NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2004-0337-3051
US Department of Agriculture
Food Safety and Inspection Service
Natchitoches, Louisiana

November 2007

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Bradley King, Angela Warren and Charles Mueller of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Statistical analysis was provided by Charles Mueller, HETAB, DSHEFS. Analytical support was provided by Kathleen Gomez of the Division of Applied Research and Technology (DART) and DataChem Laboratories, Salt Lake City, Utah. Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

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HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION

The National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS). The request called for assistance in evaluating potential exposures to chloramines in a poultry processing facility in Natchitoches, Louisiana. NIOSH investigators conducted the investigation in September 2004.

What NIOSH Did

- We tested the air for chlorine-related compounds called chloramines.
- We asked inspectors to fill out questionnaires about eye and respiratory symptoms they had at work.

What NIOSH Found

- Trichloramine levels were higher at the Maestro and Nu-Tech stations than in the offices or processing areas. Levels of soluble chlorine compounds did not differ significantly between the Maestro and Nu-Tech stations and processing areas, but were lower in the offices.
- Inspectors reported symptoms similar to those found in other poultry plants, most commonly itchy or runny nose, stuffy nose, cough, frequent sneezing, and burning and stinging eyes.

What USDA/FSIS Safety and Health Staff Can Do

- Continue to monitor reported health problems.
- Collaborate with the facility's operators to identify specific controls that may be implemented to prevent symptoms.

What USDA/FSIS Inspectors Can Do

- Tell health personnel at USDA if you have health problems that may be associated with the work environment.

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2004-0337-3051

Health Hazard Evaluation Report 2004-0337-3051
US Department of Agriculture,
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Natchitoches, Louisiana
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SUMMARY

On July 27, 2004, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS). The request called for assistance in evaluating potential exposures to chloramines in a poultry processing facility in Natchitoches, Louisiana. Inspectors from the USDA present on the evisceration line had repeatedly reported eye and upper respiratory irritation. FSIS industrial hygienists previously assessed chlorine exposures using traditional sampling and analytic methods, but typically found very low levels of chlorine in the air, none of which exceeded occupational exposure criteria. It was believed that chloramine compounds, including mono-, di- and trichloramine, may have been causing the symptoms, but due to the lack of an available method to measure chloramines in the air, this had not been investigated.

On August 30-September 3, 2004, NIOSH investigators accompanied FSIS personnel during a site visit to investigate symptoms and potential exposures. While the FSIS conducted sampling for chlorine using traditional sampling methodologies, NIOSH investigators conducted personal breathing zone and area air sampling for chloramines using a draft NIOSH method. Interviews with USDA inspectors were conducted by NIOSH investigators over the course of three shifts to document work-related symptoms.

Trichloramine levels were higher at the Maestro and Nu-Tech stations on the evisceration line (where chlorinated water was used) than in the offices or processing areas (where little or no chlorinated water was used). Levels of soluble chlorine compounds did not differ significantly between the Maestro and Nu-Tech stations and processing areas, but were lower in the offices. The respiratory symptoms reported in this study are consistent with findings among other poultry processing workers. The small number of participants in this study may have limited our ability to find statistically significant associations between work-related symptoms and trichloramine or soluble chlorine levels.

Keywords: NAICS 311615 (poultry processing), turkeys, chlorine, chloramine, soluble chlorine, trichloramine, eye irritation, upper respiratory irritation, evisceration, engineering controls.

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INTRODUCTION

On July 27, 2004, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the Environmental Health, and Safety Branch (EHSB) of the U.S. Department of Agriculture (USDA) Food Safety and Inspection Service (FSIS). The request concerned potential exposures of USDA inspectors to chlorine-related compounds, such as chloramines at a poultry-processing facility in Natchitoches, Louisiana. Symptoms reported by the inspectors included intermittent eye and upper respiratory irritation.

On August 30 – September 3, 2004, NIOSH investigators conducted a site visit to the facility in conjunction with a site visit by personnel from EHSB. While EHSB investigators collected area air samples for chlorine, NIOSH investigators collected personal breathing zone (PBZ) and area air samples for chloramines, and conducted interviews with the facility's USDA inspectors to determine the extent of symptoms among these employees.

BACKGROUND

The FSIS is responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labeled and packaged. The EHSB within the FSIS is responsible for the planning, policy development, and management of the FSIS Safety and Health Program. EHSB health and safety staff respond to occupational health concerns from USDA/FSIS inspectors present on all poultry processing lines in U.S. facilities.

