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HETA 86-446-1918
AUGUST 1988
SIOUXPREME EGG PRODUCTS, INC.
SIOUX CENTER, IOWA

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I. SUMMARY

On July 15, 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request from the president of Sonstegard Foods, Inc., to evaluate occupational exposures to raw and dried egg products at the Siouxpreme Egg Products plant, in Sioux Center, Iowa. Workers at this plant had previously been documented to have Ige-mediated occupational asthma from airborne egg protein exposure. The intent of this evaluation was to follow-up on previous findings, perform an industrial hygiene survey, and undertake an engineering control technology assessment of worker exposures to egg products at this plant. An initial site visit and walk-through survey were conducted by NIOSH personnel on September 10, 1986. A combined medical, industrial hygiene, and engineering control technology survey was undertaken during March 24-26, 1987.

Employees' exposures to iodide ions, acid gases, and total and respirable dust (aerosol mass) were all below applicable standards. Ambient air concentrations of iodide ions were less than 0.05 milligrams per cubic meter (mg/m^3). Ambient air concentrations of hydrochloric acid (HCL) were less than 0.03 mg/m^3. Ambient air concentrations of sulfuric acid (H_2SO_4) were non-detectable. Ambient air total aerosol mass concentrations were less than 2.2 mg/m^3. Ambient air respirable aerosol mass concentrations were less than 0.16 mg/m^3. There are no applicable exposure standards specifically for total and respirable protein or aeroallergen (ovalbumin, ovomucoid, and lysozyme) exposures. The results of the analysis of bulk samples of the egg products indicated a protein concentration of 28-43%. A sample of egg wash water contained 19 mg/ml of protein. All but one sample for ambient air total protein concentration were less than 0.78 mg/m^3. Ambient air respirable protein concentrations were all less than 0.48 mg/m. Ambient air concentrations of ovalbumin, ovomucoid, and lysozyme were all less than 188 micrograms per cubic meter (ug/m^3), 113 ug/m^3, and 3.5 ug/m^3, respectively.

One additional participant from the original Siouxpreme Egg hazard evaluation survey (HETA 84-163-1657) was determined to have developed Ige-mediated occupational asthma from egg protein exposure, based upon questionnaire responses compatible with occupational asthma, a physician's clinical history and examination suggestive of occupational asthma, and immunologic evidence of allergy to egg proteins (one or more positive skin-prick tests or radioallergosorbent tests (RASTs) to egg proteins). An additional five of the original participants had developed symptoms and immunologic findings compatible with possible occupational asthma from egg protein exposure.

On the basis of these data, NIOSH investigators have determined that a health hazard continued to exist among employees of the Siouxpreme Egg Products plant in Sioux Center, Iowa, from occupational exposure to airborne egg protein. Recommendations to reduce exposures to egg protein, and for screening of at-risk workers, are made in Section IX of this report, and in the engineering control technology report which was provided to the company in July, 1987.

KEYWORDS: SIC 2017, poultry and egg processing, egg protein, egg dust, occupational asthma, aeroallergens, iodide ions, acid gases

II. INTRODUCTION

On July 15, l986, NIOSH received a request from the president of Sonstegard Foods, Inc., to evaluate occupational exposures to raw and dried egg products at Siouxpreme Egg Products, Inc., Sioux Center, Iowa. An initial site visit and walk-through survey were conducted by NIOSH personnel on September l0, l986. A combined medical and industrial hygiene survey was undertaken during March 24-26, l987. Each participant in the medical study was notified of the results of his or her medical examinations on July 27, l987. A draft copy of the engineering control survey was sent to the plant for review on July 14, 1987. An interim report summarizing the results of the medical survey was distributed in October, 1987.

III. BACKGROUND

This report describes one of three similar hazard evaluations conducted within the egg processing industry. Hazard evaluations were also conducted at Estherville Foods, Inc., in Estherville, Iowa (HETA 86-447) and at the Ballas Food Products Company in Zanesville, Ohio (HETA 86-461). These latter two studies are to be reported separately.

In l986, NIOSH released a report of a health hazard evaluation among workers at Siouxpreme Egg Products, Inc., in Sioux Center, Iowa [1]. This plant processes up to a million and a half raw eggs each day, into powdered whole egg, powdered egg yolk, and liquid egg white. Workers at Siouxpreme Egg Products were complaining of "asthma-like" symptoms, including wheezing, shortness of breath, and chest tightness, which they believed were work-related. NIOSH investigators determined that five workers at Siouxpreme Egg Products had developed IgE-mediated occupational asthma from exposure to egg protein. This disease previously had not been described in the egg processing industry. Results of the study were reported in the Morbidity and Mortality Weekly Report [2], reprinted in the Journal of the American Medical Association [3], and published in the American Journal of Industrial Medicine [4] and the Journal of Allergy and Clinical Immunology [5].

On July l5, l986, representatives of NIOSH and of the United Egg Producers Association met in Cincinnati, Ohio, to discuss the findings of the hazard evaluation conducted at Siouxpreme Egg Products. It was agreed that the results of this hazard evaluation should be replicated, to determine if the occurrence of five cases of Ige-mediated occupational asthma from egg protein exposures at this plant was an isolated incident, or if IgE-mediated occupational asthma to eggs is present among workers in other facilities. The president of Sonstegard Foods, Inc., attended this meeting. He requested a follow-up evaluation of workers at Siouxpreme Egg Products, Inc., who had participated in the original hazard evaluation, and for NIOSH to conduct a further environmental assessment of worker exposures at the plant, and to examine possible environmental control strategies to minimize worker exposure to egg protein.

