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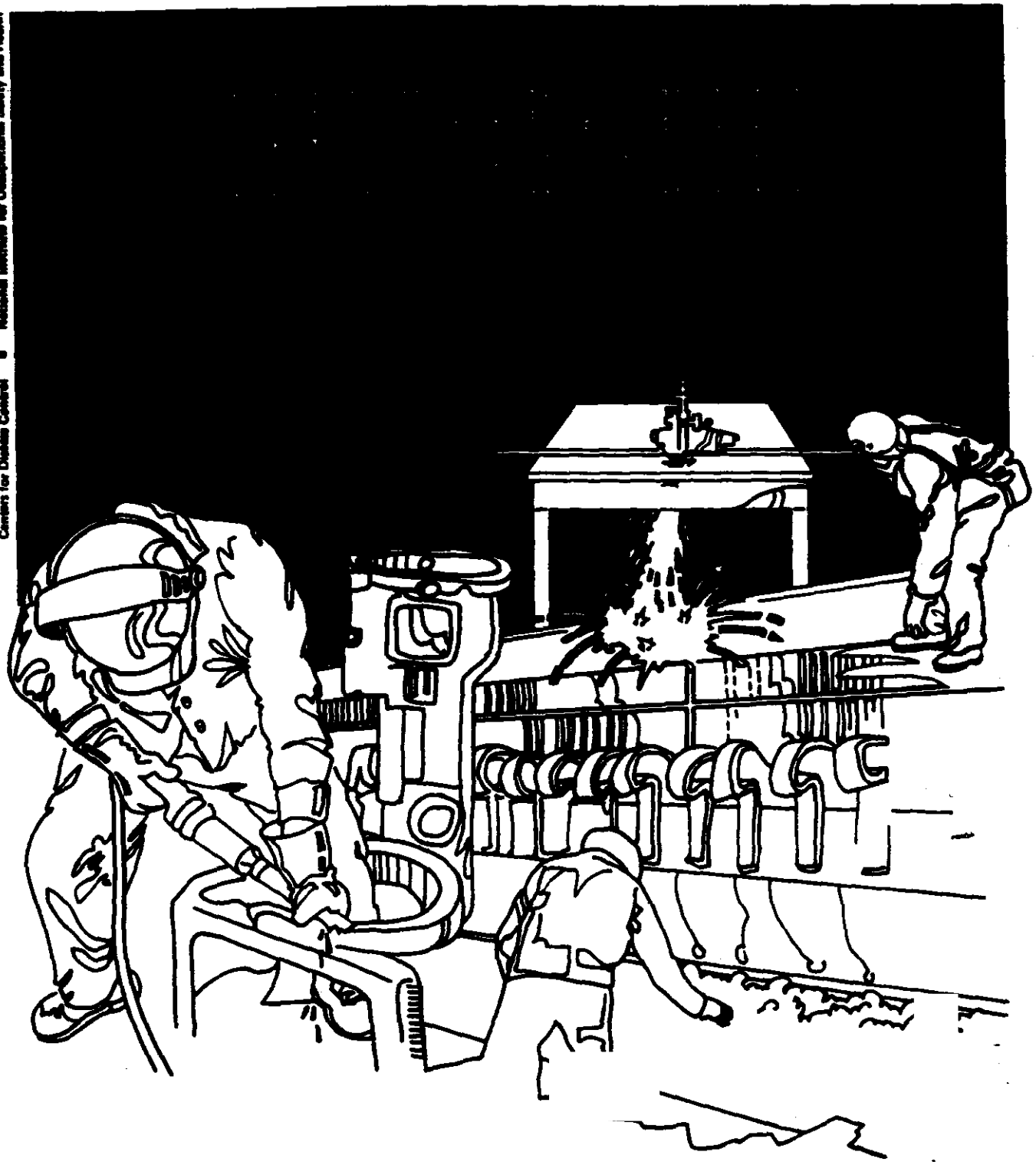

Health Hazard Evaluation Report

MHETA 87-110-19
COLUMBIA FARMS POULTRY PLA
COLUMBIA, SOUTH CAROLI

PREFACE

The Hazard Evaluations and Technical Assistance Branch of 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 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 employer 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.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) 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 the National Institute for Occupational Safety and Health.