The FSIS inspectors at Establishment P-5787 in Natchitoches, Louisiana, conduct inspections of poultry for visible contamination or disease conditions as the poultry passes through the evisceration line. The facility uses both Nu-Tech (Stork Gamco, Inc.) and Maestro (Meyn Poultry Processing, LLC) brands of evisceration line systems. The water washes on both systems use city-supplied, chloraminated water, described as having 1-4 parts per million monochloramines; the water was further chlorinated through the addition of calcium hypochlorite onsite. The facility used a Tomco hypochlorous acid pathogen management system (Tomco Equipment Co.), which added carbon dioxide (CO_2) to drive down the pH of the chlorinated water used in the washes to that of hypochlorous acid (pH between 6.5-7), resulting in improved pathogen kill.

The inspectors had reported intermittent eye and upper respiratory irritation for many years, sometimes severe enough to cause the inspectors to stop inspection activities and temporarily leave the evisceration line. The EHSB health and safety staff had conducted repeated site visits to this poultry plant over the past few years. Air sampling using traditional analytical methods for chlorine had not found levels in excess of the occupational exposure criteria, and typically levels had been very low. As a result of this ongoing irritation, the EHSB planned to visit the Natchitoches plant in September 2004 to conduct air monitoring for chlorine. Assistance was requested from NIOSH for PBZ and area air sampling for chloramines to determine if they may have been a factor in the irritative symptoms experienced.

In the past, chloramines, specifically trichloramine (NCl_3), have been suspected as a primary cause of such symptoms. Trichloramine is produced from the reaction between chlorinated water and the nitrogenous material from the poultry.[1] There have been numerous reports of eye and upper respiratory tract irritation among poultry processing workers and USDA inspectors during processing steps involving the use of super-chlorinated water, and this is considered to be a widespread problem in the industry.[1,2,3,4] Reported symptoms generally are intermittent, vary in severity, and may be accompanied by reports of a "chlorine-like" odor.

Investigations to identify the cause of irritation and determine appropriate remedial action have been conducted by the USDA, NIOSH, and others at several poultry processing plants.

Efforts to identify obvious contaminants such as chlorine or ammonia in air as the cause of irritation have generally been inconclusive. Using a draft sampling and analytical method based on work published by French researchers,[5] NIOSH investigators have evaluated chloramine exposures in poultry processing plants and have found them to be associated with respiratory and mucous membrane symptoms experienced by the workers at the sites.[4,6]

METHODS

Industrial Hygiene

PBZ air samples were collected on USDA inspectors, and area air samples were collected in areas of high (Maestro and Nu-Tech lines) and low (processing and office areas) chlorinated-water use for trichloramines and "soluble chlorine" (a combination of chlorine compounds such as monochloramine, dichloramine, hypochlorite, and hypochlorous acid). The samplers are a combination of an adsorption tube (analyzed for soluble chlorine) and a treated filter cassette (analyzed for trichloramine). Samplers were constructed from a tube containing silica gel coated with sulphamic acid and a 37-millimeter (mm) polystyrene cassette containing two quartz fiber filter pads in series pre-treated with sodium carbonate and diarsenic trioxide. NIOSH laboratorians used inductively coupled plasma atomic emission spectroscopy (ICP-AES) to analyze the sample tubes and the filters rather than an ion-selective electrode technique for the tube and ion chromatography for the filter, as described in the original French method. Analysis involved a simple extraction followed by ICP-AES for both tube and filter. During sampling, air was pulled through the silica gel-containing tube prior to passing through the filter-containing cassette. The soluble chlorine compounds were collected in the silica gel-containing tube, while the trichloramine passed through the tube. The trichloramine was then trapped separately by the filters as it chemically reacted with them. The air samples were collected using calibrated SKC sampling pumps at a flow rate of one liter per minute (Lpm). The sampling pumps were pre- and post-calibrated using a primary standard. Samplers were shipped overnight to the NIOSH laboratory after daily sampling. Upon receipt, the samples were immediately desorbed and stored (refrigerated in the dark) until analysis.

