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BALLAS EGG PRODUCTS CORPORATION
ZANESVILLE, OHIO

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I. SUMMARY

On July 21, 1986, the National Institute for Occupational Safety and Health (NIOSH) received a request to evaluate occupational exposures to raw and dried egg products at the Ballas Egg Products plant in Zanesville, Ohio. Workers at a similar plant had previously been documented to have IgE-mediated occupational asthma from airborne egg protein exposure. The intent of this evaluation was to replicate the previous findings, and determine the risk for IgE-mediated occupational asthma among employees of the Ballas Egg Products plant. An initial site visit and walk-through survey were conducted by NIOSH personnel on September 18, 1986. A combined medical and industrial hygiene survey was undertaken during February 23-26, and March 3-5, 1987.

Employees' exposures to chloride ions and acid gases were all below applicable standards. Ambient air concentration of chloride ions was less than 0.065 milligrams per cubic meter (mg/m^3). Ambient air concentration of hydrochloric acid (HCL) was less than 0.36 mg/m^3. Ambient air concentration of sulfuric acid (H_2SO_4) was less than 0.48 mg/m^3. Three area samples for total aerosol mass concentrations exceeded recommended limits with levels ranging from 11 to 31 mg/m^3. Corresponding samples for respirable aerosol mass concentrations were all below recommended limits with levels less than 0.66 mg/m^3.

Ambient air concentration for total protein ranged from 0.17 to 130 mg/m^3. Respirable protein concentrations were all less than 0.77 mg/m^3. Ambient air concentrations of ovalbumin, ovomucoid, and lysozyme were less than 223 micrograms per cubic meter (ug/m^3), 351 ug/m^3, and 672 ug/m^3, respectively. 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 35 to 81%. A sample of used egg wash water contained 1 mg/ml of protein.

Eight employees were determined to have 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). Six of the eight had peak expiratory flow rate (PEFR) measurements suggestive of bronchial lability, and three of these had a pattern of peak flow rate measurement that was obviously work-related. The overall estimated prevalence of IgE-mediated occupational asthma from egg protein exposures at this plant was eight percent. The estimated prevalence varied by job classification, and was highest among egg breakers, being 16% for workers in this job classification.

On the basis of these data, NIOSH investigators have determined that a health hazard existed among employees of the Ballas Egg Products plant in Zanesville, Ohio, from occupational exposure to egg protein. Recommendations to reduce exposures to egg protein, and for screening of at-risk workers, are made in Section IX of this report.

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

II. INTRODUCTION

On July 21, 1986, NIOSH received a request from the president of Ballas Egg Products Corporation to evaluate occupational exposures to raw and dried egg products at the Ballas Egg Products plant in Zanesville, Ohio. An initial site visit and walk-through survey were conducted by NIOSH personnel on September 18, 1986. A combined medical and industrial hygiene survey was undertaken during February 23-26, and March 3-5, 1987. Each participant in the medical study was notified of the results of his or her medical examinations on July 27, 1987. An interim report summarizing the results of the medical survey was distributed in October, 1987.

III. BACKGROUND

In 1986, 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 Eggs 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, reprinted in the Journal of the American Medical Association, and published in the American Journal of Industrial Medicine, and the Journal of Allergy and Clinical Immunology.[2-5]

On July 15, 1986, 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 the Siouxpreme Egg Products hazard evaluation should be replicated, to determine if the occurrence of five cases of IgE-mediated occupational asthma from egg protein exposure at this plant was an isolated incident, or if IgE-mediated occupational asthma from eggs is present among workers in other facilities. The president of Ballas Egg Products Corporation attended this meeting, and requested an evaluation of workers at his plant in Zanesville, Ohio. Workers at Ballas Egg Products Corporation break and separate raw eggs, and dry the separated whites, yolks, and whole egg products.

IV. PROCESS DESCRIPTION

Ballas Egg Products Corporation began operations in the 1940s in Zanesville, Ohio. Operations initially were limited to breaking and separating egg yolks and white. Drying of egg products started in the 1960s. Approximately one million eggs per day are broken. Breaking operations at the plant are structured around a 10-hour workshift,
4 days a week, Mondays through Thursdays. The egg drying processes are structured around three 8-hour workshifts, operating 24 hours each day. Approximately 100 people work at the plant. Typically, there are four office/administrative personnel, three in shipping and receiving, three in maintenance, 30 to 40 in the transfer room, 12 in the breaking room, 12 in fermentation and blending, 12 in drying, and six in night clean-up.

Semi-trailer shipments of eggs on pallets are brought into the inspection or "transfer" area by materials handlers using battery-powered manually operated forklifts. Cases of eggs are stacked on a roller/conveyor near a worker called

the "loader". The loader places two cartons of 30 eggs per carton onto the loading section of a washing machine, from which the eggs are pneumatically carried to the "leaker inspector" station, via suction cups, one per egg. Following transfer from the "loader" to the "leaker", eggs are placed on a rubberized conveyor which carries them into the washing tunnel of the washing machine. The "leaker inspectors" look for eggs that "leak" due to cracks, and set aside cracked eggs for manual breaking operation. If a cracked, leaking egg is too dirty to be manually cracked, it is discarded and sent for further processing (separation of liquid from the shell, by centrifugation) for sale of the liquid egg to a pet food company.

Eggs are washed in six automated egg washing machines. Within the washers, they are spray washed with a detergent solution of "Best Eggs Plus", which is a chlorinated egg washing detergent whose active ingredients are sodium metasilicate and sodium dichloroisocyanurate. The wash water is filtered and recirculated continually at approximately 100 degrees Fahrenheit during a five hour cycle. Aerosolization of the recirculated wash water was evident during the walk-through survey. After passing through a clean water rinse, the eggs are sprayed with a chlorinated sanitizer, whose active ingredient is sodium hypochlorite. As they exit the washing tunnel of the washing machines on the rubberized conveyor, the eggs are inspected by "candlers", who look for opacities and check for cracks. If necessary, the candlers wash eggs by hand using a scratch pad, and rinse them under a stream of chlorinated water. Eggs that are still dirty, or cracked or broken, are removed from the conveyor. Otherwise, they pass through a window in a wall, into the breaking room.

Once every hour, the leaker inspectors, loaders, and candlers rotate clockwise on their jobs. Usually, a machine is run by one loader, one leaker inspector, and two candlers.

The washed and candled eggs enter the breaking room on the same continuous conveyors that transported them through the washing machines. They fall onto the continuous chains of six breaking machines. The eggs are gripped mechanically, the shells broken and separated, and the contents dropped into separating cups. The yolks are trapped in the cups, and the white flows through. As the cups pass by the breaking machine operator, the operator must make a decision on the thoroughness of each break. If the separation of yolk and white is clean, the operator lets the cup pass by, and the resulting product streams are the separated egg yolks and egg whites. If the separation is not good, or the yolk is broken, the operator tips the cup, which sends the whole egg product into another collection system. An air valve, located under the cup, blows air across the broken eggs while still in the cups, toward the nose of the operator. The operator, thus can both see and smell any rotten egg. If a rotten egg has gotten through the washing and candling process, the operator will stop the breaking machine and remove it.