MHETA 87-110-1943
JANUARY 1989
COLUMBIA FARMS POULTRY PLANT
COLUMBIA, SOUTH CAROLINA

NIOSH INVESTIGATOR
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I. SUMMARY

On February 6, 1987, the United States Department of Agriculture (USDA) requested the National Institute for Occupational Safety and Health (NIOSH) to evaluate complaints of eye, nose and throat irritation among USDA inspectors at Columbia Farms poultry processing plant in Columbia, South Carolina. All of the complaints were reportedly from the inspection area. Complaints started on April 21, 1986 at the same time the West Columbia water treatment plant changed its disinfection process from gas chlorination to a chloramination process. Private and state consultants suspected that complaints in the poultry plant were related to the chloramination process, since nitrogen trichloride (trichloramine) was identified in the water. As a result, numerous changes were made by Columbia Farms between April and November 1986; however, workers continued to report symptoms intermittently.

NIOSH conducted an initial environmental survey of the plant on February 17-20, 1987, with follow-up surveys on July 13-16 and November 2-12, 1987. During the initial survey, nitrogen trichloride (NCl_3) concentrations ranging from 0.3-0.9 parts per million (ppm) were found in the water in the evisceration and reprocessing areas. There is no standard for NCl_3, but is is a recognized eye irritant at 4 ppm in swimming pools. Hydrogen chloride (acid mist) was also detected in the evisceration and reprocessing areas. The hydrogen chloride (HCL) analysis revealed a TWA concentration range of 0.02 to 0.20 ppm and was below the OSHA ceiling standard of 5 ppm.

On the second survey, a total of 525 area water and air analyses for chlorine, HCL, and ammonia were performed. Analysis of chlorine in the air revealed a time weighted average (TWA) concentration ranging from 0.01 to 0.18 ppm. The TWA concentrations for chlorine are below the OSHA ceiling value of 1 ppm and NIOSH's recommended exposure limit (REL) of 0.5 ppm. Hydrogen chloride revealed a TWA concentration range of 0.09 to 0.35 ppm and was below the OSHA ceiling of 5 ppm. Seventy-four air samples were collected for ammonia in the production area; four samples had concentrations that exceeded the OSHA standard of 50 ppm and NIOSH's REL of 50 ppm, 26 samples ranged between 4 and 29 ppm, and 44 did not detect anything. Chlorine concentrations in the water ranged from 0.1 to 28 ppm. It is a USDA requirement that a minimum of 20 ppm of chlorine be present in the water system serving the evisceration and reprocessing areas of processing plants before a plant can begin its daily operation. During the survey, it was not uncommon to find high chlorine levels in the water. As part of this survey, a NIOSH physician conducted an eye examination of 52 workers in the production area. On examination, no worker had moderate or severe redness of the conjunctiva of the lower eye, however, twelve of the workers did have a "slight redness" of the conjunctiva of the lower eye lid. When compared to a NIOSH survey of 1500 employees from selected USDA poultry plants on machine-paced inspections, the "slight redness" at Columbia Farms could not be attributed to in-plant exposures.

On the third survey, a total of 465 area samples for ammonia in air and water were collected. This time, the ammonia levels in the air and water were less than 1 ppm. The pH of the water ranged from 6.6-8.6, the free and total chlorine ranged from 0.1-10 ppm and 2.0-90.0 ppm respectively. A short medical questionnaire administered daily over the two week period indicated that a majority of workers had no to mild irritation. There were two days, however, when irritation among three inspectors ranged from moderate to severe and they had to be relieved from their work stations.

Ammonia and chloramines are unlikely to have been in Columbia Farms water before the water treatment plant switched to chloramination. But, after the switch to chloramination, uncombined ammonia and chloramines were detected. Because solutions of both ammonia and chloramines are known to be eye and mucosal membrane irritants, these are the likely causes of workers' symptoms at Columbia Farms. Measurements indicated that water concentrations of ammonia and chloramines were quite variable. It is possible that on days when workers are experiencing extreme irritation that the concentrations of ammonia or chloramines in the water are elevated, but this was not documented. Recommendations can be found in the body of the report.

KEY WORDS: SIC 2016 (poultry dressing plants), eye irritation, chlorine, chloramines, nitrogen trichloride.

II. INTRODUCTION/BACKGROUND

On February 6, 1987, the United States Department of Agriculture (USDA), Safety and Health Division, requested the National Institute for Occupational Safety and Health (NIOSH) to provide technical assistance in evaluating complaints of eye, nose and throat irritation among USDA inspectors at the Columbia Farms poultry processing plant in West Columbia, South Carolina. In response, NIOSH conducted a preliminary evaluation of the plant on February 17-20, 1987, and returned on two more occasions, July 13-16 and November 2-13, 1987, to conduct more extensive evaluations.

