SAMPLE	SAMPLING TIME	Concentration as mg/m3 or (ppm) 111-T	TOLUENE	LIMONENE	OTHER VOCs[1]	SAMPLE LOCATION
Area	0913-1501	4.5 (0.8)	0.1* (0.03)	0.2*	2.2	North Unit (over cutter bar)
Area	0915-1500	5.9 (1.1)	0.1* (0.03)	0.2*	2.2	South Unit (over cutter bar)
Personal	0923-1420	4.1 (0.8)	0.09* (0.02)	0.2*	1.5	Shrink wrap machine operator
Evaluation Criteria =		(200)	(100)	NE	5	

(1) As polymeric fume (mostly C_9-C_{12} aliphatic hydrocarbons)

* These values are estimates because amount detected was less than the LOQ

Limit of Detection (LOD):
- -- 5 micrograms (µg) per sample for 111-trichloroethane, toluene and limonene
- -- 10 µg per sample for total volatile organic compounds (VOCs)

Limit of Quantitation (LOQ):
- -- 15 micrograms (µg) per sample for 111-trichloroethane, toluene and limonene
- -- 30 µg per sample for total VOCs

111-T = 111-trichloroethane
mg/m³ = milligrams per cubic meter
ppm = parts of analyte per million parts of air
NE = None Established

TABLE 5

DUST EXPOSURES
THIRD FLOOR MIXING AREA

HETA 87-379
KEEBLER COMPANY, ATLANTA BAKERY
ATLANTA, GEORGIA
April 21-22, 1988

SAMPLE NO.	SAMPLING TIME	TOTAL DUST (mg/m^3)	SAMPLE LOCATION
April 21:			
FW 911	0930-1030	17.1	Mixer Helper, Mixer No. 1 (dumping sacks of graham flour into mixer for old fashion cookie mix)
FW 910	0709-1019	0.9	Mixer Helper, Mixer No. 3 (Dumping and scooping whey for process cheese)
April 22:			
FW 916	0830-1250	4.2	Mixer Helper, Mixer No. 1 (dumping sacks of graham flour into mixer for old fashion cookie mix)
FW 921	0830-1250	2.0	"
Evaluation criterion		10 (1)	(ACGIH TLV for nuisance dust)

Laboratory limit of detection = 0.01 mg/sample
mg/m^3 = milligrams per cubic meter

(1) As 8-hour time-weighted average
Note: This limit may not protect some workers from respiratory sensitization effects.

TABLE 6

AMMONIA CONCENTRATIONS
MIXING DEPARTMENT
(detector tube sample results)

HETA 87-379
KEEBLER COMPANY, ATLANTA BAKERY
ATLANTA, GEORGIA

April 21, 1988

TYPE SAMPLE	MONITORING TIME	AMMONIA CONCT. (ppm)	LOCATION
Long term measurements:			
Personal	0530-1010	8	No. 2 Mixer Operator
Personal	0515-1012	10	No. 3 Mixer Operator
Area	0540-1010	9	No. 2 mixer/scale area
Area	0544-1013	11	No. 3 mixer/scale area
Personal	0710-1020	6	Mixer helper (3rd floor)
Short term measurements:			
Area	0600	5	No. 2 mixer area
Area	0615	4	No. 3 mixer area
Area	0655	3	Center of 3rd floor
Area	0715	5	No. 3 mixer over open hopper (3rd floor)

Note: All measurements were taken in the 2nd. floor mixing area unless otherwise noted.

Evaluation Criteria:
--ACGIH TLV 8-hour TWA 25 ppm
--ACGIH STEL (15-min avg.) 35 ppm
--NIOSH REL (5-minute ceiling) 50 ppm

Note: The ACGIH STEL will be the new OSHA standard effective Sept. 1, 1989.