IV. PROCESS DESCRIPTION

On the average. approximately l.5 million eggs are processed each working day. Six semi-trailer shipments are off-loaded from the loading dock area to the whole egg-in-shell warehouse area using propane-powered forklifts. The eggs come from a variety of sources, but most come from cage laying operations in Texas, Arkansas, and Missouri. The eggs also are a variety of grades since most would not grade out for supermarket use. Some are

also dirty with a variety of material, and others are cracked or in bad condition because they have not been refrigerated. From the warehouse, the eggs are moved on the pallets to the loading and washing room for transfer by hand to egg washing machines. Thirty-six eggs (6X6 format) on separators or flats are examined and placed on the loading chute. Eggs that are cracked or broken are removed by hand and placed in the inedible tray, and ones that are overly dirty but usable are sorted onto another flat and sent to the pre-wash area. The 36 eggs from each flat are picked up by a series of suction cups on an arm and transferred over to the conveyor going into the washing tunnel. The eggs travel through the washer where they are spray washed with a mixture of detergent compound and water. The detergent in use during the study was "Best Eggs-Plus" (mono(trichloro)-tetra-(mono potassium) dichloro-penta-s-triazone and anhydrous sodium metasilicate). The wash water is recirculated continually during the five-hour cycle, and the solution is changed during the 30-minute cleanup period. After passing through a clean water rinse, the eggs are sprayed with a sanitizer containing iodine as the active ingredient. The brand name of the rinse sanitizer was "Bac-Stop" (butoxy monoether of polyoxypropylene-polyoxyethylene glycol-iodine complex (providing 1.75% titratable iodine)). Chlorine was used previously, but this was thought to be the source of the employees' complaint; so it was changed. The eggs then pass over the candling table where they are again examined. Dirty eggs are returned to the pre-wash area or sent through the washer again. Cracked or broken eggs, as well as those with visible interior spots, are thrown in the "non-edible" container.

The flats, or egg separator, are returned to the flat washing area for cleaning and drying prior to being returned to the egg suppliers. The flats are washed with a product called "Simbol". "Simbol" contains sodium hydroxide and chlorinated isocyanates.

The washed and candled eggs pass into the adjacent breaking room on the same continuous conveyor. The eggs fall into a continuous chain that grips the egg, holds and separates the shell and drops the contents into a separating cup. As the cup passes by, the operator makes a decision on the thoroughness of the break. If the separation of yolk and white is clean, the operator lets the cup pass by, and the resultant products are egg yolks and egg whites. If the separation is not good or the yolk is broken, the operator must trip each cup which sends the whole egg product into another system. Most of the egg whites are pumped to refrigerated storage where they are eventually loaded into bulk trucks for transport to other users. The egg yolk and whole eggs are pasteurized and refrigerated before they are sent to the drying room.

Liquid whole eggs or yolks are pumped to the drying area. Additives such as sugar, powdered milk, corn syrup, salt, soybean oil, and Zeilex 7 are added directly to the stream flow before it reaches the high pressure spray pump. The liquid is pumped through four nozzles into the large air drying oven. The water is evaporated, and the dryed product falls to the floor of the dryer where it is moved by chain and bar conveyor to a screw conveyor on one side of the oven. The dried material is picked up by vacuum and transported overhead to a cyclone separator. The product is removed and passed down to a sifter in the packaging room. The l2 or so products that can be produced are then weighed out into packages and sealed for storage in the warehouse prior to shipment.

V. METHODS

A. ENVIRONMENTAL

From March 24 to 26, 1987, air sampling was conducted in the transfer room, breaking room, drier areas, packaging room, warehouse, flat washing area, and "inedible" disposal area. The sampling focused on the three most apparent agents in the workplace that could cause irritant respiratory symptoms or occupational asthma, namely, iodide ions and (acid gases (HCl and H_2SO_4) from the sanitizer solution, and egg dust from the product the plant produces.

Iodide ion: Two area samples were collected in the transfer room, using midget impingers containing 20 ml of $NaHCO_3$. One area sample was similarly collected in the breaking room. The samples were analyzed following NIOSH Method 7903[6], using a DIONEX 2010i ion chromatograph.

Acid gases: Two area samples were collected in the transfer room, and one area sample in the breaking room, using silica gel solid sorbent tubes, and analyzed for acid gases (HCl and H_2SO_4) following NIOSH Method 7903[6], using a DIONEX 2010i ion chromatograph.

Aerosol mass: Area total and respirable aerosol mass samples were collected using tared, 37 millimeter (mm), 5.0 micron pore size polyvinyl chloride (PVC) filters. Gravimetric analysis was performed on the collected samples. The instrumental precision of the weighing was 0.01 mg (NIOSH Method 0500).[6] For determining the respirable fraction, NIOSH Method 0600 was employed using standard 10 mm nylon cyclones with a flowrate of 1.7 liters per minute (lpm).[6] This sampling rate provides optimum collection efficiency of dust particles smaller than 10 microns in diameter. Locations where samples were obtained are outlined in Table 3.

Protein: Personal (breathing zone) and area total and respirable protein samples were collected on 37 mm glass fiber filters, and analyzed for total protein by the Micro-Kjeldhal method.[7] The respirable fraction was obtained using standard 10 mm nylon cyclones with a flowrate of 1.7 lpm. Locations where samples were obtained are outlined in Table 4.

A bulk sample of dirty wash water from one transfer line was obtained and analyzed for total protein concentration. Bulk samples of dried egg materials were also obtained, and analyzed for total protein concentration.

Aeroallergens: Personal and area air samples were collected on Teflon filters, total aerosol concentration determined gravimetrically, and the samples analyzed for aeroallergen concentration (ovalbumin, ovomucoid, and lysozyme) by RAST inhibition.[8]

A survey was also conducted by NIOSH's Engineering and Control Technology Branch, Division of Physical Sciences and Engineering, to give recommendations for control of egg containing dusts and mists. The reader is referred to that report[15] for details of the survey.

B. MEDICAL/EPIDEMIOLOGIC

We had previously developed a questionnaire that was sensitive to identify employees with occupational asthma.[1] We suspected a respondent might have occupational asthma if he or she reported experiencing within the preceding month one of the following: wheezy or whistling respiration, episodes of shortness of breath, and/or chest tightness; and the symptoms occurred following specific activities or exposures at work; and on days away from work and on vacation, symptoms occurred less frequently or not at all. We attempted to administer this questionnaire to every participant in the previous health hazard evaluation at Siouxpreme Egg Products, Inc. Toward this end, a month prior to the follow-up medical survey, we mailed the questionnaire to each former employee who had been a participant previously. As well, during the follow-up study, we administered the questionnaire to each of the still current employees who had previously participated. We obtained completed questionnaires from 30 of 31 current employees, and from 27 of the 63 former employees.

