**HETA 91-165-2199**
**MARCH 1992**
**SIMMONS INDUSTRIES, INC.**
**SILOAM SPRINGS, ARKANSAS**

**NIOSH INVESTIGATOR:**
**Steven W. Lenhart, CIH**

## *SUMMARY*

A request was received from the President of Simmons Industries, Inc. in Siloam Springs, Arkansas for a Health Hazard Evaluation at the Simmons poultry processing plant in Southwest City, Missouri. The request concerned evaluation of the ability of the local exhaust ventilation system in the hanging room of the plant to protect chicken hangers from exposures to airborne organic dust.

Industrial hygiene sampling was conducted in the hanging rooms of the Southwest City plant and Simmons poultry processing plant in Jay, Oklahoma. Since the hanging room of the Jay plant did not have a local exhaust ventilation system, sampling was conducted at both sites to provide a comparison between the organic dust exposures experienced by the two hanging crews. Personal breathing zone sampling was conducted for one full shift at both sites on eight hangers at the Southwest City plant, and on six hangers at the Jay plant to estimate their exposures to inhalable and respirable organic dust, and inhalable and respirable bacterial endotoxin. A bacterial endotoxin is a lipopolysaccharide compound from the outer cell wall of gram-negative bacteria, which occur abundantly in organic dusts. Endotoxins have a wide range of biological activities; of most importance to occupational exposures are the activities of endotoxin in the lung.

One of the three 8-hour (8-hr) time-weighted average (TWA) inhalable dust concentrations from the Southwest City plant exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of 10 milligrams per cubic meter (mg/m$^3$) for Particulates not Otherwise Classified. All three of the 8-hr TWA inhalable dust concentrations from the Jay plant exceeded the ACGIH TLV, and one of these exceeds the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 15 mg/m$^3$ for Particulates not Otherwise Regulated. None of the 8-hr TWA respirable dust concentrations from either plant exceeded the OSHA PEL of 5 mg/m$^3$.

All six of the 8-hr TWA inhalable endotoxin concentrations from both processing plants exceeded 10 nanograms per cubic meter (ng/m$^3$), an exposure limit for endotoxin suggested in the report of a study of individuals sensitized to cotton dust. Five of the six endotoxin concentrations also exceeded 100 ng/m$^3$, a level associated with spirometric evidence of acute airways obstruction. Two of the six respirable 8-hr TWA endotoxin concentrations exceeded 10 ng/m$^3$, and none exceed 100 ng/m$^3$.

Results of personal breathing zone sampling for organic dust and endotoxin in the hanging rooms of both poultry processing plants exceeded exposure limits and exposures represented a potential health risk.  In addition, based upon the risk for adverse health effects demonstrated by the results of pulmonary function testing of poultry workers who worked in dusty environments similar to those at the Simmons poultry processing plants, recommendations were made to reduce exposures.  Improving the performance of the existing local exhaust ventilation system in the hanging room of the Simmons Southwest City processing plant, and installation of a local exhaust ventilation system in the hanging room of the Simmons Jay plant were recommended.  Two work practices recommended for reducing the amount of dust available to be generated during chicken hanging were:  (1) wetting the birds with a water spray either in their cages or while on the conveyor belt just before they enter the hanging room, and (2) thoroughly and frequently removing all dirt and excrement from cages before more birds are placed in them.  Until the performance of a local ventilation system and/or work practice changes were shown to be effective for controlling organic dust exposures of the hangers at either Simmons plant, implementation of a respiratory protection program was recommended.  A recommendation was also made to implement a medical surveillance program for chicken hangers and other employees exposed to endotoxin-containing organic dust.

**Keywords**:  SIC 2015 (Poultry Slaughtering and Processing), chicken hangers, endotoxin, organic dust, poultry processing.