TABLE 7

KEEBLER COMPANY BAKERY
ATLANTA, GEORGIA
HETA 87-379
September 29-30, 1987

Age [1]	Annual Cancer Incidence Rates [2]	Number of person-years [3]	Expected Cancers	Observed Cancers	SMR	95% Confidence Interval
15-19	17.9	145.4	0.03	0	0	---------
20-24	25.3	1771.8	0.45	0	0	---------
25-29	48.6	2618.3	1.27	0	0	---------
30-34	73.6	2726.5	2.01	2	100	0.11-3.59
35-39	111.7	2324.2	2.60	4	104	0.41-3.94
40-44	211.1	1650.0	3.48	4	115	0.31-2.94
45-49	331.8	1084.4	3.60	1	28	0.004-1.555
50-54	532.5	715.7	3.81	7	184	0.74-3.79
55-59	761.5	463.9	3.53	2	57	0.06-2.05
60-64	1096.7	235.0	2.58	4	155	0.42-3.97
65-69	1406.2	86.5	1.22	0	0	---------
70-74	1652.4	18.6	0.31	0	0	---------
75-79	1881.9	0.2	0.004	0	0	---------
80-84	2014.8	0.0	0.00	0	0	---------
85+	2027.8	11.4	0.23	0	0	---------
TOTAL	------	13,852.3	25.12	24	96	0.61-1.42

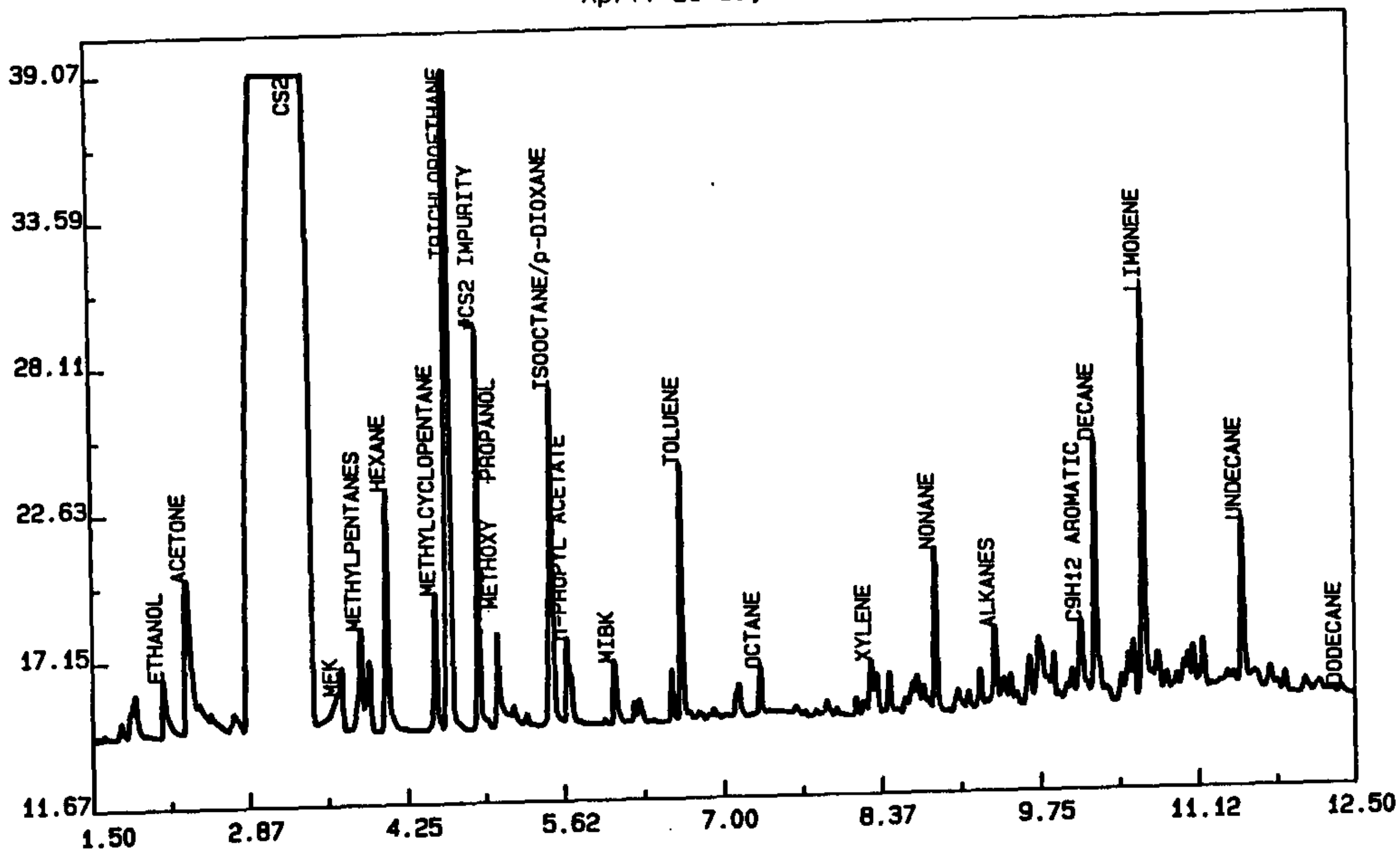
(1) Individuals were categorized into age-groups based upon their age at the time the study was conducted, unless the date of death or year of onset of disease was known.