To identify the underlying pathophysiology of positive responses, we conducted medical examinations of a sub-set of respondents, who reported asthma-like symptoms which they believed were temporally related to working at Siouxpreme Egg Products, Inc. Among former workers, many had moved out of the area, or had left no forwarding address. Therefore, we obtained participation from only three of those former employees. We also selected 22 of the current employees, 8 with symptoms (chest tightness with shortness of breath, and/or wheezing) temporally related to work, 11 with none of these symptoms, and 3 additional persons selected because of results from the 1984 study. Nineteen (86%) of the current employees selected, agreed to participate in these examinations. The follow-up medical examinations consisted of the following.

(1) A physician obtained a medical history and examined each participant. She was blinded to the questionnaire responses and the results of all other examinations. She rendered an opinion, based upon her clinical examination, whether the examinee had asthma, and if so, whether the asthma was occupational or non-occupational. She diagnosed occupational asthma if her clinical history elicited symptoms as outlined above. She diagnosed non-occupational asthma if there was a prior physician's diagnosis of asthma, preceding employment; or if there was a history suggestive of asthma, and the symptoms were not temporally related to work. She diagnosed irritant respiratory symptoms if an irritant exposure was easily identified by the subject, symptoms were present on initial exposure, symptoms generally began immediately with exposure, and intensity of symptoms appeared by history to correlate with concentration of exposure. She noted in her clinical evaluation report, that many of the individuals considered possibly to have occupational asthma, might be determined to have non-occupational asthma or irritant symptoms, depending on the results of the pulmonary function assessments and the immunologic testing; and conversely that many of the individuals considered possibly to have non-occupational asthma or irritant symptoms, might be determined to have occupational asthma, depending on the results of pulmonary and immunologic testing.

(2) Spirometry was performed toward the end of the work shift using an Ohio Medical Model 822 dry rolling sealed spirometer attached to a Spirotech 220B dedicated computer. If there was evidence of any abnormality on spirometric examination, the participant was requested to return the following morning, pre-shift, for another pulmonary function determination. We required as evidence of pulmonary function test abnormality, a forced expiratory volume in one second (FEV1) less than 80 percent of predicted, a forced vital capacity (FVC) less than 80 percent of predicted, or an FEV1/FVC ratio less than 0.7.[9]

(3) Peak expiratory flow rates (PEFRs) were measured serially, using Wright's portable mini-peak flow meters, every three hours while awake for one week. Three exhalations were recorded each time, and the maximum of the three was accepted as the PEFR determination. Any wheezing, shortness of breath, or chest tightness experienced concurrently with each PEFR determination was also reported. We diagnosed a participant to have "symptomatic bronchial lability" if the difference between the minimum and the maximum PEFR on at least one day exceeded 20 percent of the day's maximum PEFR,[10] and he/she reported wheezing, shortness of breath, or chest tightness at the time the PEFR reached the daily minimum.

(4) Skin prick tests were administered and serum specific-IgE levels were measured by the RAST method to a panel of egg allergens, including commercial egg white, yolk, and whole egg reagents (prick tests: Hollister-Steir (HS), Spokane, WA), extracts prepared from factory powdered egg white, yolk, and whole egg (prick tests and RASTs), and the egg fractions conalbumin, ovalbumin, lysozyme, and ovomucoid (prick tests and RASTs: Sigma Co., St. Louis, MO). A skin prick test was considered positive if the wheal diameter measured at least three millimeters greater than the saline control, and the histamine control was positive. RAST results were expressed as counts per minute of 125I-labeled anti-IgE bound to allergen-coated discs, and were considered positive if the tests' sera binding was more than three standard deviations above the mean of non-exposed laboratory controls. Total serum IgE levels were measured by radioimmunoassay. The normal range was l0-l25 International Units per milliliter (IU/ml), where one IU equals 2.3 mg.

(5) Skin prick tests were administered to a panel of common airborne allergens, including bluegrass, ragweed, timothy, cat hair, house dust, alternaria, hormodendrum, and house dust mites (Hollister-Steir). Negative and positive control skin tests included phosphate-buffered saline and histamine, respectively. Clinical atopy was determined by a positive response to two or more common allergens.

From prior experience[1,4], we developed survey-based diagnostic criteria for "probable" and "possible egg asthma", possible non-occupational asthma, and possible irritant respiratory symptoms. These are summarized in Table 7 and are described as follows.

(1) Probable "egg asthma": We classified a participant as having probable "egg asthma" if (a) he/she had symptoms as described above, suggestive of occupational asthma, (b) the serial peak flow rate measurements demonstrated symptomatic bronchial lability on at least one day, and (c) there was evidence of IgE-mediated allergy to egg protein, i.e., there was at least one positive prick test or

RAST to an egg protein. This definition potentially misclassifies individuals with "egg-asthma", who during the course of the one week survey, were not exposed to the situation(s) which typically precipitated their asthma. It also potentially misclassifies individuals with severe and unremitting bronchoconstriction, whose airways did not sufficiently dilate over the course of the survey, to demonstrate a 20% lability on any one day. We therefore classified as having "probable egg-asthma", participants who had compatible symptoms and evidence of allergy to egg protein (criteria (a) and (c) above), who had a history of physician-diagnosed asthma, or who were taking medications for treatment of asthma at the time of our survey.

(2) Possible egg asthma": We classified a participant as having possible "egg asthma" if he/she had symptoms suggestive of occupational asthma and evidence of IgE-mediated allergy to egg protein, but serial peak flow determinations did not yield evidence of symptomatic bronchial lability over the course of our one week survey. The absence of adequate PEFR data for analysis from a participant was treated as equivalent to adequate but negative data.

(3) Possible non-occupational asthma: We classified a participant as having possible non-occupational asthma if he/she had symptoms suggestive of asthma, apparently unrelated to work; he/she had symptomatic bronchial lability on serial PEFR determination; but he/she had no positive prick tests or RASTs to egg proteins.

(4) Possible irritant respiratory symptoms: We classified a participant as having possible irritant respiratory symptoms if he/she had episodic wheezing, and/or shortness of breath and chest tightness, apparently unrelated to work; he/she did not have symptomatic bronchial lability on serial PEFR determination or gave us insufficient data to analyze; and he/she had no positive skin prick test or RAST to egg proteins.