## *INTRODUCTION*

A request was received from the President of Simmons Industries, Inc. in Siloam Springs, Arkansas for a Health Hazard Evaluation at the Simmons poultry processing plant in Southwest City, Missouri. The request concerned evaluation of the ability of the local exhaust ventilation system in the hanging room of the plant to protect chicken hangers from exposures to airborne organic dust.

After a flock of chickens has been collected at a grower's farm and placed into cages by a crew of chicken catchers, the birds are transported by truck to a processing plant. Soon after arriving at the processing plant, the chickens are dumped from their cages onto a conveyor belt which leads into the hanging room, and a crew of chicken hangers then hangs the live birds upside down by their feet in W-shaped shackles. The birds are subsequently stunned, killed, bled-out, scalded, defeathered, washed, eviscerated, processed into a final product, chilled, packaged, and shipped for consumer consumption.

Industrial hygiene sampling was conducted in the hanging room of the Southwest City plant on April 16, 1991. In addition, industrial hygiene sampling was conducted in the hanging room of Simmons poultry processing plant in Jay, Oklahoma on April 17, 1991. Since the hanging room of the Jay plant did not have a local exhaust ventilation system, sampling was conducted at both sites to provide a comparison between the organic dust exposures experienced by the two hanging crews. Personal breathing zone sampling was conducted for one full-shift at both sites on eight hangers at the Southwest City plant and on six hangers at the Jay plant to estimate their exposures to inhalable and respirable organic dust, and inhalable and respirable bacterial endotoxin.

A bacterial endotoxin is a lipopolysaccharide compound from the outer cell wall of gram-negative bacteria, which occur abundantly in organic dusts.(1) It has been shown that the biological properties of endotoxin vary depending upon the bacterial species from which they are derived, as well as upon the state of the growth cycle of the bacteria.(2) Endotoxins have a wide range of biological activities involving inflammatory, hemodynamic, and immunological responses. Of most importance to occupational exposures are the activities of endotoxin in the lung.(3) The primary target cell for endotoxin-induced damage by inhalation is the pulmonary macrophage. Human macrophages in particular have been shown to be extremely sensitive to the effects of endotoxin in vitro.(4) Endotoxin, either soluble or associated with particulate matter, will activate the macrophage, causing the cell to produce a host of mediators.(3)

Clinically, little is known about the response to inhaled endotoxins. Exposure of previously unexposed persons to airborne endotoxin can result in acute fever, dyspnea, coughing, and small reductions in $FEV_1$, although some investigators have not been able to demonstrate acute changes in forced expiratory volume in one second ($FEV_1$).(3) The effects of repeated exposure to aerosols of endotoxins in humans are not known. Some animal studies have demonstrated a chronic inflammatory response characterized by goblet cell hyperplasia and increased mucous production. This suggests that repeated exposure may cause a syndrome similar, if not identical, to chronic bronchitis.[3]

## *METHODS*

Equipment for each inhalable dust sample consisted of a closed-face, two-piece, 37-millimeter (mm) cassette containing a tared, 5-micrometers (µm) pore size, polyvinyl chloride (PVC) filter and a cellulose supporting pad. Each cassette was connected by flexible tubing to a personal sampling pump operated at a flow rate of 1.5 liters per minute (L/min). The adjective "inhalable" is used here and throughout this report to define the mass of material collected by the sampling method. This was done in recognition of the distinction between the mass of material collected by this sampling method and the mass of material collected by both inspirable and thoracic particulate mass samplers, as defined by the American Conference of Governmental Industrial Hygienists (ACGIH).[5]

Equipment for each respirable dust sample consisted of a 10-mm, Dorr-Oliver nylon cyclone connected by flexible tubing to a personal sampling pump operated at a flow rate of 1.7 L/min. Respirable dust particles separated by the cyclone were collected on a tared, 5-µm pore size, PVC filter supported by a cellulose pad and contained in a closed-face, two-piece, 37-mm cassette. Field blanks for both inhalable and respirable dust were submitted for each day of testing.