During analysis of the tubes, extraction was performed by placing the impregnated silica gel from the tube into a 20 milliliter (mL) vial. Ten mL of a 1 gram/liter (g/L) sulfamic acid solution was added to each vial and allowed to sit for 1 hour with occasional agitation. The sample extracts were decanted into another vial and refrigerated until analysis. Samples were analyzed for chloride using an ICP-AES method at a wavelength of 134.724 nanometers (nm). An instrumental limit of detection (LOD) was determined to range between 1 and 4 micrograms (µg)/sample, with a limit of quantitation (LOQ) that ranged between 4.7 and 13 µg/sample, depending on the batch of samples processed per day.

During analysis of the filters, each filter was removed from the cassette, placed in a 20 mL sample vial, and 10 mL of deionized water was added. The filters were rotated for 1 hour, then analyzed on the ICP-AES at a wavelength of 134.724 nm. An instrumental LOD for trichloramine was determined to range between 1 and 3 µg/sample, with a LOQ ranging between 3.6 and 10 µg/sample, depending on the batch of samples processed per day.

Additionally, NIOSH investigators collected a side-by-side sample at each of the sample locations. These were sent to a private contract laboratory to investigate the possibility of using ion chromatography rather than ICP as the method of analysis. Sampling results from the contract laboratory and the comparison with the NIOSH laboratory analysis can be found in the Appendix.

Medical

Because this was a technical assistance request from the USDA, only USDA line inspectors were asked to complete the questionnaires. Four shifts with six line inpsectors per shift were

assessed. Some inspectors worked primarily in the office area, but went onto the line periodically. Two types of questionnaires were given to the inspectors. The first questionnaire, or baseline questionnaire, had questions about demographics (age, gender, job title, and years worked); personal history of allergies, eczema, asthma, and smoking; whether upper and lower respiratory symptoms occurred at work in the last 4 weeks (not related to having a cold); and whether those symptoms remained the same, occurred more or less frequently, or did not occur at all on days off work. The inspectors completed this questionnaire at home and returned it to the NIOSH investigators during their next work shift. An "end of the work shift" questionnaire was given to the inspector on days that PBZ samples were collected for that inspector. This questionnaire assessed acute upper and lower respiratory symptoms experienced during the shift. Symptoms related to having a cold were not included. Upper respiratory symptoms included burning or stinging eyes, watery eyes, stuffy or itchy nose, frequent sneezing, and sore throat. Lower respiratory symptoms included wheezing, shortness of breath, and chest tightness. Cough was also included on the questionnaire and could be classified as either an upper or lower respiratory symptom.

Statistical Analysis

SAS version 9.1.3 was used for statistical analysis. Medians were calculated for each air measure for those with and without each daily symptom. Exact Wilcoxon two-sample tests were used to compare air measures for those with and without each daily symptom. Only NIOSH laboratory results were used in these analyses. Paired *t*-tests were used to determine how closely the results of the NIOSH laboratory's analytical method matched the results from the contract laboratory. Pearson's correlation coefficient was used to determine the strength of the relationship between the NIOSH laboratory results and the contract laboratory results. Values for sampling results that were 'non-detectable' were assigned the value of one half the LOD. A *p*-value of less than 0.05 was considered statistically significant.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the 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 increases 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),[7] (2) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs),[8] and (3) the American Conference of Governmental Industrial Hygienists' (ACGIH®) threshold limit values (TLVs®).[9] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are

likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

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 STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Chloramines

Chloramines are formed by the reaction between chlorine disinfectants and nitrogenous compounds such as ammonia, amines, or organic nitrogen-containing material. The species and concentrations of chloramine are influenced by the concentration of residual chlorine, ammonia (or other nitrogen sources), pH, and temperature.[4] In general, the lower the pH and the greater the chlorine to ammonia ratio, the higher the likelihood of producing chloramines.

Soluble Chlorine

The term soluble chlorine is used in this report to designate a combination of chlorine compounds collected using the silica gel-containing tube portion of the sampler used. These chlorine compounds include monochloramine, dichloramine, hypochlorous acid, and hypochlorite. No occupational exposure criteria have been developed for soluble chlorine or for any of its specific constituents.

Trichloramine

Trichloramine, or nitrogen trichloride (NCl_3), is a brownish-yellow gas, has a pungent chlorine odor (sometimes described as rotting grapefruit or geraniums) and is a strong irritant that causes excessive tearing of the eyes.[4,10] NCl_3 has low solubility, aerates easily, and decomposes rapidly in sunlight. Eye and respiratory tract irritation appear to be the primary effects of exposure, although asthma has been documented in lifeguards and swimming instructors.[11] The irritant characteristics of NCl_3 seem to be similar to that of chlorine.[12] Occupational exposure criteria for NCl_3 have not been established.