VI. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Recommended Exposure Limits (RELs),[11] 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[12] and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[13] Often, the NIOSH RELs and ACGIH TLVs are lower than the corresponding OSHA PELs. Both NIOSH RELs and ACGIH TLVs usually are based on more recent information than are the OSHA PELs. The OSHA PELs also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

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

A. Iodide ions

There are no applicable exposure standards for airborne idodide ions. The OSHA PEL for exposure to iodine is 1 mg/m^3 as a time weighted average (TWA). The ACGIH TLV for exposure to iodine is 1 mg/m^3 as a ceiling level, not to be exceeded at any time. There is no NIOSH REL for iodine.

Iodine vapor is irritant and corrosive. Inhalation of iodine vapor leads to excessive flow of tears (epiphora), tightness in the chest, sore throat, and headache.[14]

B. Acid gases

The OSHA PEL and ACGIH TLV for exposure to HCL is 7 mg/m^3 as a ceiling level, not to be exceeded at any time. There is not a NIOSH REL for HCL. Inhalation of HCL may cause throat irritation, gastritis and chronic bronchitis.[14]

The OSHA PEL, ACGIH TLV and NIOSH REL for H_2SO_4 are all 1 mg/m^3 as TWAs. Exposure to H_2SO_4 may cause tracheo- bronchitis, inflammation of the mouth (stomatitis), conjunctivitis, and gastritis.[14]

The sampling and analytical methods utilized in this study were those recommended for use when sampling the air for the iodine, HCL, and H_2SO_4 in a gaseous state. After the contaminants are collected in a liquid or sorbent media, a specific ion in the desorption solution is quantified. The gaseous concentration is then calculated, assuming that the detected ion is representative of the total molecule. However, during this study the detection of specific ions cannot be used to calculate back to gas concentration because the specific ions are part of a different molecule. Since there are no standards for halogen organic complexes like those used in this plant, a straight-forward interpretation of the results is not feasible.

A worst case approach would be to consider that all of the contaminants were in a gaseous state and that their effects are additive. This concept has some merit in that these chemicals all have been shown to demonstrate irritant-type symptoms. This approach, which is also suggested in the ACGIH Threshold Limit Values booklet for l987-88,[14] utilizes the following formula:[12]

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} = 1$$

where C_1 = concentration of chemical
where T_2 = TLV for chemical

As the formula implies, if the sum exceeds one, the calculated "mixture" TLV has been exceeded.

C. Aerosol mass

The OSHA PEL for nuisance dusts is 15 mg/m^3 for total dust and 5 mg/m^3 for the respirable fraction. The ACGIH TLV for total nuisance dust in 10 mg/m^3. Excessive concentrations of nuisance dusts in the workroom air may seriously reduce visibility, may cause unpleasant deposits in the eyes, ears, and nasal passages (Portland cement dust), or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by the rigorous skin cleansing procedures necessary for their removal.

D. Protein dust

There are no occupational exposure standards or recommendations specific for egg dust, and no standard for airborne dust of organic origin. Consequently, the only workplace exposure standard applicable to the protein and aeroallergen concentrations measured in this study is that for airborne nuisance dust, which by definition has little adverse effect on the lungs. As noted by the ACGIH, however, the nuisance dust guidelines are not meant to "apply to those substances which may cause physiologic impairment at lower concentrations, and for which threshold limits have not yet been recommended."[14] Exposure to egg protein may lead to sensitization. Allergic reactions may develop in sensitized persons subsequently exposed to egg protein. Sensitized persons may react to allergens at low concentrations and the responses may be dose related. The ACGIH TLV for subtilisins, a proteolytic enzyme, thus, a dust of organic origin, illustrates the order of magnitude of the dust level that may be necessary to protect the worker from respiratory sensitization. The ACGIH recommends a ceiling limit of 0.06 ug/m^3 for proteolytic enzymes of Bacillus subtilis.[12]

VII. RESULTS

A. ENVIRONMENTAL

Of the three area samples for iodide ions (Table 1), two were less than the limit of detection (0.025 mg/m^3) and one was 0.028 mg/m^3. The three area samples for HCL concentration ranged from 0.008 mg/m^3 in the breaking room, to 0.030 mg/m^3 in the transfer room (Table 2) with an average concentration of 0.020 mg/m^3. All three samples for H_2SO_4 were non-detectable at a limit of detection of 0.044 mg/m^3 (Table 2).

The six area samples for total aerosol mass concentration (Table 3) ranged from 0.05 mg/m^3 on the mezzanine near the new dryer, to 2.2 mg/m^3 in the packaging area of the new dryer with an average of 0.77 mg/m^3. The two samples collected in the breaking room would reflect an aerosol rather than a dust exposure. The average total aerosol mass concentration for the breaking room was 0.88 mg/m^3.

The four area samples for respirable aerosol mass concentration ranged from 0.03 mg/m^3 in the packaging room of the old dryer, to 0.16 mg/m^3 in the old dryer room with an average of 0.09 mg/m^3.
Personal exposure samples for total protein concentration (Table 4, 14 samples collected) ranged from non-detectable (analytical limit of detection of 0.10 mg/m^3) to 0.78 mg/m^3 in the transfer room; and from 0.16 to 0.18 mg/m^3 in the breaking room. One personal sample for the dryer operator was 0.39 mg/m^3. One sample obtained during a simulation of the cleaning of a dryer was non-detectable. Two personal samples for the packaging operator were 0.63 and 2.6 mg/m^3.[6] One personal sample for the inedible disposal operator was 0.18 mg/m^3.

Area samples for total and respirable protein concentration (Table 4) were non-detectable in the mezzanine area of the new dryer, and in the packaging area of the old dryer. Measured total and respirable protein concentrations near the old dryer were 0.39 mg/m^3 and 0.48 mg/m^3, respectively. Measured total and respirable protein concentrations in the packaging area for the new dryer were non-detectable and 0.37 mg/m^3, respectively.

Bulk samples of the egg products produced at the plant measured 28 to 43% protein (Table 5).

The sample of dirty wash water contained 19 mg/ml of protein (Table 5).

The eight personal exposure samples for ovalbumin ranged from 6.8 ug/m^3 in the breaking room to 188 ug/m^3 for the dryer cleaning simulation; ovomucoid concentration ranged from non-detectable (1.0 mg/m^3 limit of detection) in the breaking room to 113 ug/m^3 in the transfer room; and lysozyme concentration ranged from non-detectable (0.03 ug/m^3 limit of detection) to 3.5 ug/m^3 in the transfer room (Table 6).