All inhalable and respirable dust samples were analyzed for particulate weight by gravimetric analysis according to National Institute for Occupational Safety and Health (NIOSH) Method 0500[6] with the following modifications: (1) filters were stored in a environmentally controlled room (21 ± 3 °C and 40 ± 3% R.H.) and were subjected to the room conditions for a long duration for stabilization, and (2) the filters and backup pads were not vacuum desiccated. The total weight of each sample was determined by weighing the mass of collect dust plus the filter on an electrobalance and subtracting the previously determined tare weight of the filter. The instrument precision of weighings done at one sitting is 0.01 milligram (mg).

Endotoxin analysis was performed on all gravimetric dust samples, and inhalable and respirable endotoxin concentrations were calculated. After gravimetric analysis, each dust-laden filter was placed aseptically into a separate screw-cap, sterile, nonpyrogenic plastic 50-milliliter (ml) centrifuge tube and mailed to the NIOSH laboratory in Morgantown, West Virginia. Each filter was extracted in 10 ml of sterile, nonpyrogenic water by rocking each sample at room temperature for 60 minutes. The supernatants were then decanted into 50 ml centrifuge tubes and centrifuged at 2200 revolutions per minute and 4 °C for 10 minutes. Endotoxin analyses were performed in duplicate by the quantitative chromogenic

Limulus amebocyte lysate test (QCL-1000; Whittaker Bioproducts, Walkersville, Maryland). Results were reported in terms of endotoxin units (EU) that were compared to the standard, EC-5. A conversion factor of 10 EU/nanogram (ng) was used to express results as nanograms per cubic meter ($ng/m^3$).

## *EVALUATION CRITERIA*

### General Guidelines

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH investigators employ environmental evaluation criteria for assessment 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/day, 40 hours/week for a working lifetime without experiencing adverse health effects. It is important to note; however, not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, 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 levels established by the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus the overall exposure may be increased above measured airborne concentrations. Evaluation criteria typically change over time as new information on the toxic effects of an agent become available.

The primary sources of evaluation criteria for the workplace are: NIOSH Criteria Documents and Recommended Exposure Limits (RELs),[(7)] ACGIH Threshold Limit Values (TLVs),[(5)] and the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[(8)] These values are usually based on a time-weighted average (TWA) exposure, which refers to the average airborne concentration of a substance over an entire 8- to 10-hour workday. Concentrations are usually expressed in parts per million (ppm), milligrams per cubic meter ($mg/m^3$), or micrograms per cubic meter ($\mu g/m^3$). In addition, some substances have a short-term exposure limit (STEL) or ceiling limit, which is intended to supplement the TWA limit where there are recognized toxic effects from short-term exposures.

For specific substances NIOSH recommendations or the ACGIH TLVs may be lower than the corresponding OSHA standards, as they are based primarily on the prevention of occupational disease. In contrast, OSHA PELs and other standards are required to take into account the economic feasibility of reducing exposures in affected industries, public notice and comment, and judicial review. In evaluating worker exposure levels and NIOSH recommendations for reducing exposures, it should be noted that employers are legally required to meet the requirements of OSHA standards.

**Organic Dust**

The 1991-92 ACGIH TLV-TWA concentration applicable to organic dust is 10 $mg/m^3$ of sampled air for Particulates Not Otherwise Classified (PNOC).(5) The OSHA PELs applicable to organic dust are 15 $mg/m^3$ for total dust of Particulates Not Otherwise Regulated and 5 $mg/m^3$ for the respirable fraction of Particulates Not Otherwise Regulated.(7) The limits for organic dust exposures described here might not be protective, since these "nuisance" dust concentrations are meant to be applied to dusts that do not produce significant disease or toxic effect.(5)

**Endotoxin**

Occupational exposure criteria have not been established for bacterial endotoxin by either OSHA, NIOSH, or ACGIH. However, Jacobs has reported that a sufficient toxicological data base is believed to exist for establishing an occupational limit for endotoxin based on acute changes in pulmonary function.(3) Eight-hour
(8-hr) TWA concentrations have been suggested for over-shift decline in $FEV_1$ [100 - 200 $ng/m^3$], for chest tightness [300 - 500 $ng/m^3$], and for fever [500 - 1,000 $ng/m^3$].(2)