RESULTS

Industrial Hygiene

NIOSH laboratory results from the sampling are summarized in Tables 1 through 3. Table 1 shows the results of the area air samples collected near three evisceration line stations where chloraminated washwater is used (Nu-Tech station #3, Nu-Tech station #4, Maestro cabinet, and Maestro station #4). Table 1 also shows the results of area air samples from the processing area, located away from the usage of the water. Table 2 shows the results of PBZ samples collected on inspectors at these stations on the evisceration line. Table 3 shows the results of PBZ samples collected on inspectors who worked the majority of their shifts in an office at the facility.

The mean of the trichloramine concentrations in the area air samples in the Maestro and Nu-Tech stations (near the super-chlorinated water sources) was 189.5 $\mu g/m^3$ compared to 4.8 $\mu g/m^3$ in the processing area (away from the chlorinated water sources) ($p<0.01$). The means of the soluble chlorine concentrations in these two areas were not significantly different.

The mean trichloramine concentrations of PBZ samples from inspectors on the evisceration line was 119.3 $\mu g/m^3$ compared to 30.1 $\mu g/m^3$ for those in the office ($p<0.01$). Soluble chlorine levels were also higher on the line, with a mean of 67.2 $\mu g/m^3$ compared to 17.3 $\mu g/m^3$ in the office ($p<0.01$).

Medical

Of 24 inspectors, 12 (50%) completed an initial questionnaire. The mean age of inspectors who completed this questionnaire was 46.4 years (range: 33-62 years). Their mean tenure was 11.8 years (range: 1 month-26 years). Sixty-seven percent reported a history of hay fever, and 25% reported a history of asthma. There were no current smokers, but 44% reported being former smokers. Itchy or runny nose, stuffy nose, cough, and frequent sneezing were the most frequently reported work-related symptoms (Table 4).

End of the work-shift symptom questionnaires were administered to 14 of 24 (58%) inspectors. Only four inspectors completed two separate end of the work-shift symptom questionnaires; the total number of questionnaires was 18. The most commonly reported symptoms reported on this questionnaire were itchy or stuffy nose, burning or stinging eyes, and cough. The median trichloramine and soluble chlorine levels were higher among workers reporting these three symptoms than those without symptoms (see Table 5). None of the differences were statistically significant.

DISCUSSION AND CONCLUSIONS

Trichloramine levels were higher at the Maestro and Nu-Tech stations, where large quantities of chlorinated water was used, than in the offices or processing areas, where additional water was either not used or used very little. Decreasing the solution pH, as was done at the Maestro and Nu-Tech stations, favors formation of trichloramine, and may explain the predominance of trichloramine over soluble chlorine compounds. Levels of soluble chlorine compounds did not differ significantly between the Maestro and Nu-Tech stations and processing areas, but were lower in the offices.

Itchy/runny nose, stuffy nose, cough and frequent sneezing were the most commonly reported work-related symptoms reported in the 4 weeks prior to the survey. The respiratory symptoms reported in this study are consistent with findings among other poultry processing workers. The small number of participants in this study may have limited NIOSH investigators' ability to find statistically significant associations between work-related symptoms and trichloramine or soluble chlorine levels.

RECOMMENDATIONS

1. USDA/FSIS inspectors should continue to report symptoms they experience to occupational safety and health specialists at USDA to allow for continued investigation of the specific conditions that may be associated with times of increased symptoms.

2. USDA staff should continue to collaborate with the facility's operators to identify specific controls that may be implemented for the prevention of such symptoms. Solutions found to be helpful in other poultry processing plants where similar symptoms have occurred include improving ventilation throughout the evisceration areas, improving engineering controls for capturing airborne chlorine compounds around equipment such as sprayers, and improving flushing of used wash water.

REFERENCES

1. Sanderson W, Weber A, Echt A [1995]. Case reports: epidemic eye and upper respiratory irritation in poultry processing plants. Appl Occup Environ Hyg *10*(1):43-49.

2. NIOSH [1994]. Hazard evaluation and technical assistance report: Tyson Foods, Monett, Missouri. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA Report No. 93-230-2405.