(2) Rates for metropolitan Atlanta, Georgia from the Surveillance, Epidemiology, and End Results (SEER) Program.

(3) Person-years experienced by workers at Keebler (12/74 through 9/87).

FIGURE 1
GC/MS CHROMATOGRAM for SHRINK WRAP FILM EMISSIONS

HETA 87-379
KEEBLER COMPANY, ATLANTA BAKERY
ATLANTA, GEORGIA
April 21-23, 1988



SEQ 6202 CT-1

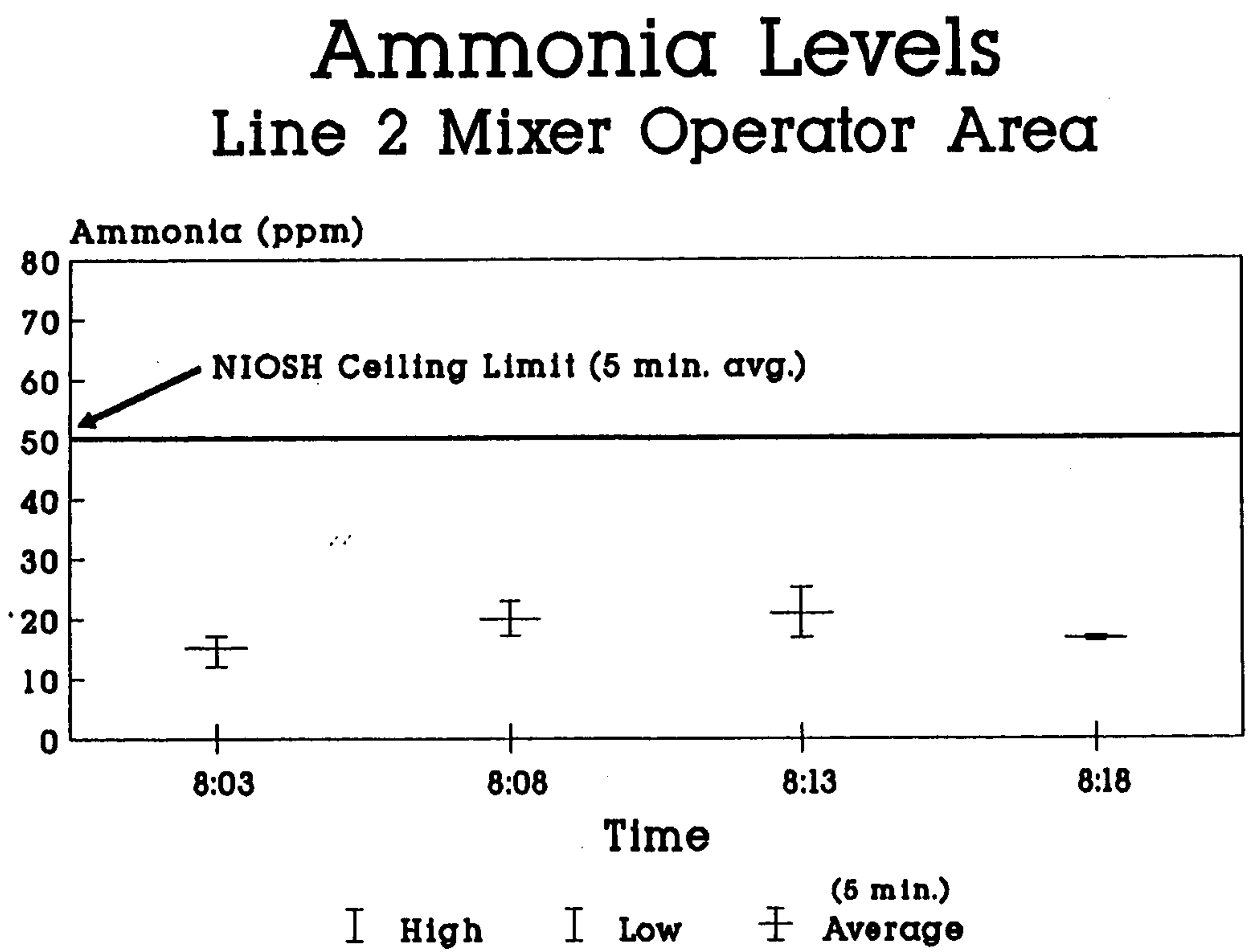


Figure 2

April 20, 1988 (scaling)