An 8-hr TWA threshold for airborne endotoxin of 10 $ng/m^3$ has also been suggested based on a decline in $FEV_1$ for individuals sensitized to cotton dust.(9) The exposure system for the study from which this recommendation was made consisted of a commercial carding machine in a cardroom, an exposure room, and connecting duct work. Airborne dust concentrations were determined in the exposure room using four vertical elutriators.(9) The vertical elutriator has traditionally been the instrument of choice for cotton dust sampling because it will not collect cotton fly lint fibers and dust particles with an aerodynamic mass medial diameter larger than 15 µm.(10)

## *RESULTS*

The results of sampling are presented in Tables I and II for the Simmons Southwest City, Missouri plant and in Tables III and IV for the Jay, Oklahoma plant. One 8-hr TWA inhalable dust concentration from the Southwest City plant exceeds the ACGIH TLV of 10 $mg/m^3$. Six of the nineteen individual concentrations exceed 10 $mg/m^3$, and three of these six exceed 15 $mg/m^3$. All three of the 8-hr TWA inhalable dust concentrations from the Jay plant exceed the ACGIH TLV, and one of these exceeds the OSHA PEL of 15 $mg/m^3$. Fourteen of the eighteen individual concentrations exceed 10 $mg/m^3$, and nine of these fourteen exceed 15 $mg/m^3$. None of the 8-hr TWA respirable dust concentrations from either plant exceeds the OSHA PEL of 5 $mg/m^3$.

The results of endotoxin sampling at the Simmons Southwest City, Missouri, and Jay, Oklahoma plants are presented in Tables II and IV, respectively. All six of the 8-hr TWA inhalable endotoxin concentrations exceed 10 $ng/m^3$, an exposure limit for endotoxin suggested in the report of a study of individuals sensitized to cotton dust.(9) Five of the six endotoxin concentrations also exceed 100 $ng/m^3$, a level associated with spirometric evidence of acute airways obstruction.(2) All except two of the thirty-seven individual sample concentrations exceed 10 $ng/m^3$ (range: 0.67 - 782 $ng/m^3$). Two of the six respirable 8-hr TWA endotoxin concentrations exceed 10 $ng/m^3$, and none exceed 100 $ng/m^3$. Three of the nine individual concentrations exceed 10 $ng/m^3$ (range: <0.06 - 70.4 $ng/m^3$).

## *DISCUSSION*

A total of 82,000 birds were shackled in 7.5 hours by eight hangers on the day of sampling at the Southwest City plant. Therefore, each hanger shackled approximately 1,370 birds per hour. A total of 61,200 birds were shackled by 5.5 hangers (one hanger worked for only half a day) in eight hours on the day of sampling at Jay. This rate represents an average of approximately 1,390 birds per hour per hanger. While the average number of birds shackled per hanger is similar at both processing plants, the organic dust concentrations of the hangers at the Southwest City plant (with local exhaust ventilation) are somewhat less than those of the hangers at the Jay plant (without local exhaust ventilation). However, airborne organic dust and endotoxin exposures at both plants represent a potential health risk.

Swedish researchers recently published an article in which they described a study of 23 chicken hangers who shackled an average of 1,000 birds per hour per hanger.(1) The Swedish hangers were exposed to dust concentrations which averaged 6.3 mg/m$^3$ (range: 0.4 - 15 mg/m$^3$) and to inhalable endotoxin concentrations which averaged 400 ng/m$^3$ (range: 20 - 1500 ng/m$^3$). The mean level of respirable endotoxin was 10 ng/m$^3$ (range: 5 - 14 ng/m$^3$). Before- and after-shift pulmonary function testing resulted in an over-shift decrease of vital capacity (VC) in 17 of 23 workers (range: 1 - 17%) and an over-shift decrease of forced expiratory volume in one second ($FEV_1$) in 15 hangers (range: 1 - 22%). Mean over-shift decreases of VC (3.1%) and $FEV_1$ (4.1%) were reported, which suggests an important respiratory health risk.