B. MEDICAL/EPIDEMIOLOGIC

Data for each participant in the follow-up survey were summarized in tabular form in the interim report distributed in October 1987. We determined that one participant in the study had "probable egg asthma", by our survey-based criteria (summarized in Table 7). His case history follows. The ID number corresponds to the data tabulated in the interim report.

ID 70l6: This participant had been employed at Siouxpreme Egg Products Inc. for approximately three years prior to our survey. He had a two pack-year history of smoking. He had been diagnosed to have asthma by a physician approximately five months prior to this survey, and at the time of the survey was using an epinephrine inhaler daily. He denied any family history of allergy. By questionnaire he reported having begun to experience chest tightness and wheezing about one year prior to this survey. This he related to specific activities at work. His symptoms occurred less frequently on days away from work and on vacations, than on days at work. He reported occasional sneezing at work, and occasional itchy, watering or tearing eyes while at work. He was not a participant in the follow-up examinations conducted during the original survey (in 1985) at Siouxpreme Egg Products Inc. The examining physician noted marked rhinorrhea, and slight wheezing on deep breathing with more marked wheezing on forced expiration. Based upon his clinical history, the examining physician concluded he had probable non-occupational asthma, and probable occupational conjunctivitis and sinusitis eye exposure to powdered egg yolk. His pulmonary function tests (forced spirometry) were normal. His PEFR determinations demonstrated only one day during which he had bronchial lability greater than 20 percent (Figure 1). He reported having exposure to egg products on all seven days tested. He was using an inhalational epinephrine preparation on all days for which he gave us peak flow determinations. He had positive skin-prick tests to conalbumin, ovalbumin, ovomucoid, lysozyme, and HS egg yolk. He had one positive RAST to ovomucoid. He had no positive skin-prick tests to common airborne allergens. His serum total IgE level was normal. A smear of his nasal discharge demonstrated numerous eosinophils, and a conjunctival smear demonstrated a few eosinophils.

There were six participants who were classified as having "possible" egg asthma. They all had symptoms on questionnaire compatible with occupational asthma, and at least one positive skin test or RAST to egg proteins. Five of the six had been asymptomatic in the first study. The sixth was previously identified as one of five original cases of "egg asthma". Three of the five had been participants in the original follow-up survey, and thus had previously had their skin test's reactivity and RASTs to egg proteins determined. All three had previously been skin test and RAST negative. The sixth participant with "possible" egg asthma, who had previously been diagnosed in the first Siouxpreme Egg Products survey, to have IgE-mediated occupational asthma, had ceased employment approximately one year prior to this follow-up survey. She had bronchial lability on four of seven days of PEFR determinations (Figure 2). She was, however, asymptomatic throughout and thus not identifiable as either a definite or probable case of occupational asthma by our strict definition. (Our strict definition required pulmonary symptoms as the PEFR reached its daily minimum.) She was classified as a possible case of occupational asthma, since she had compatible symptoms that were temporally related to work, and she had ten positive skin-prick tests to egg products and four positive RASTs.

VIII. DISCUSSION

The original intent of this hazard evaluation, plus the similar hazard evaluation conducted at Estherville Foods (HETA 86-447) and the Ballas Food Products (HETA 86-461), was to attempt to replicate the original Siouxpreme Egg Products, Inc. study (HETA 84-163-1657) and determine if cases of Ige-mediated occupational asthma due to airborne egg exposures could be found elsewhere in the egg processing industry. An additional goal of the Estherville Foods hazard evaluation was to determine the prevalence of Ige-mediated

occupational asthma due to egg exposures at a plant where eggs were broken and separated, but not dried. We have demonstrated that Ige-mediated occupational asthma is present at each of three egg processing plants where we have conducted hazard evaluation surveys, and with longitudinal follow-up, we have found additional cases of "egg asthma" among employees of the Siouxpreme Egg Products plant. We believe the evidence to be indisputable, that the risk for Ige-mediated occupational asthma among egg-exposed workers, is generalized within the egg processing industry, and not just limited to the one plant that was the site of our initial evaluation. Overall, by plant, the prevalence of egg asthma (by restrictive case criteria) varies from five to ten percent. By job classification within plant, the prevalence is as high as 33% (among candlers at the Estherville Foods plant). Workers exposed both to liquid aerosols of raw eggs, as well as to dried egg products, develop Ige-mediated occupational asthma from egg exposures.

Employees' exposure to iodide ions, HCl and H_2SO_4 were well below any recognized exposure guidelines. The worst possible exposure scenario, considering simultaneous exposure to the three contaminants, can be calculated as follows from data in Table 1 and 2:

	Highest Concentration (mg/m^3)	Evaluation Criteria (ACGIH-TLV) (mg/m^3)
Iodine	0.028	1
HCL	0.030	7
H_2SO_4	non-detected	1

$$\frac{0.028}{1} + \frac{0.030}{7} + \frac{0}{1} = \text{guidance value}$$

$$0.028 + 0.004 + 0 = 0.032$$

If the guidance value exceeded one, the exposure would be considered potentially hazardous. Since it is well below this value, it is unlikely that the exposures will cause adverse health effects unless these substances are playing a role in the sensitization process or if an individual is particularly sensitive.

Total and respirable dust (aerosol mass) exposures were all below applicable recommendations and standards. For corresponding samples, respirable aerosol mass levels were much lower than total aerosol mass levels. Evaluating the employees' exposure to total and respirable protein and aeroallergens (ovalbumin, ovomucoid, and lysozyme) is difficult. There are no occupational exposure standards or recommendations specific for egg dust. Egg proteins can cause allergic reactions. Thus, the nuisance dust recommendations are not applicable. Control of occupational asthma among egg exposed workers will require adherence to exposure levels that are more restrictive than the closest prevailing standards.

This study demonstrated the presence of airborne proteins and aeroallergens in areas where both wet and dry processes were being performed. Exposures to egg protein can occur as a consequence of aerosolization of dirty

egg washer water which was shown to contain up to 19 mg/ml of protein. Candlers appear to be most heavily subjected to the steam exposures from egg washers. Exposures to egg protein dust can occur at the drying and packaging operations. The dried egg products contain 28 to 43% protein by weight.