Approximately 65% of the eggs are dried, and the rest are sold either liquid or frozen. Egg whites are fermented to remove sugar, prior to drying. There are two white dryers and one yellow dryer, each of which feeds a "Rotex" or sifter. Following sifting, the dried product is augered out to packaging. In the blending room, drums of dried egg yolk solids are dumped into ribbon blender with Zeolex (sodium aluminosilicate).

Liquid product is canned and frozen in the "canning room". This is not a regular job, and typically transfer room personnel are assigned to this operation.

A cleaning crew cleans all washing and breaking machinery, beginning at 5:00 P.M.

V. METHODS

A. ENVIRONMENTAL

From March 3-5, 1987, air sampling was conducted in the transfer room, the breaking room, the white and yellow dryer areas, and the blend packaging room. The sampling focused on the three most apparent agents in the workplace that could cause irritant respiratory symptoms or occupational asthma, namely, chloride ions, and acid gases (HCl and H_2SO_4) from the detergent solution, and egg dust from the product the plant produces.

Chloride ion: Two area samples were collected in the transfer area, 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, using a DIONEX 2010i ion chromatograph.[6]

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

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 weighings 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.

Bulk samples of clean and dirty sanitizer water were obtained from the transfer and breaking rooms, and analyzed for total protein.

Bulk samples of dried egg materials were also obtained and analyzed for total protein concentration.

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

B. MEDICAL/EPIDEMIOLOGIC

The medical survey procedures were similar to those used previously at Siouxpreme Egg Products, Incorporated.[1] We administered a questionnaire to every available employee at the plant, to identify workers with symptoms suggestive of occupational asthma. These were, as demonstrated previously, episodic wheezing, shortness of breath, and/or chest tightness, occurring following specific activities or exposures at work, and occurring less frequently or not at all on days away from work and on vacations. We invited all respondents who reported wheezing; and/or shortness of breath and chest tightness; regardless of temporal relationship to work; and an approximately equal number of respondents with none of these chest symptoms to participate in follow-up examinations. [Note: This criterion for inclusion in the follow-up examinations, differs from the criterion established for the hazard evaluation at the Estherville Foods plant, HETA 86-447. At Estherville Foods, the symptomatic respondents, invited to participate in the follow-up examinations, must have had their symptoms temporally related to work, in a pattern as described above.] In the follow-up survey:

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% of predicted, a forced vital capacity (FVC) less than 80% of predicted, or an FEV1/FVC ratio less than 0.7.[9]

3. 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% of the day's maximum PEFR, and he/she reported wheezing, shortness of breath, or chest tightness at the time the PEFR reached the daily minimum.[10]

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 unit 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, 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.[1,4]

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 the 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 even though 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 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 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, 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. Chloride ions

There are no applicable exposure standards for chloride ions. The OSHA PEL for exposure to chlorine is 3 mg/m^3 as a ceiling level, not to be exceeded at any time. The NIOSH REL is 1.5 mg/m^3 as a 15 minute ceiling. The ACGIH has noted an intended change in the TLV from 3 mg/m^3 to 1.5 mg/m^3 as a TWA and intends to add a short term exposure limit (STEL) of 3 mg/m^3.

Exposure to chlorine can cause coughing, shortness of breath, itching or burning of the eyes, nose, and throat.[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_2S0_4 are all 1 mg/m^3 as TWAs. Exposure to H_2S0_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 chlorine, 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 1987-1988, 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 one
where T_1 = TLV for chemical one

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 is 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 is 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

The three area samples had chloride ion concentrations (Table 1) of 0.023 mg/m^3, 0.056 mg/m^3, and 0.065 mg/m^3, with an average of 0.048 mg/m^3. Two of three area samples for acid gases (Table 2) were non-detectable (limit of detection 0.007 mg/m^3 for HCl and 0.044 mg/m^3 for $H_2 SO_4$). One sample each for HCl and for H_2SO_4 were 0.036 mg/m^3 and 0.48 mg/m^3, respectively.

The six area samples for total aerosol mass concentration (Table 3) ranged from 0.06 mg/m^3 in the yellow dryer rotex room to 31 mg/m^3 in the blend packaging room. Corresponding samples for respirable aerosol mass concentration (Table 3) ranged from 0.01 mg/m^3 in the yellow dryer rotex room to 0.66 mg/m^3 in the blend packaging room. The average respirable aerosol mass concentration was 0.27 mg/m^3.

Personal exposure samples for total protein concentration (Table 4) ranged from 0.31 to 0.48 mg/m^3 in the transfer room (seven samples collected); and from 0.17 to 0.38 mg/m^3 for breakers (three samples collected). Personal exposure samples for the yellow dryer operator and the yellow dryer rotex operators were 0.72 mg/m^3 and 0.37 mg/m^3, respectively. The personal exposure sample for the white dryer operator was 10.0 mg/m^3, while the personal exposure samples for the blend packaging room operator ranged from 11 to 130 mg/m^3.

Area samples for total protein concentration (Table 4) were 0.23 mg/m^3 and 0.30 mg/m^3 in the yellow dryer rotex room; 8 mg/m^3 and 25 mg/m^3 in the white dryer rotex room; and 32 mg/m^3 in the blend packaging room.

Area samples for respirable protein concentration (Table 4) were 0.22 mg/m^3 and 0.40 mg/m^3 in the yellow dryer rotex room, 0.72 mg/m^3 and 0.77 mg/m^3 in the white dryer room, and 0.35 mg/m^3 and 0.41 mg/m^3 in the blend packaging room. The average respirable protein exposure concentration was 0.48 mg/m^3.

Over the course of a work-shift, protein concentration in the sanitizer water from the transfer area increased from 0.35 mg/ml, to 1.0 mg/ml. Protein concentration in the sanitizer water from the breaking area increased from 0.10 mg/ml, to 0.64 mg/ml. (Table 5).

Bulk samples of the egg products produced at this plant measured 34-8l% protein (Table 5).

The 10 personal exposure samples for ovalbumin ranged from 2.1 ug/m^3 for the yellow dryer rotex operator to 161 ug/m^3 for the blend packaging room operator; ovomucoid concentration ranged from non-detectable (l.0 ug/m^3 limit of detection) for the yellow dryer rotex operator to 351 ug/m^3 for the white dryer operator; and lysozyme concentration ranged from non-detectable (0.03 ug/m^3 limit of detection) to 672 ug/m^3 for the white dryer operator (Table 6).