Unpublished results of before- and after-shift pulmonary function testing of ten North Carolina chicken hangers are in agreement with the results presented in the Swedish report.(11) Area air sampling produced 8-hr TWA inhalable dust concentrations ranging from 4.18 to 10.3 mg/m$^3$ and 8-hr TWA respirable dust concentrations ranging from 0.20 to 0.68 mg/m$^3$. Area air sampling produced 8-hr TWA inhalable endotoxin concentrations ranging from 28 to 253 ng/m$^3$ and 8-hr TWA respirable endotoxin concentrations ranging from 1 to 40 ng/m$^3$. A mean over-shift decrease of 5.5% was observed for $FEV_1$. Four hangers had over-shift decreases in $FEV_1$ which exceeded 5%, and one of these hangers had a decrease of 26%. A prudent assumption is that continued exposure to agents that cause acute reductions in lung function may indicate an increased risk for the development of chronic lung disease.(12)

The authors of a study of North Carolina chicken catchers exposed to endotoxin-containing organic dust reported that the workers evaluated had high rates of chronic respiratory symptoms suggestive of chronic bronchitis.(13) Personal breathing zone sampling on catchers from six catching crews produced 8-hr TWA concentrations which averaged 20.2 mg/m$^3$ for inhalable dust (range: 5.74 - 39.8 mg/m$^3$) and 1.75 mg/m$^3$ for respirable dust (range: 0.55 - 4.18 mg/m$^3$). The mean levels of inhalable endotoxin and respirable endotoxin were 250 ng/m$^3$

(range: 27 - 700 ng/m$^3$) and 13 ng/m$^3$ (range: 3 - 34 ng/m$^3$), respectively.[14] The results of pre- and post-shift spirometry on 39 catchers produced decreases over the work shift of all three pulmonary function indices evaluated (i.e., FVC, $FEV_1$, and $FEV_1$/FVC); the decreases in FVC (-2.2%) and $FEV_1$ (-3.4%) were statistically significant.[13]

## *RECOMMENDATIONS*

Based upon the results of organic dust and endotoxin sampling which exceeded exposure limits, and based upon the risk for adverse health effects demonstrated by the results of spirometry performed by poultry workers who worked in dusty environments similar to those at the Simmons poultry processing plants, measures should be taken to reduce exposures. Methods should be explored for improving the performance of the existing local exhaust ventilation system in the hanging room of the Simmons Southwest City processing plant. Methods which might prove to be successful include the addition of a downdraft ventilation system to the carousel and a conditioned air shower at a location just above and behind the hangers. The organic dust concentrations experienced by hangers at Simmons Jay plant suggests the need for installation of a local exhaust ventilation system. The arrangement of the current shackle line at this facility should permit installation of a slotted hood behind the line with a conditioned air shower behind the hangers for delivering supply air.

Two work practices which might result in a reduction of the amount of dust available to be generated during chicken hanging are: (1) wetting the birds with a water spray either in their cages or while on the conveyor belt just before they enter the hanging room, and (2) thoroughly and frequently removing all dirt and excrement from cages before more birds are placed in them. (Both of these measures might also serve the purpose of extending the shelf-life of the finished chicken product, since there is a relationship between shelf-life and the cleanliness of the birds when they arrive at the receiving area of the processing plant.[15,16])

Until the performance of a local ventilation system and/or work practice changes are shown to be effective for controlling organic dust exposures of the hangers at either the Southwest City or Jay plant, hangers should be required to wear NIOSH/Mine Safety and Health Administration (MSHA) approved air-purifying respirators. Respirators should be fitted and used in accordance with OSHA requirements for an acceptable respiratory protection program as described in 29 Code of Federal Regulations, Part 1910.134. Because the results of personal breathing zone sampling on chicken catchers at other facilities have demonstrated excessive exposures to organic dust and endotoxin,[14] an evaluation should be conducted of the exposures of catchers employed by Simmons so they too can be included in the respiratory protection program, if necessary.