3. NIOSH [1989]. Hazard evaluation and technical assistance report: Columbia Farms Poultry Plant, Columbia, South Carolina. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA Report No. 87-110-1943.

4. NIOSH [2003]. Hazard evaluation and technical assistance report: Bil-Mar Foods, Inc., Storm Lake, Iowa. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA Report No. 2002-0257-2916.

5. Hery M, Gerber JM, Hecht G, Subra I, Possoz C, Aubert S, Dieudonne M, Andre JC [1998]. Exposure to chloramines in a green salad processing plant. Ann Occup Hyg *42*(7):437-451.

6. NIOSH [2000]. Hazard evaluation and technical assistance report: Wampler Foods, Inc., Hinton, Virginia. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA Report No. 2000-0105-2794.

7. NIOSH [1992]. Recommendations for occupational safety and health: compendium of policy documents and statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

8. CFR [2003]. 29 CFR 1910.1000. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

9 ACGIH® [2006]. 2006 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

10 Barbee SJ, Thackara JW, Rinehart WE [1983]. Acute inhalation toxicology of nitrogen trichloride. Am Ind Hyg Assoc J *44*(2):145-146.

11. Thickett KM, McCoach JS, Gerber JM, Sadhra S, Burge PS [2002]. Occupational asthma caused by chloramines in indoor swimming-pool air. Eur Respir J *19*:827-832.

12. Gagnaire F, Axim S, Bonnet P, Hecht G, Hery M [1994]. Comparison of the sensory irritation response in mice to chlorine and nitrogen trichloride. J Appl Toxicol *14*:405-409.

TABLES

Table 1
Area Air Sample Results for Trichloramine and Soluble Chlorine
USDA/FSIS Inspection Stations
NIOSH Lab Analysis
HETA 2004-0337-3051
August 31-September 2, 2004

LOCATION	DATE/SHIFT	TRICHLORAMINE ($\mu g/m^3$)	SOLUBLE CHLORINE ($\mu g/m^3$)
MAESTRO 4	8/31 AM	243.6	49.4
MAESTRO 4	8/31 PM	117.3	37.7
MAESTRO 4	9/2 AM	ND	19.6
MAESTRO CABINET	9/2 AM	131.7	30.4
NU-TECH 3	8/31 AM	368.6	82.6
NU-TECH 3	8/31 PM	120.5	53.3
NU-TECH 3	9/2 AM	230.4	69.6
NU-TECH 4	8/31 AM	337.5	90.8
NU-TECH 4	8/31 PM	121.9	no sample
NU-TECH 4	9/2 AM	222.7	86.0
PROCESSING	8/31 AM	ND	93.4
PROCESSING	8/31 PM	9.5	31.5
PROCESSING	9/2 AM	ND	19.8
Maestro/Nu-Tech Mean		**189.5**	**57.7**
Processing Mean		**4.8***	**48.2**

ND denotes non-detectable
$\mu g/m^3$ denotes micrograms per cubic meter
* LOD/2 was substituted for ND in order to calculate mean

Table 2
Personal Breathing Zone Air Sample Results for Trichloramine and Soluble Chlorine
USDA/FSIS Inspectors on the Evisceration Line
NIOSH Lab Analysis
HETA 2004-0337-3051
August 31-September 2, 2004

DATE/SHIFT	TRICHLORAMINE ($\mu g/m^3$)	SOLUBLE CHLORINE ($\mu g/m^3$)
08/31 AM	176.9	97.5
08/31 AM	147.5	102.9
08/31 AM	166.5	78.9
08/31 AM	193.4	85.1
08/31 AM	207.3	ND
08/31 PM	71.3	64.7
08/31 PM	74.5	46.4
08/31 PM	57.7	25.6
08/31 PM	73.2	66.0
08/31 PM	64.8	46.7
09/02 AM	118.3	77.1
09/02 AM	96.9	89.8
09/02 AM	126.4	64.0
09/02 AM	96.3	98.2
09/02 AM	119.1	61.9
Mean:	**119.3**	**67.2***

ND denotes non-detectable
$\mu g/m^3$ denotes micrograms per cubic meter
*LOD/2 was substituted for ND in order to calculate mean

Table 3
Personal Breathing Zone Air Sample Results for Trichloramine and Soluble Chlorine
USDA/FSIS Office Staff
NIOSH Lab Analysis
HETA 2004-0337-3051
August 31-September 2, 2004