B. MEDICAL/EPIDEMIOLOGIC

(1) CASE HISTORIES

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 six participants in the study had "probable egg asthma", by our survey-based criteria (summarized in Table 7). For three of these probable egg asthmatics, the PEFR data showed an obvious temporal relationship to work. Their case histories follow. ID numbers correspond to the data tabulated in the interim report.

> ID 6038: This participant had been employed at Ballas Egg Products Corporation for less than one year. Her jobs had included candling, and breaking eggs. She had a 13 pack-year smoking history. She denied any personal or family history of asthma, hayfever, or eczema. By questionnaire, she stated that during the month she was hired, she began to experience shortness of breath which she related to work, and which occurred less frequently on days away from work than on workdays. Approximately five months prior to the survey, she began to experience wheezing, which she did not specifically relate to workplace exposures. Nevertheless, the wheezing occurred less frequently away from work than on workdays. She had noticed daily, an itchy, runny, stuffy, nose and frequent sneezing at work. The examining physician noted slight wheezing on forced expiration, and based on her clinical history, concluded that she had irritant symptoms on occupational exposure to chlorine and to cleaning solutions. However, the possibility of occupational asthma was also suggested by her history, and could not be excluded by clinical evaluation. Her pulmonary function tests (forced spirometry)

were normal. Her PEFR over seven days, demonstrated symptomatic bronchial lability temporally related to work (Figure 1). Specifically, she was exposed to egg products on four of seven days, and on each of these four days had greater than 20 percent bronchial lability. On three of seven days she was not exposed to egg products, and on each of those days her bronchial lability was less than 20 percent. In addition, on three of the four days on which she was exposed to egg products, her peak flow tracing yielded an obvious "U-shaped" pattern. She had positive skin-prick tests to factory whole egg, factory egg white, HS egg white, and ovalbumin. Her RASTs were all negative. She had one positive skin-prick test to common airborne allergens, namely, cat hair.

ID 6050: This worker had been employed at Ballas Egg Products Corporation for over twenty years, as a candler, a breaker, and an egg inspector. She had never smoked cigarettes. Approximately 4 years prior to our survey, she had been diagnosed by a physician to have asthma. At the time of the survey, she was taking oral theophylline, a bronchodilating drug. As well, she stated that she previously had received prednisone and albuterol by inhalation. She denied any personal history of eczema, hay fever, or other allergies. She had a family history of asthma and hay fever. By questionnaire, she reported wheezing, shortness of breath, and chest tightness that had begun approximately one and one-half years prior to our survey. This she related to activities at work. The wheezing and chest tightness occurred less frequently on days away from work than on workdays. However, the shortness of breath occurred the same on days away from work as well as on workdays. She denied nasal or eye symptoms while at work. The examining physician found her focused physical examination to be unremarkable, and diagnosed non-occupational asthma. Her pulmonary function tests (forced spirometry) were normal. Her PEFR determination demonstrated bronchial lability during two of four days when she had occupational exposure to egg products (Figure 2). Interestingly, these two days followed three days during which she stated she was not exposed to egg products. On the three days when she was not exposed to egg products, her bronchial lability was less than 20 percent. She was taking oral theophylline on all days for which PEFR determinations were made. She had positive skin-prick tests to HS egg white and egg yolk, and to conalbumin, ovalbumin, ovomucoid, and lysozyme. She had positive RASTs to factory whole egg and factory egg yolk, conalbumin, lysozyme, and ovomucoid. As well, she had a moderately elevated total serum IgE level.

ID 6065: This participant had worked at Ballas Egg Products Corporation for over ten years. She had worked as a candler, and as an egg breaker. She had never smoked cigarettes. She stated that she had been diagnosed by a physician to have asthma approximately three years prior to our survey. She denied any personal history of eczema, hayfever, or other allergies. She had no family history of asthma, hayfever, or eczema. By questionnaire, approximately three and one-half years prior to our survey, she began to experience wheezing and shortness of breath which she related to workplace exposures. Her symptoms occurred less frequently on days away from work than on workdays. She noticed chest tightness beginning approximately two years prior to our survey, which also occurred after workplace exposures and less frequently on days away from work than on workdays. She denied nasal symptoms, but occasionally had itchy, watery, or teary eyes while at work. The examining physician noted slight wheezing on

forced expiration, and diagnosed her possibly to have occupational asthma with associated sinusitis, and irritant symptoms on exposure to chlorine and cleansing solutions. Her pulmonary functions tests (forced spirometry) demonstrated an obstructive pattern. Her PEFRs demonstrated significant bronchial lability on three of four days for which she reported egg exposure (Figure 3). On all three days when she reported no egg exposure, her bronchial lability was less than 20 percent. On all days, she was taking bronchodilating medications. She had positive skin-prick tests to factory whole egg, egg yolk, egg white; HS whole egg, egg yolk, and egg white; and to conalbumin and ovalbumin. Her serum total IgE level was normal.

Three participants who had "probable" occupational asthma by our survey-based criteria, had bronchial lability that did not obviously appear to be temporally related to work.

ID 6023: This participant had worked at Ballas Egg Products Corporation for at least 10 years, always in the candling room. She was an ex-smoker, with approximately a 20 pack-year history of smoking. She denied any previous personal or family history of asthma, hayfever, or eczema. Approximately one year prior to our survey, she began to experience wheezing, shortness of breath, and chest tightness, which she related to workplace exposures. Her symptoms did not occur at all on days away from work. She had occasional itchy, runny, stuffy nose while at work, occasional sneezing, and occasional itchy, watery, or tearing eyes while at work. The examining physician diagnosed irritant symptoms on workplace exposures, but could not exclude the possibility of occupational asthma suggested by her history. Her pulmonary function tests (forced spirometry) demonstrated a restrictive pattern. Her PEFR determinations demonstrated significant bronchial lability on six of seven days, including days both when she reported egg exposure and when she reported no egg exposure (Figure 4). Interestingly, on the last day for which she gave a PEFR determination, which followed three days when she reported no egg exposure, her PEFR demonstrated a continual fall from its maximum to its minimum, suggestive of a (Monday morning) bronchoconstrictive pattern. She had one positive skin-prick test to HS egg yolk, and one positive RAST to lysozyme. She had one positive skin-prick test to common airborne allergens, namely to mites. Her total serum IgE level was moderately elevated.

IDs 6057 and 6028 were also classified as having probable occupational asthma by our criteria. One worked as a blender, the other as an egg breaker. They both had symptomatic bronchial lability on at least one day, suggestive of asthma; their bronchial lability was not obviously temporally related to work from the PEFR tracings alone. Each had only one positive skin or RAST to egg proteins. The examining physician concluded that participant 6057 had occupational asthma with associated rhinitis, on exposure to egg yellow powder; and participant 6028 had possible non-occupational asthma, sinusitis, and conjunctivitis.