After implementation of a respiratory protection program, simultaneous lapel and in-mask sampling should be performed on a sample set of respirator wearers to ensure that the respirator selected is indeed sufficient to protect its user during all conditions of use. Such sampling should be conducted periodically to further ensure that there have been no significant changes in the conditions of respirator usage that might reduce the effectiveness of the particular respirator in service.(16)

A medical surveillance program should be made available to chicken hangers and other employees exposed to endotoxin-containing organic dust. Pre-placement, periodic, and termination (of exposure) medical evaluations should include: (a) a medical and occupational history addressing past and present respiratory illnesses, symptoms, and exposures, and (b) tests of pulmonary function. (Pertinent medical records, including medical surveillance results from previous employment, should be reviewed as part of the pre-placement evaluation.) The evaluations should be repeated at six-month intervals, or more often if indicated by previous finding or employee reports of respiratory symptoms. Pulmonary function tests should be administered by trained technicians, and equipment and test procedures should conform to guidelines recommended by the American Thoracic Society.(18) The medical surveillance program should be under the supervision of a physician with knowledge of occupational respiratory disease. Any worker detected by the surveillance program as having findings suggestive of occupational respiratory disease should be further evaluated by a physician with expertise in this field. Generally, someone with an occupational respiratory disease is advised to avoid further exposure to any substance that contributes to the condition.

Although it was not related directly to the issue which prompted this report, a safety hazard was observed in the live hang area of the Southwest City plant. The potential hazard involved the close proximity of the last hanger to a section of the metal fence surrounding the carousel. One hanger jumped the fence to shackle a bird and risked slipping on the wet floor. Another hanger attempted to reach across the fence to shackle a bird and risked catching a finger in a shackle. The fence should be extended to permit more distance for the last hanger to fill empty shackles without having to jump over or reach across the fence to do so.

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## *AUTHORSHIP AND ACKNOWLEDGEMENTS*

| | |
|---|---|
| Originating office: | Hazard Evaluations and Technical Assistance Branch<br>Division of Surveillance, Hazard Evaluations and Field Studies |
| Report prepared by: | Steven W. Lenhart, CIH<br>Industrial Hygienist<br>Industrial Hygiene Section |
| | Donna Humphries<br>Office Automation Assistant<br>Industrial Hygiene Section |

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2. NIOSH Region VIII (Denver, CO)
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4. PHS Region VI (Dallas, TX)
5. PHS Region VII (Kansas City, MO)

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

TABLE I

Dust Concentrations during Chicken Hanging
at the Southwest City, Missouri Processing Plant
Simmons Industries, Inc.
Siloam Springs, Arkansas
April 16, 1991
HETA 91-165