Although total aerosol concentration was low (0.95 mg/m^3 on a sample taken in the transfer room), this sample had the highest concentration of ovomucoid (113 ug/m^3). The sample with the highest total aerosol concentration (14 mg/m^3), a personal sample collected on the packaging operator, had no detectable

lysozyme. Thus, it appears that total aerosol concentration does not adequately reflect exposure to specific aeroallergens.

IX. RECOMMENDATIONS

A. Environmental

Recommendations have previously been made that are applicable to controlling airborne egg exposures at this plant. These recommendations were contained in the report of the first hazard evaluation, where "egg asthma" was first identified [1], in the control technology report written in support of the follow-up evaluation at Siouxpreme Egg Propducts (HETA 86-446)[17], in the letter following the industrial hygiene walk-through survey at Ballas Egg Products, and in the interim report of the medical survey at Ballas Egg Products. The following recommendations are compiled verbatim from these original sources.

Occupational exposures can be controlled by the application of a number of well-known principles, including engineering measures, work practices, and personal protection. 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/equipment modification, isolation or automation, local ventilation) and work practices, are generally the preferred and most effective means of control both in terms of 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 isolated control rooms, isolation booths, fresh-air showers, improved work practices, and personal protective equipment.

In general, a combination of the above control measures is required to provide worker protection. Process and workplace monitoring devices, personal exposure monitoring, and medical monitoring are important mechanisms for providing feedback concerning effectiveness of the controls in use. Ongoing monitoring and maintenance of controls to insure proper use and operating conditions, and the education and commitment of both workers and management to occupational health are also important ingredients of a complete, effective, and durable control program.

These principles of control apply to all situations but their optimal application varies from case to case. A discussion of the probable exposure sources as well as the application of the above principles are discussed in the following sections for each processing area.

Transfer room: Visible aerosol escaped from the freshly washed eggs, from the conveyor entrance and exit to the washer. Since the wash water is contaminated by broken eggs and is recirculated for the five-hour production run, this mist may be an important source of exposure to egg protein. The breaking room is maintained under positive pressure. Therefore, any mist generated during egg breaking escapes through the transfer/breaking windows into the transfer room. The control strategy addresses the two major aerosol sources (the washer and the transfer window) and the lack of fresh air supply to the area.

Although the halogen (chloride or iodide) ions in the egg washing area do not appear to be the cause of the asthmatic symptoms, the ventilation system from the washing machines could be connected directly to a roof mounted fan. This would provide more positive removal of the decontamination mist.

Ideally, all the mist sources in the breaking room could be controlled, thus eliminating the transfer/breaking windows as an exposure source for the workers in the transfer room. Because of the difficulty involved in accomplishing complete control in the breaking room, exhaust hoods should be placed directly above the transfer/breaking windows to contain the air leaving the breaking room.

To prevent localized cold/hot spots, and to avoid drafts, the air exhausted from the transfer room should be replaced with clean, tempered air. This make-up air should be distributed within the transfer room. To receive the maximum benefit from this clean air, it should be introduced directly above the candler and loader work stations in the form of a low velocity air shower.

Breaking room: The control strategy for the breaking room has three elements: minimizing the generation of egg-containing aerosol, containing the escape of the generated aerosol, and diluting any aerosol that may escape.

The egg breaking machines utilize compressed air to remove egg shells and/or yolk. Pressure gauges should be installed on each machine and the pressure reduced to the minimum necessary to accomplish the task of shell and/or yolk removal. Venturi type nozzles are available which use a small quantity of compressed air to induce motion of the ambient air. This type of nozzle operates at much lower pressures resulting in more air movement at lower air velocity, thereby reducing the probability of atomization, and lowering noise levels.

The egg breaking machine should be enclosed as much as possible. Local exhaust ventilation in the breaking room should be provided to contain the mist generated by the egg breaking machines. Exhaust hoods should be installed over the transfer room windows. To receive the maximum benefit from the clean makeup air, it should be introduced directly above the breaking machine operators.

Packaging operations: The packaging operation is labor intensive, requiring repetitive lifting of filled boxes and many steps for the completion of each package. Several dust sources were observed during the operation: 1) the sock fill spout; 2) the open bags during filling at the fill spout and during weighting on the scale; 3) the open surplus container beside the scale; and 4) the bag as air is squeezed out in preparation for tying closed. Local exhaust ventilation should be provided at all points of transfer of dried product, to control dust during filling operations. The discharge from a roof mounted exhaust fan should be away from all possible air inlets to prevent reentrainment of egg dust. This system should adequately protect workers from large quantities of egg dust, but will not protect the sensitized worker from exposure to low levels of egg dust.

The operator's potential dust exposures can be further reduced by better utilizing the fresh air supply into the packaging room. The existing fresh air duct should be redirected to an airscreen located above the operator's primary work station in front of the fill spouts.

Dryers: It is recommended that as a minimum, dust-exposed operators wear a NIOSH-approved dust and mist respirator during cleaning of the dryer. Employees should be instructed in the proper use and care of respirators, as part of an overall respirator program.

Dust-exposed employees should be instructed not to blow their clothes off with a compressed air hose.

B. Medical

Every worker with asthma related to workplace exposure to egg proteins should be offered a work assignment that will minimize inhalational egg exposure. Each worker should be assessed by a physician conversant in the management of the asthmatic patient, and receive optimal therapy for treatment of asthma.

Each worker who develops episodic wheezing, shortness of breath, and/or chest tightness, or other symptoms compatible with asthma, should be evaluated for workplace-related asthma. The diagnosis requires a compatible history, with documentation of reversible episodic airways obstruction. If occupational asthma is diagnosed, then the preceding recommendation would apply.

Persons in whom IgE-mediated hypersensitivity reactions have been documented should not receive immunizations with vaccines grown in eggs. Such vaccine most likely to be offered to an adult is the influenza vaccine. Yellow fever vaccine is also manufactured in eggs, and would be contraindicated.

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XI. ACKNOWLEDGMENTS

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XII. Distribution and availability of report

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 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 address. Copies of this report have been sent to:

1. Siouxpreme Egg Products, Inc., Sioux Center, Iowa
2. NIOSH, Region VIII
3. OSHA, Region VII
4. Grading Branch, Poultry Division AMS, U.S. Department of Agriculture, Washington, D.C.

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 calandar days.