Ammonia Exposure
Line 3 Mixer Operator

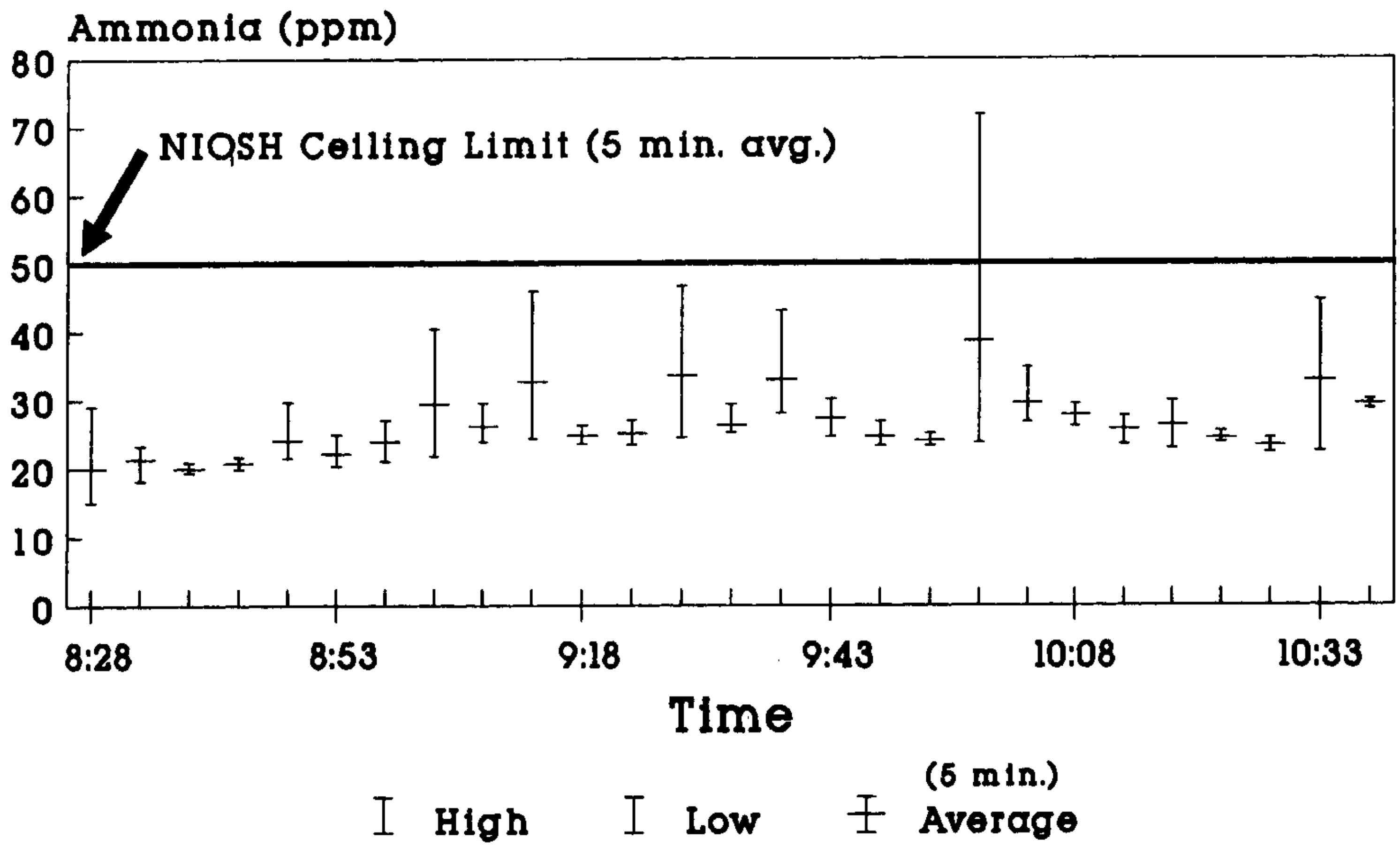


Figure 3

April 20, 1988

APPENDIX

DATA LOGGER OUTPUT DATA

HETA 87-379
KEEBLER COMPANY, ATLANTA BAKERY
ATLANTA, GEORGIA

April 21, 1988

"TEST START DATE: Ø4-21-88"
"TEST START TIME: 18:21"
" TEST LOCATION: Keebler Mixing Dept."
" EMPLOYEE NAME: Mixer Operators

METROSONICS dl-332 SN 1289 V2.4 12/86

CURRENT DATE: 4/21/88
CURRENT TIME: 18:22:36

CALIBRATION
Ø.Ø893 V = 5.ØØØ ppm
Ø.6325 V = 5Ø.ØØØ ppm

LOWER ALARM: 28.994 ppm
UPPER ALARM: 5Ø.375 ppm

UNITS: ppm

INPUT READS:- 2.396 ppm
TEST STARTING DATE: 4/21/88
TEST STARTING TIME: 5:43:4Ø
ELAPSED TIME: Ø DAYS 4:42:33
OVERALL AVG: 18.589 ppm
OVERALL MIN: 7.214 ppm
MIN OCCURRED 4/21/88 @ 5:43:4Ø
OVERALL MAX: 71.8Ø7 ppm
MAX OCCURRED 4/21/88 @ 1Ø:Ø1:17
STEL: 32.258 ppm
STEL OCCURRED 4/21/88 @ 1Ø:ØØ:38

```
 TIME HISTORY
PERIOD LENGTH:  0:01:00
# OF PERIODS  COMBINED:    5


    MIN         AVG         MAX                     LO          HI

DATE:  4/21/88  TIME:  5:53:40  Mixer Opr. No. 2, Dumping sacks of ammonium
                                bicarbonate into mixer

   8.126       8.424       8.788   *             |            |
   8.598       9.302      10.163  -*             |            |
   9.376       9.691      10.139   *             |            |
   9.426       9.791      10.163   *             |            |
   9.666       9.981      10.412   *             |            |
   9.873      10.180      10.561   *+            |            |
  10.031      10.354      10.644   *+            |            |
  10.213      10.801      11.207  -*             |            |
  10.081      10.487      10.892   *+            |            |
  10.296      10.868      12.168  -*             |            |
  10.934      11.348      12.102    *            |            |
  10.752      11.108      11.530    *            |            |
  10.470      11.191      11.994   -*            |            |
  10.892      11.290      11.895    *            |            |
  11.390      11.655      11.920    *            |            |
  11.307      12.235      13.817   -*            |            |
  12.682      13.113      13.469    *            |            |
  12.392      12.856      13.229    *            |            |

DATE:  4/21/88  TIME:  7:23:40
  12.566      13.469      14.297     *+          |            |
  11.953      12.475      12.980    -*           |            |
  11.812      12.185      12.599    -*           |            |
  11.332      12.027      13.080    *+           |            |
  11.663      12.003      12.458    *+           |            |
  11.928      12.260      12.574    -*           |            |
  10.122      11.837      12.806   -*+           |            |

                                8:03 Mixer No. 2 Opr. begins scaling
  12.052      15.192      17.106     - *+        |            |
  17.172      19.939      23.004         -* +    |            |
  16.783      20.875      25.141        -   * +  |            |
@ 16.178      16.708      17.031       *         |            |
```