| Hanger | Sample Number | Sampling Period | Dust Concentration (mg/m$^3$) | 8-hr TWA Concentration (mg/m$^3$) |
|---|---|---|---|---|
| | | **Inhalable Dust** | | |
| A | 2842 | 0610 - 0829 | 6.73 | 10.59 |
| | 2828 | 0900 - 1023 | 16.77 | |
| | 2840 | 1023 - 1130 | 5.20 | |
| | 2833 | 1155 - 1329 | 17.31 | |
| | 2832 | 1329 - 1440 | 8.58 | |
| B | 2848 | 0610 - 0832 | 5.21 | 9.51 |
| | 2835 | 0857 - 1027 | 14.37 | |
| | 2847 | 1027 - 1130 | 7.13 | |
| | 2839 | 1155 - 1331 | 17.29 | |
| | 2826 | 1331 - 1440 | 6.15 | |
| C | 2850 | 0610 - 0836 | 7.49 | 8.26 |
| | 2834 | 0856 - 1025 | 5.07 | |
| | 2846 | 1025 - 1130 | 7.86 | |
| | 2845 | 1155 - 1327 | 13.40 | |
| | 2844 | 1327 - 1440 | 9.27 | |
| D | 2843 | 0610 - 0833 | 6.12 | ----- |
| | 2829 | 0920 - 1028 | 11.76 | |
| | 2841 | 1028 - 1132 | 5.21 | |
| | 2827 | pump failure | ----- | |
| | 2838 | 1320 - 1440 | 5.17 | |
| | | **Respirable Dust** | | |
| E | 2831 | 0610 - 0833<br>0900 - 1129<br>1155 - 1440 | 3.68 | 3.50 |
| F | 2830 | 0610 - 0834<br>0857 - 1130<br>1155 - 1440 | 0.84 | 0.81 |
| G | 2836 | 0610 - 0835<br>0857 - 1130<br>1155 - 1440 | 0.34 | 0.33 |
| H | 2837 | 0610 - 0834<br>0900 - 1129<br>1155 - 1440 | 1.62 | 1.54 |

TWA: Time-weighted average

TABLE II

Endotoxin Concentrations during Chicken Hanging
at the Southwest City, Missouri Processing Plant
Simmons Industries, Inc.
Siloam Springs, Arkansas
April 16, 1991
HETA 91-165

| Hanger | Sample Number | Sampling Period | Endotoxin Concentration (ng/m$^3$) | 8-hr TWA Concentration (ng/m$^3$) |
|---|---|---|---|---|
| **Inhalable Endotoxin** | | | | |
| A | 2842 | 0610 - 0829 | 80.7 | 133 |
| | 2828 | 0900 - 1023 | 266 | |
| | 2840 | 1023 - 1130 | 8.3 | |
| | 2833 | 1155 - 1329 | 236 | |
| | 2832 | 1329 - 1440 | 79.2 | |
| B | 2848 | 0610 - 0832 | 27.4 | 103 |
| | 2835 | 0857 - 1027 | 299 | |
| | 2847 | 1027 - 1130 | 17.8 | |
| | 2839 | 1155 - 1331 | 183 | |
| | 2826 | 1331 - 1440 | 0.67 | |
| C | 2850 | 0610 - 0836 | 142 | 79.7 |
| | 2834 | 0856 - 1025 | 16.6 | |
| | 2846 | 1025 - 1130 | 17.2 | |
| | 2845 | 1155 - 1327 | 145 | |
| | 2844 | 1327 - 1440 | 21.9 | |
| D | 2843 | 0610 - 0833 | 34.8 | ----- |
| | 2829 | 0920 - 1028 | 66.0 | |
| | 2841 | 1028 - 1132 | 13.6 | |
| | 2827 | pump failure | ---- | |
| | 2838 | 1320 - 1440 | 15.4 | |
| **Respirable Endotoxin** | | | | |
| E | 2831 | 0610 - 0833<br>0900 - 1129<br>1155 - 1440 | 50.9 | 48.5 |
| F | 2830 | 0610 - 0834<br>0857 - 1130<br>1155 - 1440 | 0.10 | 0.10 |
| G | 2836 | 0610 - 0835<br>0857 - 1130<br>1155 - 1440 | ----- | ----- |
| H | 2837 | 0610 - 0834<br>0900 - 1129<br>1155 - 1440 | 6.98 | 6.67 |