Columbia Farms is located on Hwy 378 within the city limits of West Columbia, South Carolina. The plant has been in operation for 27 years. There are three major work areas in the plant: 1) the live-receiving area, 2) the processing/inspection area, and 3) the packing/shipping area. In the live-receiving area, the chickens are mechanically unloaded from trucks, hung on shackles by their feet and mechanically killed and de-feathered. The live-receiving area is physically separated from the rest of the plant by a wall to prevent contamination of the rest of the plant. In the processing/inspection area, the chickens are mechanically eviscerated. The water spray on this machine is required by USDA to have a minimum of 20 parts per million (ppm) of chlorine for disinfection purposes. This machine removes the entrails for inspection. Inspection refers to the postmortem examination of poultry for disease and defects by USDA personnel. Chickens with minor imperfections are reprocessed. In reprocessing, the water used for cleaning the birds must also contain at least 20 ppm of chlorine. The packing/shipping area is primarily responsible for rapid chilling and packaging of the chickens for shipment as whole birds or parts.

Columbia Farms has two working shifts and one clean-up shift per day. Over 100,000 chickens are processed per day. The first shift starts at 7 am, and the second shift starts at 4 pm. Before the start up of the second shift, there is a partial clean-up of the plant. At the end of the second shift, there is a thorough breakdown of equipment for cleaning, which lasts until the start of the first shift. There are approximately 140 employees and 9 inspectors on the day shift, and 70 employees with five inspectors on the second shift.

Columbia Farms, which is immediately next door to West Columbia's water treatment plant, is first on the water line to receive water and is one of the city's largest users. Around April 14, 1986, the water treatment plant changed its form of water treatment from chlorine gas to chlorine gas plus ammonia (chloramination). The reasons for the change were threefold; 1) it was more cost-efficient; 2) the chlorine residual is more stable and remains in the water longer; and 3) trihalomethane concentrations are reduced. Trihalomethanes are considered carcinogenic. When ammonia is added to chlorine in water, the chloramination process will form mono-, di-, tri-chloramines.

These reactions are:

1) $NH_3 + HOCl \text{ ---- } NH_2Cl \text{ (mono)} + H_2O$

2) $NH_2Cl + HOCl \text{ ---- } NHCl_2 \text{ (di)} + H_2O$

3) $NHCl_2 + HOCl \text{ ---- } NCl_3 \text{ (tri)} + H_2O$

At water treatment plants, the rate of reaction between ammonia and chlorine varies depending on the pH (3-9), mole ratio of chlorine to ammonia (1:1, 2:1, 3:1, etc.), temperature (50-80°F), and contact time (10-60 minutes). Typically, at water treatment plants that have chloramination, ammonia is added separately to the process, either before (pre-ammoniation) or after (post-ammoniation) addition of chlorine, to produce a chlorine base which is more stable and remains in the water distribution system longer. The order of ammonia addition is important and can have an important effect on the type reaction that occurs. At West Columbia, the post-ammoniation process is used. Rice and Bolding [1] found that pre-ammoniation was more effective in preventing off-tastes, odors and trihalomethane formation. Post-ammoniation, from studies by White, was generally less effective for preventing off-tastes, odors, and trihalomethane formation.[2] Trihalomethanes (THM) are formed in the treatment process from the reaction of chlorine with organic products (humic materials) present in raw water. Organic materials are the products of decaying vegetation, aquatic plants, and wastewater discharges, [3] and their presence is usually highest during the spring and fall months.

On April 21, 1986 when the West Columbia water treatment plant changed over to chloramination, Columbia Farms personnel began experiencing eye, nose and throat irritation. Prior to this date, there were no reported complaints to management of eye, nose or throat irritation. On April 25, 1986, Columbia Farms requested the South Carolina Occupational Safety and Health Administration (SCOSHA) to investigate the complaints from their employees and USDA inspectors.

SCOSHA took air samples for ammonia, chlorine, carbon monoxide, organics, respirable dust and water samples for chlorine and pH. All air samples were found to be within SCOSHA permissible exposure limits (PEL). The water samples collected for chlorine and pH were also within acceptable limits. As complaints continued into June, Columbia Farms asked a local consulting firm (Carr and Associates) and the State Department of Health and Environmental Control (DHEC) for their assistance in evaluating the problem. Their investigations revealed an acidic pH, and low levels of nitrogen trichloride and free ammonia in the Columbia Farms water.[4] Air samples for fungi were also collected and analyzed. None of the fungi identified were considered pathogenic. Upon finding NCl_3 and knowing that the city of West Columbia had recently changed its water treatment process, NCl_3 was the suspected etiologic agent. NCl_3 is known to be a mucosal membrane irritant. It was recommended that activated carbon filters be installed on the incoming water line to remove the chloramines.