Table 1

Area Iodide Ion Sample Results

Siouxpreme Egg Products
Sioux Center, Iowa
HETA 86-446

March 26, 1987

Sample Description				
Area	Job Description/Location	Time	Volume (m^3)	Iodide Ion Concentration (mg/m^3)
Transfer Room	Candling area-line No. 3	0822-1149	0.21	0.028
Transfer Room	Loading area-line No. 4	0823-1148	0.21	ND
Breaking Room	Breaking machine-line No. 3	0825-1143	0.20	ND
OSHA*				1.0 TWA (as iodine)

Analytical Limit of Quantitation: 0.01 mg/sample (approximately 0.05 mg/m^3)
Limit of Detection: 0.005 mg/sample (approximately 0.025 mg/m^3)

ND = Non Detectable Concentration
* = Evaluation criteria is the Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) as a time-weighted average (TWA) concentration.

Table 2

Area Acid Gases Sampling Results

Siouxpreme Egg Products
Sioux Center, Iowa
HETA 86-446

March 25, 1987

Area	Sample Description: Job Description/Location	Time	Volume (m^3)	Acid Gas Concentration (mg/m^3): Hydrochloric Acid	Sulfuric Acid
Transfer room	Candling area-line no.3	0734-1526*	0.083	0.030	ND
Transfer room	Loading area-line no. 3	0732-1526*	0.085	0.022	ND
Breaking room	Breaking machine-line no. 2	0735-1528*	0.079	0.008	ND
OSHA				7.0 (ceiling)	1.0 (TWA)

Analytical Limit of Detection: for hydrochloric acid 0.006 mg/sample (approximately 0.007 mg/m^3)
for sulfuric acid 0.004 mg/sample (approximately 0.04 mg/m^3)

ND = Non-Detectable Concentration
* = Sampling discontinued during cleanup
** = Evaluation criteria is the Occupational Safety and Health Administration (OSHA) permissible exposure limit as a ceiling or time-weighted average (TWA) concentration.

Table 3

Area Aerosol Mass Sampling Results

Siouxpreme Egg Products
Sioux Center, Iowa
HETA 86-446

March 25-26, 1987

Sample Description				Aerosol Mass Concentration (mg/m^3)	
Area	Job Description/Location	Time	Volume (m^3)	Total	Respirable
Breaking room	Breaking machine-line no. 2	0735-1528*	0.83	1.1	-
Breaking room	Breaking machine-line no. 3	0750-1533	0.93	0.65	-
New dryer	On mezzanine near hopper	0715-1533	1.0	0.05	-
New dryer	On mezzanine near hopper	0715-1533	0.85	-	0.07
Old dryer	On window ledge in old dryer room	0737-1545	0.94	0.31	-
Old dryer	On window ledge in old dryer room	0737-1544	0.83	-	0.16
Packaging (new dryer)	On sink near weighing station	0736-1549	0.99	2.2	
Packaging (new dryer)	On sink near weighing station	0736-1547	0.83	-	0.10
Packaging (old dryer)	On shelf near weighing station	0853-1609	0.87	0.33	-
Packaging (old dryer)	On shelf near weighing station	0853-1609	0.74	-	0.03

Analytical Limit of Detection: 0.01 mg/sample

* = Sampling discontinued during cleanup

Table 4

Personal and Area Protein Sampling Results

Siouxpreme Egg Products
Sioux Center, Iowa
HETA 86-446

March 25-26, 1987

Sample Description				Protein Concentration (mg/m^3)		
				Area		Personal
Area	Job Description/Location	Time	Volume (m^3)	Total	Respirable	Total
Egg warehouse	On stand near warehouse doors	0720-1522	0.96	0.14	-	
Flat washing	On beam over flat washer	0850-1607	0.87	ND	-	
Inedible disposal	Inedible disposal operator	0743-1532*	0.75	-	-	0.18
Transfer room	Loader (boxes) - line no. 2	0737-1524*	0.82	-	-	0.78
Transfer room	Candler/loader - line no. 1	0738-1449*	0.74	-	-	0.74
Transfer room	Loader(boxes) - line no. 6	0740-1540*	0.84	-	-	0.38
Transfer room	Loader (boxes) - line nos. 1,2, &3	0740-1526	0.81	-	-	0.46
Transfer room	Loader (boxes) - line nos. 1,3, &4	0744-1525*	0.79	-	-	ND
Transfer room	Candler/loader - all 6 lines	0745-1527*	0.79	-	-	0.54
Breaking room	Breaker - line no. 6	0730-1527*	0.83	-	-	0.16
Breaking room	Breaker - line no. 5	0731-1530*	0.81	-	-	0.18
Breaking room	Breaker - line no. 4	0734-1430*	0.70	-	-	0.16
New dryer	On mezzanine near hopper	0715-1533	1.0	ND	-	-
New dryer	On mezzanine near hopper	0715-1533	0.85	-	ND	-
Old dryer	Dryer cleaning simulation	1358-1421	0.046	-	-	ND
Old dryer	On window ledge in old dryer room	0737-1544	1.0	0.39	-	-
Old dryer	On window ledge in old dryer room	0737-1545	0.83	-	0.48	-
Dryer rooms	Dryer operator	0810-1442*	0.66	-	-	0.39
Packaging (both dryers)	Packaging operator	0752-1445*	0.71	-	-	2.6
Packaging (both dryers)	Packaging operator	0730-1432*	0.64	-	-	0.63
Packaging (new dryer)	On sink near weighing station	0736-1550	0.99	ND	-	-
Packaging (new dryer)	On sink near weighing station	0736-1549	0.84	-	0.37	-
Packaging (old dryer)	On shelf near weighing station	0853-1609	0.87	ND	-	-
Packaging (old dryer)	On shelf near weighing station	0853-1609	0.74	-	ND	-

Analytical Limit of Quantitation: 0.10 mg/sample (approximately 0.10 mg/m^3)

ND = Non-Detectable Concentration
* = Sampling discontinued during lunch break.