TWA: Time-weighted average

TABLE III

Dust Concentrations during Chicken Hanging
at the Jay, Oklahoma Processing Plant
Simmons Industries, Inc.
Siloam Springs, Arkansas
April 17, 1991
HETA 91-165

| Hanger | Sample Number | Sampling Period | Dust Concentration (mg/m$^3$) | 8-hr TWA Concentration (mg/m$^3$) |
|---|---|---|---|---|
| | | **Inhalable Dust** | | |
| I | 2857 | 0607 - 0836 | 9.87 | 12.90 |
| | 2855 | 0845 - 0947 | 15.81 | |
| | 2862 | 0947 - 1057 | 5.90 | |
| | 2865 | 1121 - 1225 | 17.08 | |
| | 2870 | 1225 - 1338 | 12.64 | |
| | 2777 | 1338 - 1448 | 18.76 | |
| J | 2854 | 0607 - 0837 | 14.84 | 16.50 |
| | 2858 | 0845 - 0940 | 13.78 | |
| | 2860 | 0940 - 1055 | 11.52 | |
| | 2863 | 1121 - 1229 | 20.91 | |
| | 2776 | 1229 - 1343 | 20.09 | |
| | 2778 | 1343 - 1450 | 18.00 | |
| K | 2852 | 0607 - 0835 | 9.68 | 14.81 |
| | 2859 | 0845 - 0946 | 18.15 | |
| | 2861 | 0946 - 1056 | 7.71 | |
| | 2864 | 1121 - 1223 | 23.22 | |
| | 2869 | 1223 - 1345 | 12.52 | |
| | 2779 | 1345 - 1450 | 24.08 | |
| | | **Respirable Dust** | | |
| L | 2851 | 0607 - 0837<br>0845 - 1053 | 2.75 | ----- |
| M | 2856 | 0607 - 0835<br>0845 - 1051 | 0.96 | 2.57 |
| | 2867 | 1121 - 1458 | 4.47 | |
| N | 2853* | 0607 - 0837<br>0845 - 1053 | 0.74 | 1.24 |
| | 2866 | 1121 - 1458 | 1.79 | |

TWA: Time-weighted average

* Feather found in the inlet of cyclone at the end of the sampling period.

TABLE IV

Endotoxin Concentrations during Chicken Hanging
at the Jay, Oklahoma Processing Plant
Simmons Industries, Inc.
Siloam Springs, Arkansas
April 17, 1991
HETA 91-165

| Hanger | Sample Number | Sampling Period | Endotoxin Concentration (ng/m$^3$) | 8-hr TWA Concentration (ng/m$^3$) |
|---|---|---|---|---|
| **Inhalable Endotoxin** | | | | |
| I | 2857 | 0607 - 0836 | 105 | 117 |
| | 2855 | 0845 - 0947 | 169 | |
| | 2862 | 0947 - 1057 | 13.0 | |
| | 2865 | 1121 - 1225 | 152 | |
| | 2870 | 1225 - 1338 | 54.1 | |
| | 2777 | 1338 - 1448 | 224 | |
| J | 2854 | 0607 - 0837 | 522 | 394 |
| | 2858 | 0845 - 0940 | 126 | |
| | 2860 | 0940 - 1055 | 88.4 | |
| | 2863 | 1121 - 1229 | 307 | |
| | 2776 | 1229 - 1343 | 782 | |
| | 2778 | 1343 - 1450 | 289 | |
| K | 2852 | 0607 - 0835 | 124 | 236 |
| | 2859 | 0845 - 0946 | 366 | |
| | 2861 | 0946 - 1056 | 34.5 | |
| | 2864 | 1121 - 1223 | 419 | |
| | 2869 | 1223 - 1345 | 167 | |
| | 2779 | 1345 - 1450 | 469 | |
| **Respirable Endotoxin** | | | | |
| L | 2851 | 0607 - 0837<br>0845 - 1053 | 21.3 | ----- |
| M | 2856 | 0607 - 0835<br>0845 - 1051 | 0.30 | 32.0 |
| | 2867 | 1121 - 1458 | 70.4 | |
| N | 2853* | 0607 - 0837<br>0845 - 1053 | 0.11 | 0.41 |
| | 2866 | 1121 - 1458 | 0.76 | |

TWA: Time-weighted average

* Feather found in the inlet of cyclone at the end of the sampling period.