Also during this time frame, Columbia Farms had a new supply air ventilation system installed in the inspection area. For a period of 3-4 months, the complaints stopped. Then on November 20, 1986, inspectors left the line due to eye, nose and throat irritation. In December, Columbia Farms had a water treatment company install a large, commercial activated carbon filter (13 cubic feet) to filter water for the evisceration/reprocessing and inspection areas. Because the complaints continued, NIOSH was requested to conduct a health hazard evaluation.

III. METHODS

First Survey

NIOSH conducted a survey February 17-20, 1987, in an attempt to correlate eye or nose irritation to water concentrations of chlorine, pH, and nitrogen trichloride. In addition, NIOSH reviewed documentation that six USDA inspectors had submitted in support of workers compensation claims for eye and nose irritation.

For two weeks prior to and during the survey, the poultry plant clean-up crew was asked not to use acid/alkaline cleaners on the floor areas in order to eliminate this as a possible etiologic factor.

A brief medical questionnaire was used to determine the prevalence of eye and nose irritation at the work place from February 17-19. Questionnaires were handed out and collected on a daily basis from all USDA inspectors in the inspection area. Each inspector was asked to indicate how he or she was affected in terms of eye and/or nose irritation at work that day, using the following scale: 1-none ("I did not have any personal symptoms of irritation"); 2-mild ("I had slight symptoms of irritation personally, but they did not interfere with my normal inspection activities"); 3-moderate ("I had definite symptoms of irritation personally, that slightly interfered with my normal inspection activities"); and 4-severe ("I had extreme symptoms of irritation personally, that markedly interfered with my normal inspection activities").

Between February 17-20, the water was monitored for pH, free and total chlorine and nitrogen trichloride (NCl_3). Hydrochloric acid mist, relative humidity, air and water temperatures were also taken. Area air and water samples were collected in six different locations (see Figure I). Water samples collected by NIOSH personnel for pH and total chlorine were analyzed by the staff at the West Columbia water treatment plant. All other environmental samples were analyzed at NIOSH laboratories. To measure for acid mists, a jumbo silica gel solid sorbent tube (400/200mg) was utilized in-line with a low flow pump calibrated at 500 cubic centimeters(cc) per minute. A 50-liter sample was collected on nineteen silica gel tubes throughout evisceration,

inspection, and reprocessing. To analyze the water samples for free and total chlorine and nitrogen trichloride, the La Motte-Palin DPD-FAS test kit was used. The test kit procedure is the same as the one found in the 13th edition of Standard Methods for Water and Wastewater testing.[5] There is no validated field method for testing NCl_3 in air, so NCl_3 in air was not monitored. The water pH was analyzed using a pH meter and ion specific electrode for pH ranges from 1 to 14. Temperature of the water was also taken with this meter. Relative humidity and air temperatures were measured with a sling psychrometer.

Second Survey

On the July survey, NIOSH collected area air samples for chlorine, hydrochloric acid mist, and ammonia. Low flow pumps were used: in line with silica gel tubes to collect hydrochloric acid mist; in line with impingers containing sulfamic acid to collect chlorine; in line with impingers containing 0.1 N sulfuric acid to collect ammonia. Water samples were analyzed for pH, free available chlorine (FAC), total chlorine, and chloramines using the La Motte test kit.

During the July survey, NIOSH investigators administered a questionnaire to all USDA inspectors, production workers, and packers in order to determine the prevalence of symptoms since April 1986 (Appendix A). In addition, the NIOSH investigators administered a daily questionnaire to each USDA inspector and all production employees working near the inspectors, in order to determine the presence and severity of symptoms (Appendix B). The live-receive area, maintenance staff, and office workers were not included in the NIOSH survey.

A NIOSH physician examined the external surface of the eyes of inspectors and all production workers working near the inspectors to document signs of irritation, specifically, redness of the conjuctiva of the lower eye lid or injection of the sclera.

Third Survey

Based on the July survey, the NIOSH investigators presumed that the irritating agent was ammonia. Consequently, area air and water samples were collected for ammonia during the November survey. With this survey, NIOSH had a contract laboratory perform the air and water analyses for ammonia. Approximately, 465 area samples were collected and analyzed for ammonia. Also, the pH, free and total chlorine in water were again checked using the La Motte test kit.

In addition, a short questionnaire was administered by NIOSH investigators to each worker on the inspection line just prior to the end of each shift. The inspectors' questionnaires were self-administered and distributed to each inspector during break and collected at the end of the shift from the inspector in charge.