Four participants were classified as having "possible" occupational asthma by our survey-based criteria. Descriptions of the participants follow.

ID 6003: This participant had worked at Ballas Egg Corporation for over thirty years. He was a non-smoker. He had been diagnosed approximately seven years prior to our survey, to have asthma related to his exposure to egg products. He denied a history of eczema or hayfever, but

stated he was allergic to dust, molds, and grass. He denied a family history of asthma, hayfever, or eczema. By questionnaire, he reported that approximately thirty years prior to our survey he had begun to have wheezing, shortness of breath, and chest tightness, which he related to workplace exposures to dried egg whites. His symptoms occurred less frequently on days away from work than on workdays. The examining physician noted slight wheezing on forced expiration, and concluded based upon his clinical history that he probably had occupational asthma, with associated rhinitis and conjunctivitis, plus non-occupational rhinitis and conjunctivitis on exposure to grass, dusts, and molds. His pulmonary function tests (forced spirometry) demonstrated a restrictive pattern. His PEFR determinations demonstrated asymptomatic bronchial lability on one of four days for which he performed the determinations. He had positive skin-prick tests to factory whole egg and egg white; HS whole egg, egg yolk, and egg white; and to conalbumin, lysozyme, and ovomucoid. All his RASTs were negative. He had positive skin-prick tests to six common airborne allergens. His total serum IgE was normal.

ID 6019: This participant had worked at Ballas Egg Products approximately two years prior to our survey. He had a 9 pack-year history of smoking. He denied any personal or family history of asthma, eczema, or hayfever. By questionnaire, he reported wheezing and chest tightness temporally related to work, which began approximately four months after having been hired. The examining physician concluded he had irritant respiratory symptoms on exposure to chlorine and cleaning agents, but noted that the possibility of occupational asthma was suggested by his history and could not be excluded by clinical evaluation. His pulmonary function tests were normal. His PEFR determinations failed to demonstrate any significant bronchial lability. He had no positive skin-prick test to egg allergens or to common airborne allergens. He had one positive RAST to factory whole egg. His serum total IgE level was normal.

ID 6029: This participant had been employed at Ballas Egg Products Corporation for approximately six years prior to our survey. He worked in the blending room. He had a 10 pack-year smoking history. He denied any personal history of asthma, eczema, or hayfever. Approximately three and one-half years prior to our survey, he reported beginning to experience wheezing, shortness of breath, and chest tightness temporally related to work. The examining physician concluded he probably had occupational asthma with associated sinusitis, rhinitis, and conjunctivitis, on exposure to powdered egg white. His pulmonary function tests were normal. His PEFR determinations did not reveal symptomatic bronchial lability on any of seven days. He had positive skin-prick tests to four egg allergens, namely, HS whole egg and egg white, conalbumin, and lysozyme. He had positive RASTs to conalbumin and lysozyme. He had positive skin-prick tests to six common airborne allergens. His total serum IgE level was moderately elevated.

ID 6046: This worker had been employed at Ballas Egg Products Corporation for approximately six years prior to our survey. He worked in the candling room. He had a 5 pack-year smoking history. He denied any personal or family history of asthma, hayfever, or eczema. Approximately four months prior to our survey, he began to experience wheezing which he believed was

temporally related to work. The examining physician concluded he possibly had occupational asthma or exposure to dried egg powder, with associated sinusitis and conjunctivitis. His pulmonary function tests were normal, and his PEFR determinations did not reveal bronchial lability on any of the seven days for which we had data. He had positive skin-prick tests to factory whole egg and egg white; HS egg white; and conalbumin, ovomucoid, and lysozyme. He had positive RASTs to factory egg white, conalbumin, lysozyme, and ovomucoid. He had no positive skin-prick tests to common airborne allergens. His serum total IgE level was normal.

Of the other participants who were not classified as having occupational asthma, either probable or possible, a number had more than one positive skin-prick test or RAST to egg allergens. It is possible that these individuals might go on to develop occupational asthma at some later date. For instance ID 6004, who had three positive skin tests and two positive RASTs to egg proteins, was thought by the examining physician to have irritant respiratory symptoms on exposure to chlorine and cleaning solutions, with rhinitis; ID 6018, who had seven positive skin tests and five positive RASTs, was thought by the examining physician to have non-occupational sinusitis.

Two participants in the medical follow-up had changes on their pulmonary function tests suggestive of severe restrictive lung disease. These three individuals were referred to the Allergy Clinic of the Deaconess Hospital, Cincinnati, Ohio, at NIOSH's expense, to undergo further examinations to rule out the presence of interstitial lung disease. Both individuals were diagnosed by the allergy consultant to NIOSH, as having asthma, most likely occupational asthma. Neither individual had any evidence of interstitial lung disease.

(2) ANALYSIS OF MEDICAL SURVEY DATA

We administered the questionnaire to 96 of 99 (97%) current employees. Of the three non-respondents, two were unavailable for medical reasons unrelated to possible work-related respiratory disease, and one declined to participate. Responses to the screening questions, namely, wheezing, shortness of breath and chest tightness, are summarized in Table 8.

Twenty of 22 respondents who reported work-related wheezing, and/or work-related shortness of breath and chest tightness; three of nine who reported work-related shortness of breath or chest tightness alone; and 4 of 15 who reported wheezing, shortness of breath, or chest tightness, that was not work-related; participated in the follow-up examinations. Fifty denied wheezing, shortness of breath, or chest tightness. Nineteen of 30 asymptomatics who were invited, participated in the follow-up examinations.

The physician's clinical assessments, and the classifications of participants based upon the survey-based criteria, are compared in Table 9. (Note that while the physician's assessment of occupational asthma has only one category, namely, "possible", the survey-based classification of egg asthma is divided into two categories, namely, "probable" and "possible". The Kappa statistic of 0.603 demonstrates moderate agreement[15] between the two.

We are reasonably certain that the eight participants for whom there was diagnostic concordance by two independent, albeit imperfect, tests (physician's assessment and survey-based criteria) were correctly classified.[16] Tables 10 and 11 summarize by job category, the numbers of questionnaire respondents, participants in the follow-up examinations, and dually diagnosed cases of egg asthma. The estimated minimum prevalence of occupational asthma in each job category is given in Table 11. The estimated prevalences are minimum, since it is possible that one or more of the questionnaire respondents excluded from participation in the follow-up, may have had occupational asthma. The numerators of the estimated prevalence are thus minimum counts of likely egg asthmatics within the plant, while the denominators are total counts of questionnaire respondents by job classification.

The estimated minimum of prevalence of egg asthma within the plant as a whole is 8%. By current job classification, the estimated minimum prevalence varies from 0% among warehouse, maintenance and clean-up, egg yellow exposed, and "other" workers; to 16% among egg breakers. It is important to note, that egg asthma has occurred among employees exposed primarily to the liquid raw egg aerosols generated in the transfer and the breaking rooms, and among employees exposed primarily to dried egg dust in the drying and blending operations.