DATE/SHIFT	TRICHLORAMINE ($\mu g/m^3$)	SOLUBLE CHLORINE ($\mu g/m^3$)
8/31 AM	55.0	21.8
8/31 PM	ND	ND
9/2 AM	21.4	20.7
Mean:	**30.1***	**17.3***

ND denotes non-detectable
$\mu g/m^3$ denotes micrograms per cubic meter
* LOD/2 was substituted for ND in order to calculate mean

Table 4
Self-Reported Work-Related Symptoms[a]
USDA/FSIS Inspectors
HETA 2004-0337-3051
August 31-September 2, 2004

Symptom	Number of Inspectors Reporting Symptom
Itchy, runny nose	10/12
Stuffy nose	10/12
Cough	9/12
Frequent sneezing	9/12
Sore throat	8/12
Burning or stinging eyes	8/12
Watery eyes	7/11
Chest tightness	6/12
Shortness of breath	5/12
Wheezing	4/12

Defined as experienced at work during the last 4 weeks,
but occurred less frequently or not at all on days away from work

Table 5
Symptoms Experienced During Workshift[a]
USDA/FSIS Inspectors on the Evisceration Line
HETA 2004-0337-3051
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	TRICHLORAMINE (µg/m^3)			SOLUBLE CHLORINE (µg/m^3)		
	n	**Median**	**p-value[b]**	**n**	**Median**	**p-value[b]**
Wheezing						
yes	0	N/A	N/A	0	N/A	N/A
no	18	96.6		18	64.4	
Cough						
yes	7	96.9	0.18	7	85.1	0.21
no	11	73.2		11	61.9	
Shortness of breath						
yes	0	N/A	N/A	0	N/A	N/A
no	18	96.6		18	64.4	
Chest tightness						
yes	1	74.5	0.89	1	46.4	0.67
no	17	96.9		17	64.7	
Itchy or stuffy nose						
yes	9	119.1	0.0503	9	77.1	0.55
no	9	71.3		9	46.7	
Frequent sneezing						
yes	3	147.5	0.36	3	85.1	0.13
no	15	96.3		15	61.9	
Watery eyes						
yes	1	71.3	0.67	1	64.7	1.0
no	17	96.9		17	64.0	
Burning, stinging eyes						
yes	9	118.3	0.07	9	77.1	0.26
no	9	64.8		9	46.7	
Sore throat						
yes	5	96.3	0.70	5	64.7	0.85
no	13	96.9		13	64.0	

[a]defined as experienced during workshift on day of sampling, excluding cold and seasonal allergy symptoms
[b]Wilcoxon exact test
µg/m^3 denotes micrograms per cubic meter

APPENDIX

NIOSH investigators collected a duplicate sample (obtained side-by-side) for each of the samples that was to be analyzed by the NIOSH analytical laboratory. The duplicate samples were sent to a private contract laboratory to investigate the use of ion chromatography as a method of analysis for both tube and filter, rather than ICP as used by NIOSH chemists. For the tube portion of the samplers, the sorbent sections of each sample were desorbed in 10 mL of 1.0 g/L sulfamic acid solution. Then 0.10 mL of 0.5M potassium iodide was added to each sample. All samples were briefly shook and allowed to stand for several minutes. An aliquot of each sample was then analyzed by a Dionex 300 ion chromatograph for the chloride ion concentration. The chromatograph was equipped with a WISP 717P autosampler. A conversion factor of 1.48 was applied to the results to convert from chloride ion to soluble chlorine. The LOD for the soluble chlorine was 3 µg/sample, with an LOQ of 10 µg/sample. For the filter portion of the samplers, the front and back filter of each sample were desorbed separately in 10.0 ml of ASTM type II water. An aliquot of each desorbed sample was solid-phase extracted with an SPE cartridge. An aliquot of solid-phase extracted sample was then analyzed by a Dionex 300 ion chromatograph for the chloride ion concentration. A conversion factor of 1.13 was applied to the results to convert from chloride ion to trichloramine. The LOD for the trichloramine was 2 µg/sampler with an LOQ of 7 µg/sample. Results of the sampling using this method of analysis are summarized in Tables A1, A2, and A3.