IV. EVALUATION CRITERIA

Based on the results of accumulated experience with worker health and animal experiments, occupational health exposure criteria for individual substances have been established and/or recommended by NIOSH, the American Conference of Governmental Industrial Hygienists (ACGIH), and the Occupational Safety and Health Administration (OSHA). 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.

The exposure criteria described below are reported as time-weighted average (TWA) exposure recommendations averaged over a full work shift; short term exposure limit (STEL) recommendations for a 10-15 minute TWA exposure period; and ceiling levels (C) not to be exceeded for any amount of time. These exposure criteria and standards are commonly reported as parts contaminant per million parts air (ppm) or milligrams of contaminant per cubic meter of air (mg/m^3). Occupational criteria for the contaminants evaluated in this study are as follows:

SUBSTANCE	NIOSH (REL)	ACGIH (TLV)	OSHA (PEL)
HCL(acid mist)	N/A	N/A	5 PPM (C)
Chlorine	0.5 PPM*(C)(15)	1 PPM	1 PPM (C)
Ammonia	50 PPM*(C)(5)	25 PPM	50 PPM

*- if instantaneous monitoring is not feasible, then the ceiling can be assessed by sampling over a 5-15 minute period.

In the absence of evaluation criteria for pH and NCl_3 in water, it was necessary to review literature in order to recommend acceptable limits to prevent eye irritation. Because there are no occupational exposure criteria for NCL_3 in water, there has been no documentation that NCL_3 below 4 ppm causes eye irritation.[6] Eye irritation has been reported after swimming in pools with chloramine concentrations in the range of 4.0 to 10 ppm.[7] In swimming pools, pH is maintained between 7.0 and 8.5 to minimize eye irritation.[6,8,9]

There has been no documentation that NCl_3 below 4 ppm causes eye irritation.[6] Eye irritation from chloramines in swimming pools has been reported in the ranges of 4.0 to 10 ppm.[7]

V. RESULTS

First Survey

Environmental

Air temperatures within the poultry plant ranged from 52 to 60° F over the shift, with 100% relative humidity. The poultry plant water temperatures ranged from 51 to 74° F, with the higher temperatures being mainly on the inspection line at the six inspector stations. Water samples were collected at six locations within the plant (see Figure I): (1) pre-filter, (2) post-filter, (3) filtered inspector's water, (4) the hyper-chlorinated water on evisceration machine #2, (5) the hyper-chlorinated reprocessing water, (6) and water from the high pressure hoses. In the eviscerating and reprocessing areas, the free available chlorine in the super chlorinated water ranged between 9.7 to 26.8 ppm, and the pH ranged between 4.3 to 7.9. At the other four locations the free available chlorine ranged between 1.6 and 3.4 ppm and the pH ranged between 6.9 and 7.6.

Nitrogen trichloride was detected at levels ranging between 0.3 and 0.9 ppm in the super-chlorinated water from the eviscerating and reprocessing areas on two of the three survey days. Nitrogen trichloride was detected when Columbia Farms, at the NIOSH investigator's request, changed their chlorination process during the survey from liquid sodium hypochlorite to chlorine gas. Water used in the evisceration and reprocessing areas is super-chlorinated by Columbia Farms per USDA regulations. Chlorine gas usage tends to decrease the pH of water while sodium hypochlorite increases the pH. Consequently, when chlorine gas is used in the presence of chloramines, NCl_3 formation should increase as the pH decreases. However, there was no evidence that NCl_3 increased with the use of chlorine gas. Also, on two of the three survey days, the activated carbon filter was by-passed. There was no opportunity to see if the NCl_3 was being removed by the filtration system, because Columbia Farms ran out of gas chlorine. Nitrogen trichloride was not detected at any of the other sample locations.

Of nineteen area air samples collected for HCL mists (Table I), eight (TWA) samples detected HCl mist ranging from 0.02 to 0.20 ppm, well below the ceiling standard of 5.0 ppm.

Medical

Nine USDA inspectors worked in the inspection area each day during the February 17-20, 1987 survey: however, only six of the inspectors filled out questionnaires. The reported complaints of the six inspectors can be found in Table II. Typically, two or three inspectors would report eye irritation on one day, and a different group would report symptoms on another day. Sometimes, of those inspectors working opposite each other, only one would have eye irritation. Also, there was no clear pattern to the time of day that symptoms occur. For example, two inspectors commented that symptoms were most severe in the afternoon, especially after the floors in the inspection area were washed down during the lunch break. However, inspectors reported complaints on April 6 and April 20-23, thirty minutes after starting to work in the morning.