The estimated prevalence of egg asthma for office workers, egg white exposed, and blending workers, are based upon one case in each job classification. Because of small numbers, and the propensity for current job to misclassify workers by relevant (with respect to the precipitation of egg asthma) job exposures, any perceived trend in prevalence by job ought to be viewed with caution. For example, the office worker classified as having "egg asthma" reports he became sensitized as a consequence of his exposure to the egg white dryer. As an administrative person, he is able to avoid the circumstances that precipitate his symptoms. Table 12 summarizes the relationship of atopy and egg asthma. The prevalence odds ratio for atopy among dually classified egg asthmatics, versus non-symptomatics, within the follow-up participants, is 1.1. The prevalence odds ratio for follow-up participants with work-related symptoms, not dually diagnosed as egg asthma, versus non-symptomatics, is 0.8.

VIII. DISCUSSION

The original intent of this hazard evaluation, plus the similar hazard evaluation conducted at Estherville Foods (HETA 86-447) and the follow-up evaluation at Siouxpreme Egg Products, Inc. (HETA 86-446), was to attempt to replicate the original Siouxpreme Egg 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. 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 chloride ions, HCl, and H_2S0_4 were well below any recognized exposure guidelines. The worst possible exposure scenario, considering exposure to the three contaminants, can be calculated as follows from data in tables l and 2.

	Highest Exposure Concentration (mg/m^3)	Evaluation Criteria (ACGIH TLV) (mg/m^3)
Chloride ion	0.065	3
HCl	0.036	7
H_2SO_4	0.48	l

$$\frac{0.065}{3} + \frac{0.036}{7} + \frac{0.48}{l} = \text{guidance value}$$

$$0.02 + 0.005 + 0.48 = 0.505$$

If this guidance value exceeded one, the exposure would be considered potentially hazardous. Since it is 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.

For some samples obtained in the packaging and drying rooms, total dust (aerosol mass) recommended limits were exceeded. Respirable dust (aerosol mass) 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. However, several of the samples in the dryer and packaging operations had total protein concentrations exceeding l0 mg/m^3.

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 wash water which was shown to contain
l mg/ml of protein. Candlers appear 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 34-8l% protein.

There does not appear to be any direct correlation between any of the aeroallergens measured and total aerosol concentration.

Control of occupational asthma among egg exposed workers will require adherence to exposure levels that are more restrictive than the closest prevailing standards.

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 Products (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. 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.

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. The 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. Ballas Food Products, Inc., Zanesville, Ohio
2. NIOSH, Region IV
3. OSHA, Region V
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 Chloride Ion Sampling Results

Ballas Egg Products
Zanesville, Ohio
HETA 86-461

March 5, 1987

Sample Description				
Area	Job Description/Location	Time	Volume (m^3)	Chloride Ion Concentration (mg/m^3)
Transfer room	Loading area - line no. 5	1153-1603	0.25	0.065
Transfer room	Candling area - line no. 5	1153-1603	0.25	0.056
Breaking room	Breaking machine - line no. 5	1153-1603	0.25	0.023

Analytical Limit of Quantitation: 0.0076 mg/sample (approximate 0.03 mg/m^3)
Limit of Detection: 0.002 mg/sample (approximately 0.008 mg/m^3)

Table 2

Area Acid Gases Sampling Results

Ballas Egg Products
Zanesville, Ohio
HETA 86-461

March 4, 1987

Sample Description				Acid Gas Concentration (mg/m^3)	
Area	Job Description/Location	Time	Volume (m^3)	Hydrochloric Acid	Sulfuric Acid
Transfer room	Loading area - line no. 5	0910-1503*	0.055	0.036	ND
Transfer room	Candling area - line no. 5	0912-1505*	0.015	ND	0.48
Breaking room	Breaking machine - line no. 5	0908-1507*	0.057	ND	ND
OSHA**				7.0 (ceiling)	1.0 (TWA)

Analytical Limit of Detection: for hydrochloric acid 0.006 mg/sample
for sulfuric acid 0.004 mg/sample

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

Ballas Egg Products
Zanesville, Ohio
HETA 86-461

March 4-5, 1987

Sample Description				Aerosol Mass Concentration (mg/m^3)	
Area	Job Description/Location	Time	Volume (m^3)	Total	Respirable
Yellow dryer rotex room	Three feet from sifter filler	0851-1542	1.1	0.06	-
Yellow dryer rotex room	Three feet from sifter filler	0851-1542	0.74	-	0.01
Yellow dryer rotex room	Three feet from sifter filler	0813-1534	1.1	0.09	-
Yellow dryer rotex room	Three feet from sifter filler	0813-1534	0.75	-	0.04
White dryer rotex room	On frame above sifter	0900-1534	1.0	3.6	-
White dryer rotex room	On frame above sifter	0900-1534	0.71	-	0.48
White dryer rotex room	On frame above sifter	0759-1539	1.2	11	-
White dryer rotex room	On frame above sifter	0759-1539	0.78	-	0.25
Blend packaging room	On work table near packaging operators	0852-1455	0.91	31	-
Blend packaging room	On work table near packaging operators	0852-1455	0.65	-	0.15
Blend packaging room	Below sifter near filler	0808-1353	0.86	14	-
Blend packaging room	Below sifter near filler	0808-1353	0.59	-	0.66

Analytical Limit of Detection: 0.01 mg/sample (approximately 0.01 mg/m^3)