DATA LOGGER OUTPUT (Page 3 of 4)

```
DATE:  4/21/88  TIME:  8:28:48  Mixer No. 3 Opr. (wearing Miran probe)

  15.010     19.972     29.060        -  *     +            |
  18.141     21.372     23.244          - *+   |            |
  19.310     20.022     20.809           *+    |            |
  19.790     20.684     21.645           -*    |            |
  21.571     24.048     29.690            - *  +            |
  20.312     22.068     24.835           -* +  |            |
  20.958     23.816     26.964            - *+ |            |
  21.728     29.433     40.476            -    *      +     |
  23.816     26.053     29.482              -* +            |
  24.296     32.664     45.902              -  | *       +  |
  23.534     24.570     26.293             -*+ |            |
  23.385     25.059     27.055             -*+ |            |
  24.504     33.591     46.639              -  | *       +  |
  25.150     26.235     29.400              -* +            |
  27.991     33.011     43.085                -| *     +    |
  24.628     27.279     30.054              - *+            |
  23.253     24.595     26.798             -*+ |            |
  23.244     24.048     25.100             -*  |            |
  23.683     38.661     71.807             -   |    *       |            +
  26.616     29.524     34.710               - *  +         |

DATE:  4/21/88  TIME: 10:08:48
  26.136     27.718     29.424               -*+            |
  23.369     25.622     27.594             - *+|            |
  22.789     26.276     29.772             - * +            |
  23.725     24.313     25.282             -*  |            |
  22.176     23.286     24.230             *+  |            |
  22.283     32.837     44.593             -   | *      +   |
@ 28.695     29.333     29.913                -*            |
```

DATA LOGGER OUTPUT (Page 4 of 4)

AMP DIST
SAMPLES LOGGED: 16953

ppm	SAMPLES		%
5.889	96	*	000.56
7.546	927	*****	005.46
9.202	2507	***************	014.78
10.860	3385	********************	019.96
12.516	1197	*******	007.06
14.173	372	**	002.19
15.830	244	*	001.43
17.487	94	*	000.55
19.144	908	*****	005.35
20.800	830	*****	004.89
22.457	1437	********	008.47
24.114	1584	*********	009.34
25.771	1119	*******	006.60
27.428	674	****	003.97
29.085	514	***	003.03
30.742	219	*	001.29
32.398	166	*	000.97
34.055	120	*	000.70
35.712	85	*	000.50
37.369	77	+	000.45
39.026	93	*	000.54
40.683	62	+	000.36
42.340	88	*	000.51
43.996	42	+	000.24
45.653	33	+	000.19
47.310	4	.	000.02
48.967	4	.	000.02
50.624	3	.	000.01
52.281	6	.	000.03
53.937	4	.	000.02
55.594	3	.	000.01
57.251	6	.	000.03
58.908	4	.	000.02
60.565	5	.	000.02
62.222	4	.	000.02
63.879	6	.	000.03
65.535	5	.	000.02
67.192	10	.	000.05
68.850	6	.	000.03
70.506	10	.	000.05