Randomly chosen plant employees in the evisceration, reprocessing and inspection line areas were asked how they felt. The employees indicated that they had not had any problems since July 1986.

Between December 31, 1986 and January 14, 1987, six USDA inspectors had filed workers compensation claims for eye and respiratory irritation symptoms. Each of these workers had seen a different physician for evaluation. In three of the six cases, the workers had reported work-related eye and nose irritation to the physician, but the physician noted no objective medical findings at the time of the examination. In two of the six cases, conjunctival irritation was noted by the physician. In an additional case, eye tearing was observed by the physician, and wheezing was heard. No case was observed by a physician before and after a shift.

Second Survey

Environmental

Water samples for pH, free available chlorine (FAC), and the chloramines (mono, di, tri) were collected at the same six locations as the first survey. There were 525 water sample analyses performed; results have been summarized below:

	Ranges	
Sample Station	pH	FAC(ppm)
City Water	6.9-7.3	0.1-1.7
Pre-filter	6.8-7.0	0.1-1.7
Post-filter	5.5-7.1	ND
Filtered inspector's water	5.8-7.2	ND
Evisceration	6.8-7.6	10-26
Reprocessing	7.3-7.7	9-28
Wash Down	6.7-7.3	0.1

ND = None Detected

The FAC during the survey fluctuated on the incoming city and pre-filtered water with ranges from 0.1 to 1.7 ppm, with Wednesday (7/15) having the highest reported value. On Wednesday, the FAC was 1.7 ppm for both the day and evening shift. The post filter and inspection FAC were zero, wash down was 0.1 ppm, and in evisceration/reprocessing the FAC ranged from 9 to 28 ppm. Since the spray water in evisceration and reprocessing is required by USDA to maintain at least 20 ppm chlorine for disinfection purposes, 20 ppm or higher would be expected in these two areas.

When analysis was conducted for the chloramines using the La Motte test kit, values were obtained for monochloramine, dichloramine and trichloramine (nitrogen trichloride). However, according to the instruction manual, monochloramine is unlikely to be present with nitrogen trichloride. In some of our readings, both of these chloramines were present and in others they were not. When La Motte Chemical Co. was contacted for an explanation and interpretation, the NIOSH investigator was told that the results were probably invalid because the quantitation procedure in the instruction manual was inadequately defined and that La Motte Chemical Co. was in the process of changing the test procedure. Therefore no chloramine concentrations are reported, even though levels were found.

A total of 173 area air samples were collected for chlorine, HCl, ammonia and pH.

Location	Chlorine Concentration Range (ppm)	Hydrogen Chloride Concentration Range (ppm)	Ammonia Concentration Range(ppm)	pH Range
Evisceration	.01-.13	.05-.13	2.8-56	6.2-7.2
Reprocessing	.03-.12	.12-.15	0.8-70	5.6-6.6
Inspection #1	.02-.06	.04-.18	1.4-26.6	6.1-6.5
Inspection #2	.02-.05	.07-.13	1.3-11.2	5.6-7.2
Inspection #3	.01-.05	.05-.14	2.8-18.2	5.6-7.0
Packaging	ND	.05	ND	
Controls	ND	ND	ND	

Seventy-four area air samples were collected for ammonia in the evisceration, inspection, and reprocessing areas. Four samples had concentrations that exceeded the federal standard of 50 ppm and NIOSH's REL of 50ppm, 26 samples ranged between 4 and 29 ppm, and 44 samples did not detect anything. At levels of 4-29 ppm, eye irritation complaints have been noted to range from "barely to moderate".[10] At Columbia Farms the refrigeration units use ammonia as a refrigerant and the odor of ammonia can be detected when near these units. However, the levels of ammonia in the air around these units were below 2.0 ppm.

From our measurements, a new ventilation system that had been installed in the inspection area in June 1986 was supplying 100% outside air at approximately 17,000 cubic feet of air per minute (CFM). Air flow in the inspection area was qualitatively evaluated with smoke tubes and found to be highly turbulent. This turbulence is largely a result of the suspended ceiling fans, which are pointed in various directions to help provide additional cooling of employees during the summer months.