Table 4

Personal and Area Protein Sampling Results

Ballas Egg Products
Zanesville, Ohio
HETA 86-461

March 4-5, 1987

Sample Description				Protein Concentrations (mg/m^3)		
				Area		Personal
Area	Job Description/Location	Time	Volume(m^3)	Total	Respirable	Total
Transfer area	Candler/leaker/loader-line no. 5	0759-1626*	1.2	-	-	0.48
Transfer area	Candler/leaker/loader-line no. 5	0801-1630*	1.2	-	-	0.48
Transfer area	Candler/leaker/loader line no. 6	0753-1625*	1.2	-	-	0.42
Transfer room	Candler/leaker/loader-line no. 1	0744-1612*	1.1	-	-	0.40
Transfer room	Leaker-line no. 1	0746-1047	0.45	-	-	0.31
Transfer room	Candler/leaker/loader	0752-1440*	0.89	-	-	0.37
Transfer room	Candler/leaker/loader	0754-1616*	1.1	-	-	0.37
Breaking room	Breaker-line no. 5	0735-1624	1.3	-	-	0.38
Breaking room	Breaker-line no. 2	0739-1623*	1.2	-	-	0.17
Breaking room	Breaker-line no. 3	0742-1625*	1.2	-	-	0.25
Yellow dryer rotex room	Three feet from sifter filler	0813-1534	1.1	0.30	-	-
Yellow dryer rotex room	Three feet from sifter filler	0813-1534	0.75	-	0.22	-
Yellow dryer rotex room	Three feet from sifter filler	0851-1542	1.1	0.23	-	-
Yellow dryer rotex room	Three feet from sifter filler	0851-1542	0.74	-	0.40	-
Yellow dryer	Dryer operator	0830-1407	0.84	-	-	0.72
Yellow dryer	Rotex operator	0722-1403	1.0	-	-	0.37
White dryer rotex room	On frame above sifter	0900-1534	0.99	8.0	-	-
White dryer rotex room	On frame above sifter	0900-1534	0.71	-	0.77	-
White dryer rotex room	On frame above sifter	0759-1539	1.2	25	-	-
White dryer rotex room	On frame above sifter	0759-1539	0.78	-	0.72	-
White dryer	Dryer operator	0825-1358	0.83	-	-	10
Blend packaging room	Packaging operator	0822-1435*	0.83	-	-	31
Blend packaging room	Packaging operator	0821-1440*	0.93	-	-	11
Blend packaging room	On work table near packaging operators	0852-1455	0.65	-	0.41	-
Blend packaging room	Rotex operator	0729-1100	0.53	-	-	130
Blend packaging room	Below sifter near filler	0808-1353	0.86	32	-	-
Blend packaging room	Below sifter near filler	0808-1353	0.59	-	0.35	-

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

Ballas Egg Products
Zanesville, Ohio
HETA 86-461

March 4, 1987

Sample Description	Protein Concentration
Dirty sanitizer water from transfer area	1.0 mg/ml
Clean chlorinated spray water from transfer area	0.10 mg/ml
Clean sanitizer water from transfer area	0.35 mg/ml
Clean sanitizer water from breaking area	0.10 mg/ml
Dirty sanitizer water from breaking area	0.64 mg/ml
Egg yolk solids	35g/100g
Paterurized free flowing dried egg yolk solids	34g/100g
Egg white solids	81g/100g

g = grams

Table 6

Personal and Area Aeroallergen Sampling Results

Ballas Egg Products
Zanesville, Ohio
HETA 86-461

March 4-5, 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/leaker/loader-line no. 6	P	0804-1627*	1.2	160	15	ND	0.96
Transfer room	Candler/leaker/loader-line no. 1	P	0748-1607*	1.1	140	24	0.11	0.85
Breaking room	Breaker-line no. 3	P	0737-1621*	1.3	112	21	ND	0.42
Yellow dryer	Dryer operator	P	0720-1401	1.0	106	7.9	ND	0.92
Yellow dryer	Rotex operator	P	0814-1405	0.88	2.1	ND	ND	0.19
White dryer	Dryer operator	P	0724-1358	0.99	93	351	672	9.8
Blend pack. room	On work table near packaging opers.	A	0852-1455	0.91	223	101	2.3	28
Blend pack. room	Packaging operator	P	0726-1348*	0.85	161	239	19	28
Blend pack. room	Box maker/feeder	P	0728-1350*	0.86	132	262	65	41
Blend pack. room	Below sifter near filler	A	0808-1353	0.86	182	101	2.2	14
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

BALLAS EGG PRODUCTS
ZANESVILLE, OHIO

HETA 86-461

	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

TABLE 8
Numbers of Respondents to Questionnaire,
By Reported Symptoms, and Temporal Relationship of Symptoms to Work
BALLAS EGG PRODUCTS, INC.
ZANESVILLE, OHIO
HETA 86-46l

	Number	Participated in Follow-up
Work-related symptoms		
W, SOB, and CT	9	9
W and SOB	4	3
W and CT	5	4
W only	3	3
SOB and CT	1	1
Sub-total	22	20
SOB only	6	1
CT only	3	2
Sub-total	9	3
Symptoms not work-related		
W, SOB, and CT	0	0
W and SOB	1	1
W and CT	1	1
W only	3	2
SOB and CT	0	0
SOB only	0	0
CT only	5	0
Sub-total	10	4
Non-symptomatic		
Invited for follow-up	30	19
Excluded from follow-up	25	
Sub-total	55	

W = Wheezing
SOB = Shortness of breath
CT = Chest tightness

TABLE 9

Survey-Based Classifications

BALLAS EGG PRODUCTS
ZANESVILLE, OHIO

HETA 86-461

PHYSICIAN DIAGNOSIS	PROBABLE OCCUP. ASTHMA	POSSIBLE OCCUP. ASTHMA	POSSIBLE NON-OCCUP. ASTHMA	POSSIBLE IRRITANT SYMPTOMS	OTHER INCLUDING NO SX.	TOTAL
POSSIBLE OCCUP. ASTHMA	4	4	1	3	1	13
POSSIBLE NON-OCCUP. ASTHMA	1	1	2	3	0	7
POSSIBLE IRRITANT SYMPTOMS	0	0	0	6	1	7
OTHER INCLUDING NO SX.	0	0	0	2	17	19
TOTAL	5	5	3	14	19	46

KAPPA = 0.603

VAR(K) = 0.005

S.E.(K) = 0.068

SX = Symptoms

TABLE 10
Summary of Questionnaire Respondents, by Symptoms and Job
BALLAS EGG PRODUCTS
ZANESVILLE, OHIO
HETA 86-46l

Job	Number of Respondents to Quest.	Number* of Asymptomatic Respondents	Number* of Respondents with Eligible Sx.** Work-Related	Not Work-Related	Number* of Respondents with Ineligible Sx.*** Work Related	Not Work-Related
Office	7	6 (3)	1 (1)	0	0	0
Warehouse	6	4 (3)	0	0	1 (0)	1 (0)
Candling & Traying	31	14 (3)	7 (7)	3 (2)	5 (2)	2 (0)
Breaking	19	9 (2)	7 (7)	1 (1)	1 (1)	1 (0)
Maintenance & Clean-up	11	7 (4)	1 (1)	1 (1)	2 (0)	0
White exposed	8	3 (1)	4 (3)	0	0	1 (0)
Yellow exposed	6	6 (1)	0	0	0	0
Blending	6	4 (1)	2 (1)	0	0	0
Other	2	2 (1)	0	0	0	0
Total	96	55 (19)	22 (20)	5 (4)	9 (3)	5 (0)

* Numbers of participants in follow-up are in parentheses.

** "Eligibility" is with respect to follow-up participation criteria established for the study at the Estherville Foods plant. So-called eligible symptoms (sx) were wheezing; and/or shortness of breath and chest tightness (i.e., both reported symptoms).