Table 5

Bulk Sample Protein Results

Siouxpreme Egg Products
Sioux Center, Iowa
HETA 86-446

March 25-16, 1987

Sample Description	Protein Concentration
Dirty wash water from transfer line No. 6	19mg/ml
Free flow dried whole egg solids	43g/100g
Free flow dried egg yolks	37g/100g
Dried egg yolks	34g/100g
Dried whole egg solids	45g/100g
Free flow dried whole egg solids	42g/100g
Dried egg product	28g/100g

g = grams

Table 6

Personal and Area Aeroallergen Sampling Results

Siouxpreme Egg Products
Sioux Center, Iowa
HETA 86-446

March 24-26, 1987

Sample Description					Aeroallergen Concentration (ug/m^3)			Total Aerosol Concentration (mg/m^3)
Area	Job Description/Location	Type	Time	Volume (m^3)	ovalbumin	ovomucoid	lysozyme	
Transfer room	Candler/loader-line no. 5	P	0742-1524*	0.81	107	113	3.5	0.95
Breaking room	Breaker-line No. 4	P	0739-1535*	0.71	6.8	0.06	ND	0.30
New dryer	On mezzanine near hopper	A	0715-1533	1.0	39	2.7	0.05	0.15
Old dryer	Dryer cleaning simulation	P	1358-1421	0.05	188	9.6	ND	6.3
Dryer rooms	Dryer operator	P	0741-1434	0.83	132	47	ND	1.3
Packaging (new dryer)	Packaging operator	P	0727-1437*	0.70	140	51	ND	14
Packaging (new dryer)	On sink near weighing station	A	0736-1550	0.99	108	53	ND	2.5
Packaging (old dryer)	On shelf near weighing station	A	0818-1609	0.94	45	15	0.04	0.63
Analytical limit of detection: (approximate)					1.0	1.0	0.03	0.01

P = Personal Sample
A = Area Sample
ND = Non-Detectable Concentration
* = Sampling discontinued during lunch break

Table 7

Survey-Based Diagnostic Criteria
Derived from Questionnaire Responses, Peak Flow Data,
and Immunologic Tests

Siouxpreme Egg Products
Sioux Center, Iowa

HETA 86-446

	Probable Egg Asthma	Possible Egg Asthma	Possible Non-Occup. Asthma	Possible Irritant Symptoms
Work-related symptoms	YES	YES	YES	YES
Symptomatic bronchial lability	YES	NO	YES	NO
One or more positive prick-tests or RASTs to egg proteins	YES	YES	NO	NO

Figure 1

PEAK EXPIRATORY FLOW RATE
CASE NO. 6, ID 7016

Siouxpreme Egg Products
Sioux Center, Iowa

HETA 86-446

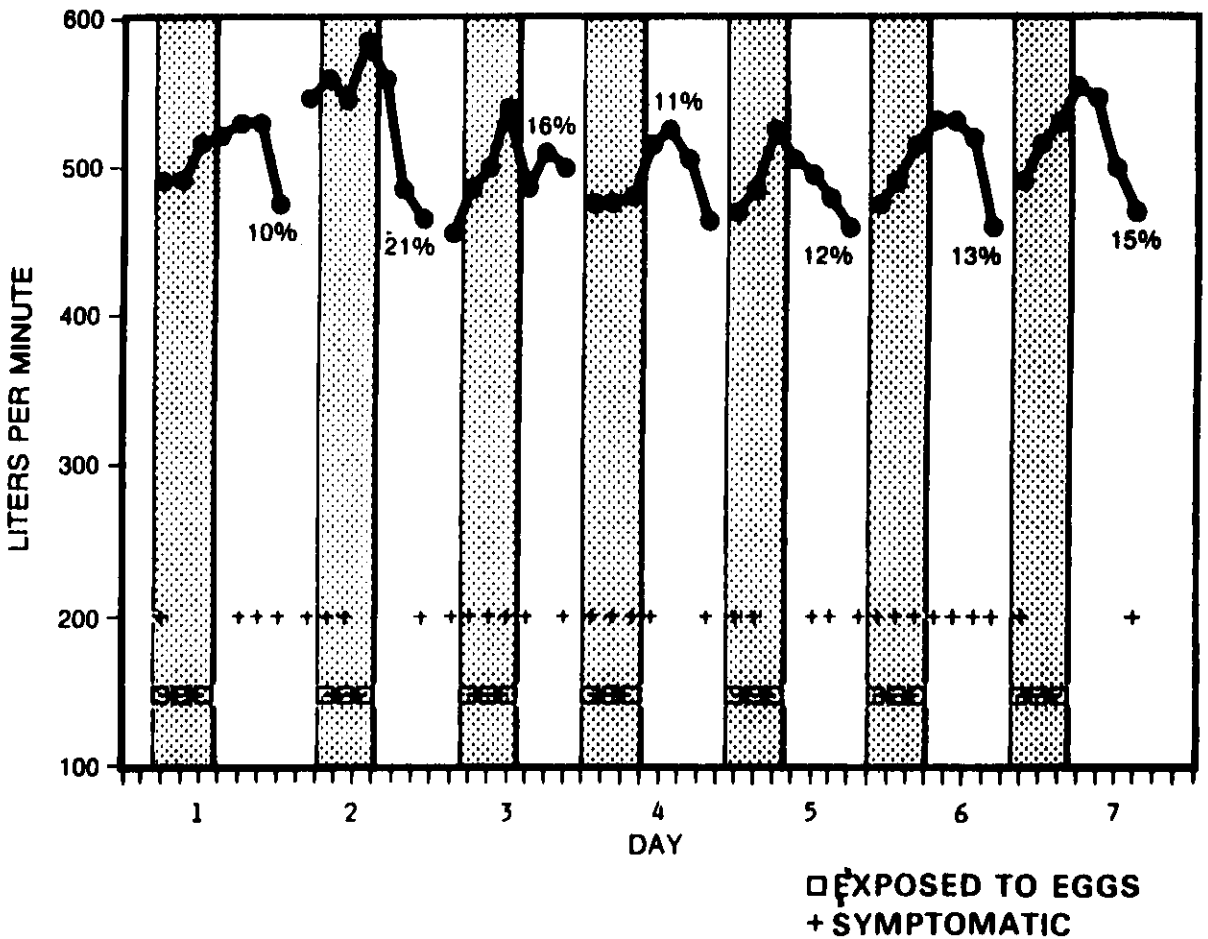

Figure 2

PEAK EXPIRATORY FLOW RATE
CASE NO. 2

Siouxpreme Egg Products
Sioux Center, Iowa

HETA 86-446