The mean of all soluble chlorine results from the NIOSH laboratory was 57.5 $\mu g/m^3$ compared to 49.0 $\mu g/m^3$ from the contract laboratory ($p=0.09$). The results were positively correlated ($r = .48$). In contrast, the mean of all trichloramine results from the NIOSH laboratory was 122.2 $\mu g/m^3$ compared to 153.0 $\mu g/m^3$ from the contract laboratory ($p<0.01$). These results were also positively correlated ($r = .91$).

While it appears that the two analytical methods return similar results for soluble chlorine, further work may be needed to determine possible causes of differences observed in the trichloramine concentrations. These differences may simply be a result of an increased sensitivity of one analytical method over the other. As this was the first attempt to compare these two methods based on side-by-side sampling, further work may be needed to verify these results in future evaluations and to determine factors in differences observed.

Table A1
Area Air Sample Results for Trichloramine and Soluble Chlorine
USDA/FSIS Inspection Stations
Contract Lab Analysis
HETA 2004-0337-3051
August 31-September 2, 2004

LOCATION	DATE/SHIFT	TRICHLORAMINE ($\mu g/m^3$)	SOLUBLE CHLORINE ($\mu g/m^3$)
MAESTRO 4	8/31 AM	290.6	63.0
MAESTRO 4	8/31 PM	159.1	52.3
MAESTRO 4	9/2 AM	149.0	43.1
MAESTRO CABINET	9/2 AM	158.5	36.6
NU-TECH 3	8/31 AM	393.1	81.1
NU-TECH 3	8/31 PM	153.0	65.3
NU-TECH 3	9/2 AM	272.4	64.2
NU-TECH 4	8/31 AM	397.0	94.3
NU-TECH 4	8/31 PM	141.0	76.1
NU-TECH 4	9/2 AM	237.2	83.0
PROCESSING	8/31 AM	ND	22.6
PROCESSING	8/31 PM	21.5	38.6
PROCESSING	9/2 AM	189.7	35.6

ND denotes non-detectable
$\mu g/m^3$ denotes micrograms per cubic meter

Table A2
Personal Breathing Zone Air Sample Results for Trichloramine and Soluble Chlorine
USDA/FSIS Inspectors
Contract Lab Analysis
HETA 2004-0337-3051
August 31-September 2, 2004

DATE/SHIFT	TRICHLORAMINE ($\mu g/m^3$)	SOLUBLE CHLORINE ($\mu g/m^3$)
08/31 AM	222.2	50.5
08/31 AM	172.6	50.6
08/31 AM	169.1	43.8
08/31 AM	226.8	57.7
08/31 AM	190.9	62.2
08/31 PM	84.5	47.9
08/31 PM	101.8	43.6
08/31 PM	71.0	51.6
08/31 PM	91.4	49.4
08/31 PM	92.3	42.4
09/02 AM	125.2	65.5
09/02 AM	131.0	34.7
09/02 AM	142.9	50.9
09/02 AM	124.0	70.9
09/02 AM	139.5	37.3

$\mu g/m^3$ denotes micrograms per cubic meter

Table A3
Personal Breathing Zone Air Sample Results for Trichloramine and Soluble Chlorine
USDA/FSIS Office Staff
Contract Lab Analysis
HETA 2004-0337-3051
August 31-September 2, 2004

DATE/SHIFT	TRICHLORAMINE ($\mu g/m^3$)	SOLUBLE CHLORINE ($\mu g/m^3$)
8/31 AM	57.4	16.7
8/31 PM	16.7	9.4
9/2 AM	19.2	ND

ND denotes non-detectable
$\mu g/m^3$ denotes micrograms per cubic meter

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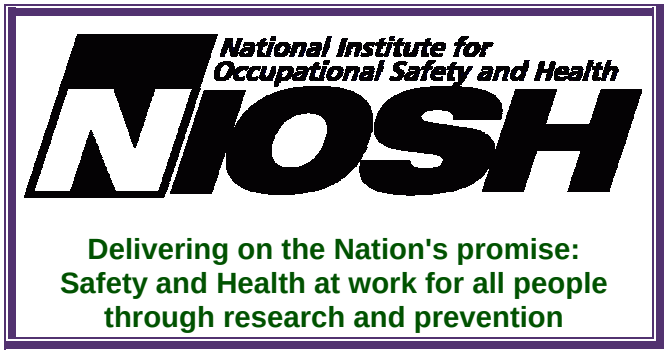

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