*** "Ineligiblity" likewise is with respect to follow-up participation criteria established for the study at the Estherville Foods plant. So-called ineligible symptoms were wheezing, shortness of breath, and/or chest tightness, not temporally related to work; or shortness of breath or chest tightness alone, regardless of temporal relationship to work.

TABLE 11

Estimated Minimum Prevalence of Occupational Asthma

BALLAS EGG PRODUCTS
ZANESVILLE, OHIO

HETA 86-46l

	Respondents with Dual Dx. of OA*	Estimated** Minimum Prevalence of OA
Office	1	14%
Warehouse	0	0%
Candling & Traying	2	6%
Breaking	3	16%
Maintenance & Clean-up	0	0%
White exposed	1	13%
Yellow exposed	0	0%
Blending	1	17%
Other	0	0%
----------	---	---
Total	8	8%

* All dually-classified OA were among participants with work-related symptoms (e.g., wheezing, shortness of breath, or chest tightness).

** To the extent that questionnaire respondents who did not participate in the follow-up actually had occupational asthma, but went undiagnosed because of their exclusion from the follow-up examinations, the estimated prevalences of occupational asthma are underestimates. The estimates minimize the size of the numerators (the numbers of dually diagnosed occupational asthmatics) and maximize the size of the denominators (the numbers of questionnaire respondents in each job classification).

Dx = diagnosis
OA = occupational asthma

TABLE 12
Atopy

BALLAS EGG PRODUCTS
ZANESVILLE, OHIO

HETA 86-46l

	YES	NO	Total	Odds Ratio*
Dual Diagnosis of OA	2	6	8	1.1
Symptomatic, Not Dual Diagnosis of OA	4	17	21	0.8
Non-symptomatic	4	13	17	
Total	10	36	46	

* The odds ratio is calculated with respect the non-symptomatics.
OA = occupational asthma