Cleaning agents used by the clean-up crew were investigated to see if they were being mixed/used properly and if their contents were irritants. The pH's of the products ranged from 8.2 to 13.0. The products are very alkaline and can cause eye and mucosal irritation. Some of the workers mentioned that there have been occasions when the products were improperly mixed, which resulted in a more concentrated solution being used throughout the poultry plant. Also, because steam is used throughout the plant to heat water, boiler additives to keep mineral deposits from forming in the boiler and water lines are used. However, the cleaners and boiler additives did not seem to be the cause of the irritative symptoms because: (1) the irritation reportedly occurred even when cleaners were mixed properly; (2) the irritation reportedly occurred even when no boiler additives were present; (3) these materials had been used long before problems of irritation were reported; (4) symptoms continued even after use of the cleaning products were halted.

Medical

Table III shows demographic characteristics of the work force by work area. Tenure generally tended to be low. Most workers have been at the plant for less than 3 years. Table IV shows the prevalence of symptoms by work area. The most common symptoms were burning, watery eyes, excessive sneezing, and stuffy, runny noses. USDA inspectors, production workers, and the clean-up crew reported about the same frequency of complaints. In general, packers reported complaints less frequently. Although only a subset of workers on the third shift were interviewed (14/29), they had a prevalence of complaints similar to other areas. Processing workers on the second shift indicated that they were experiencing symptoms similar to those reported by the first shift, but somewhat less frequently than on the first shift (see Table V). Almost all production workers and USDA inspectors employed in April 1986 reported that they first began to experience symptoms around April 21, 1986. No worker reported having symptoms before April 21, 1986.

A NIOSH physician examined 12 USDA inspectors and 40 production workers. Overall, 94% (49/52) of the examined workers reported symptoms related to work. On being asked about the nature of these problems, 87% (45/52) mentioned eye symptoms and 69% (36/52) indicated nose symptoms. Three different patterns of symptoms were reported: 1) starting in the morning after beginning work, 2) after lunch when the equipment and floors have been cleaned, or 3) after leaving work. The most common pattern of symptoms was upon returning from lunch. Twenty-nine percent (15/52) of the workers commented that their symptoms were most severe when they returned to their work stations after lunch. During the lunch hour the equipment, floors and walls are hosed down with hot water (150-170°F) under high pressure. Because of a cool indoor temperature (52-60°F), the environment becomes misty which is present when the workers return from lunch.

Examination by the NIOSH physician of USDA and Columbia Farms personnel revealed that 23% (12/52) had a "slight redness" of the conjunctiva of the lower eye lid. The significance of these findings are uncertain, because the prevalence of "slight redness" of the conjunctiva in the general population of poultry plant workers is unknown and could result from many causes. When compared to a NIOSH study of 1500 employees from selected USDA poultry plants on machine-paced inspections, the "slight redness" found at Columbia Farms could not be attributed to in-plant exposures.[11]

Third Survey

Environmental

On this survey, a total of 218 water samples were collected for pH, free and total chlorine, and ammonia. Since there were problems on the second survey with the individual monochloramine, dichloramine, and trichloramine measurements, it was decided to obtain the free and total chlorine values, take the difference (combined chlorine) and report this value. Free available chlorine refers to chlorine present as hypochlorous acid (hypochlorite). Combined chlorine refers to the total concentration of chloramines.[8,9] The pH over the two weeks, with the exception of evisceration and reprocessing, ranged from 6.6-8.6. In evisceration and reprocessing, the pH ranged from 7.1-8.4. Free and total chlorine on the pre-filtered water from the water treatment plant ranged from 0.1-2.1 ppm and 1.0-4.5 respectively. In the inspection area, free and total chlorine ranged from 0.1-2.6 ppm and 2.1-2.9 ppm, respectively. For comparison, in the packaging/shipping area of the plant, where worker complaints of irritation are low, free and total chlorine ranged from 0.1-0.8 ppm and 2.1-2.9 ppm respectively. The packaging/shipping ranges are somewhat comparable to the inspection area. In wash down water the free and total chlorine ranged from 0.2-2.1 ppm and 2.0-3.0 ppm respectively. As was expected, in the evisceration/reprocessing areas, the free and total chlorine levels were high. The high chlorine levels indicated below for evisceration and reprocessing occurred on November 6, when there was a problem with the chlorinator.