FIGURE 1

PEAK EXPIRATORY FLOW RATE
CASE NO. 1, ID 6038

BALLAS EGG PRODUCTS
ZANESVILLE, OHIO
HETA 86-461

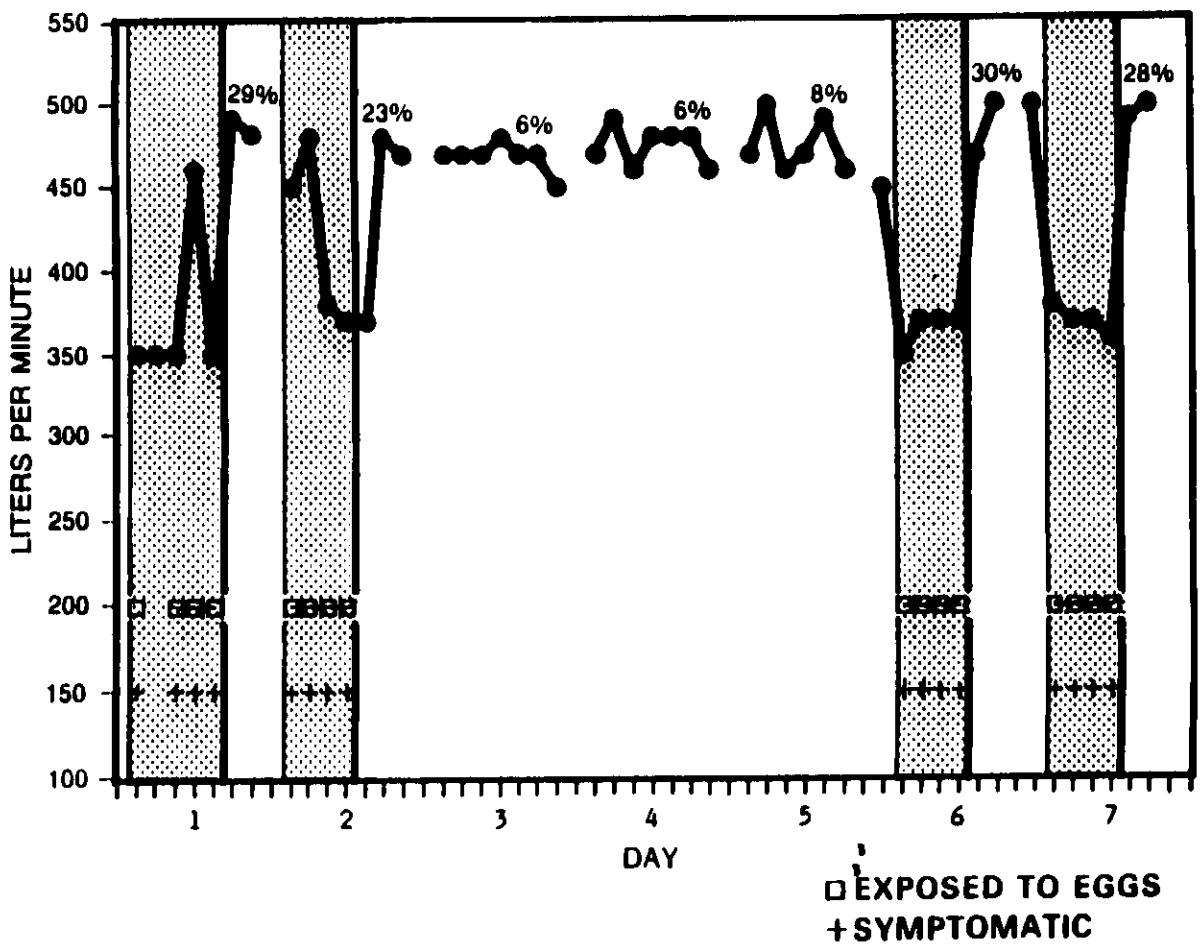

FIGURE 2

PEAK EXPIRATORY FLOW RATE
CASE NO. 2, ID 6050

BALLAS EGG PRODUCTS
ZANESVILLE, OHIO
HETA 86-461

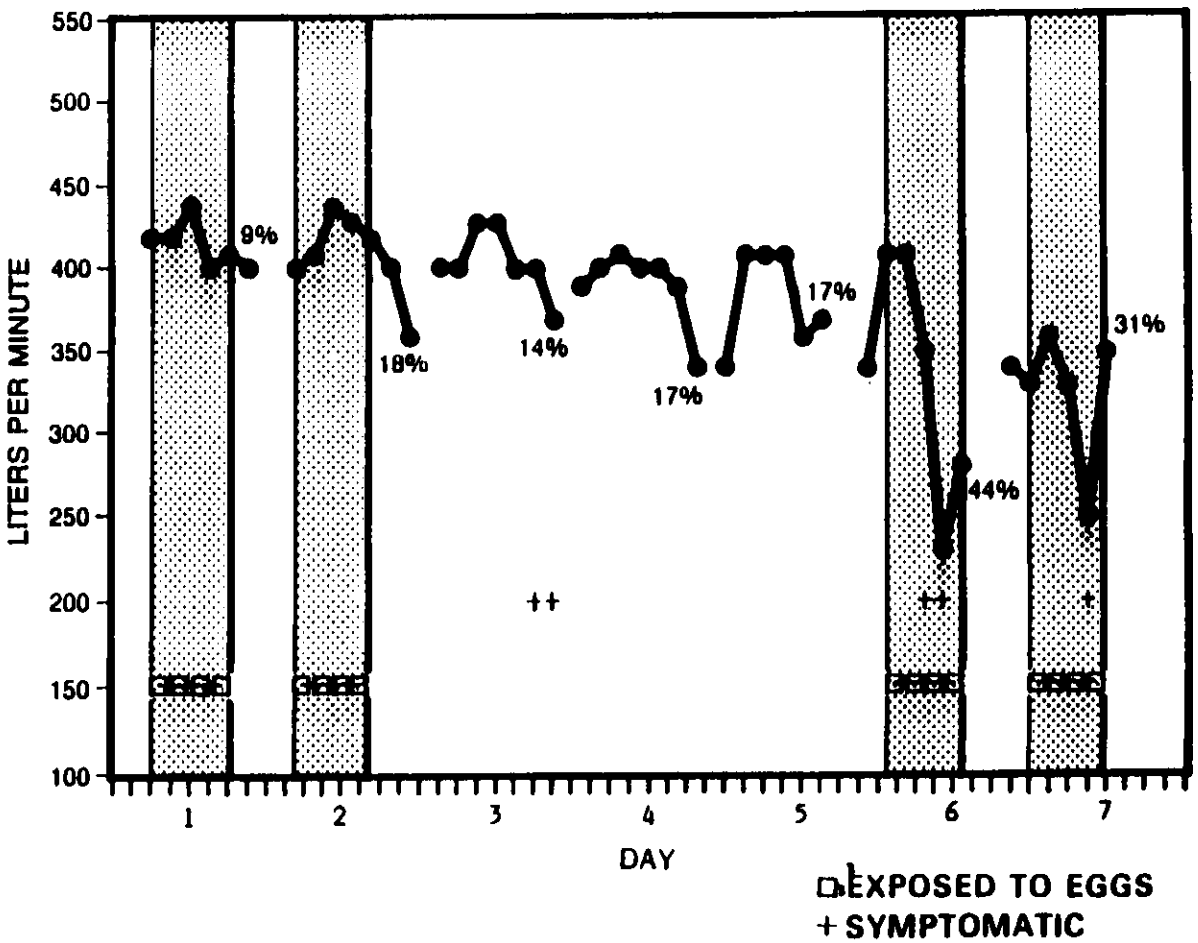

FIGURE 3

PEAK EXPIRATORY FLOW RATE
CASE NO. 3, ID 6065

BALLAS EGG PRODUCTS
ZANESVILLE, OHIO
HETA 86-461

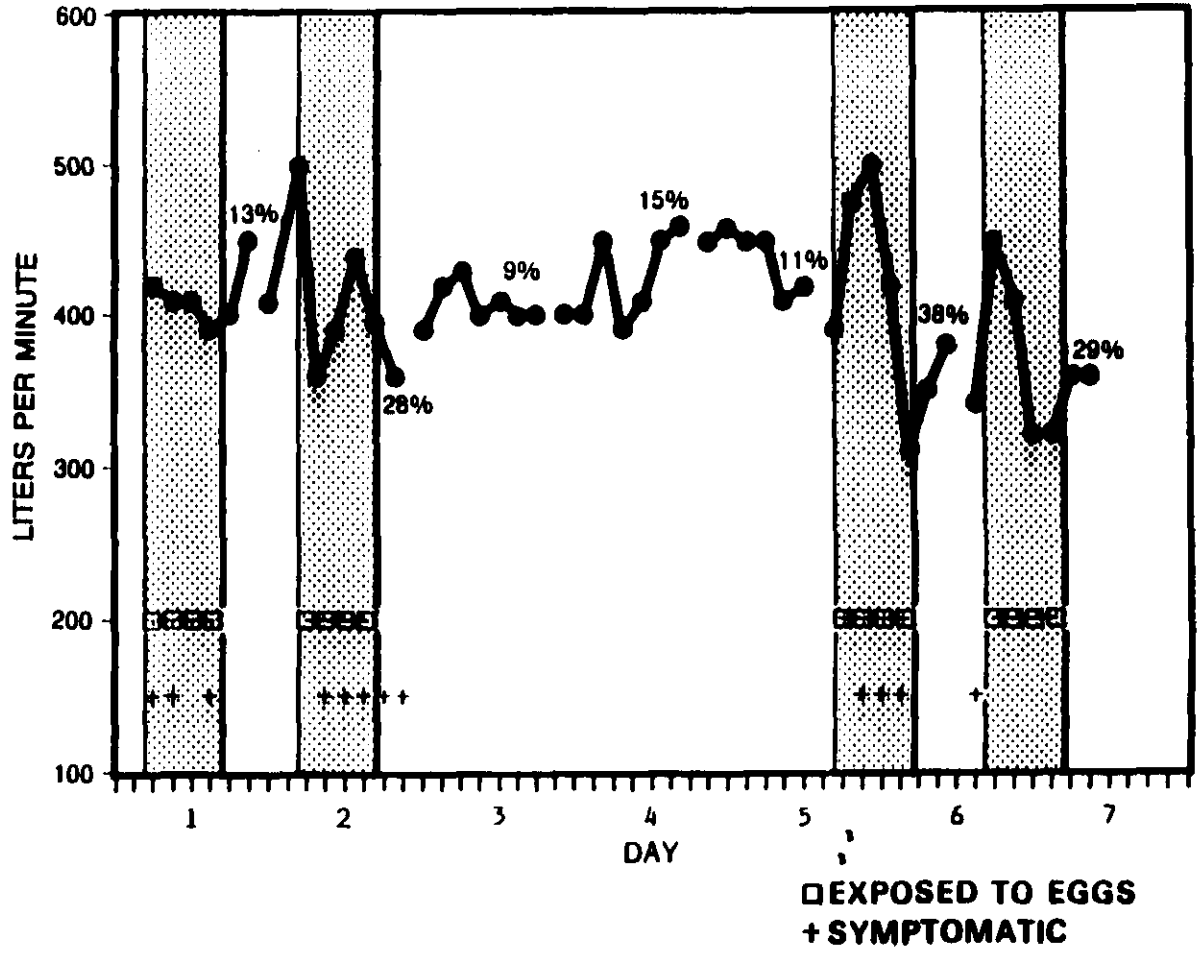

FIGURE 4

PEAK EXPIRATORY FLOW RATE
CASE NO. 4, ID 6023

BALLAS EGG PRODUCTS
ZANESVILLE, OHIO

HETA 86-461