Sample Station	pH	Ranges FAC	Total Cl	Combined(ppm)
Pre-filter	6.6-8.6	0.1-2.1	1.0-4.5	.9-2.4
Filtered inspector's water	6.6-8.6	0.1-2.6	1.5-3.6	1.4-1.0
Evisceration	7.1-8.4	10-30.4	14.4-36	4.4-5.6
Reprocessing	7.1-8.4	10-53.2	12.8-90	2.8-36.8
Packaging/shipping	6.6-8.6	0.1-0.8	2.1-2.9	2.0-2.1
Wash down	6.6-8.6	0.1-0.8	2.0-3.0	1.9-2.2

Free available chlorine(FAC) minus total chlorine = combined chlorine (chloramines)

The following are the results of water sampling for ammonia:

Inspection	0.21-1.1 ppm in filtered water 0.22-2.5 ppm in unfiltered water
Evisceration	0.14-0.63 ppm in filtered water 0.21-0.73 ppm in unfiltered water
Reprocessing	0.14-0.35 ppm in filtered water 0.22-0.75 ppm in unfiltered water
Incoming water	0.22-0.89 ppm in unfiltered water
Packing/Shipping	0.22-0.81 ppm in unfiltered water
Wash Down	0.44-2.9 ppm in unfiltered water
At Motel (4 miles away)	0.76 ppm
Poultry Plant ice	1.8 ppm
Columbia Farms Pre-filter*	0.55 ppm (taken on 11/05/87 with water treatment plant employee)
Water Treatment Plant clear well*	0.56 ppm (taken on 11/05/87 with water treatment plant employee)
Columbia Farms Pre-Filter*	0.80 ppm (taken on 11/07/87 with water treatment plant employee)
Water treatment plant finished water*	0.84 ppm (taken on 11/07/87 with water treatment plant employee)

*- sample analysis was duplicated by the city to check the validity of NIOSH's samples

Two hundred forty-seven area air samples were collected for ammonia. Ammonia concentrations were very low (less than 1.0 ppm), and much lower than the second survey values. Why these values were much lower is uncertain. The lab analysis procedure was changed for the third survey samples, but the chemist over seeing the analysis stated that the change in analysis should not have caused a discrepancy in the results. All of the above levels are below the levels (4-29 ppm) that cause eye irritation in most people.[10]

Sample location	Ammonia range (ppm)
Evisceration	0.01-0.05
Reprocessing	0.02-0.20
Inspection	0.02-0.10
Packaging/shipping	0.01-0.07
Refrigeration	1.1
Scalder	0.30
Breakroom	0.08-0.09
Outdoors	0.13

Medical

The short questionnaire was administered to all of the workers and inspectors in the inspection/processing area. Over the two week period, most of the employees' symptoms ranged from none to mild, with November 2nd being the only day that three employees and six USDA inspectors felt moderate irritation (Table VI). The USDA inspectors during the two week period, experienced more symptoms ranging from mild to moderate than did the employees. On Monday November 9th, three inspectors experienced severe irritation and were relieved on the inspection line, while employees on November 9th experienced only mild irritation.

VI. DISCUSSION AND CONCLUSIONS

Symptoms of eye and mucosal membrane irritation have been experienced by many USDA inspectors and Columbia Farm employees since April 1986. Complaints of irritation did not occur prior to this date. The complaints are primarily eye irritation, sneezing, runny stuffy nose, cough, and sore throat. There is wide variation in individual susceptibilities to the irritant, with workers standing side by side differing in the presence and level of irritation. The complaints are temporally associated with a change in the method of water chlorination at the adjacent water treatment facility. The water chlorination was changed from chlorine only to chlorine plus ammonia (chloramination).

Other than the switch to chloramination, no other plant process had changed before the onset of symptoms. Cleaners and boiler additives had been used long before complaints began, and complaints continued even after use of these agents was stopped. HCl mist concentrations were much lower than established criteria (OSHA PEL=5ppm). The pH of the water did not indicate highly acidic or highly alkaline water, although the water tends to be somewhat acidic. The FAC levels in the water tend to be variable, ranging from about 0.1 or 2.6 ppm in the general water and 9 to 30 in the super chlorinated water used on the evisceration machine and in reprocessing. It is not known how variable the FAC concentrations were before April 1986. Air concentrations of chlorine, however, were found to be much lower than established occupational exposure limits.

It is unlikely that ammonia and the chloramines were in the Columbia Farms water before the water treatment plant began chloramination. But, during the NIOSH surveys, uncombined ammonia and chloramines were detected in the water. Because solutions of both ammonia and chloramines are known to be eye and mucosal membrane irritants and because irritant levels of ammonia were measured in the air, these are the most likely causes of worker symptoms at Columbia Farms. Measurements indicate that water concentrations of ammonia and chloramines were quite variable. The high end of the ranges are 15 to 30 times greater than the low end. It is possible that on days when workers were experiencing extreme irritation that the concentrations of ammonia or chloramines in the water were elevated, but this was not documented during any of the surveys.

During water treatment, chloramines can form by several pathways, such as:

a) Sporadic formation of chloramines can take place when the amount of ammonia added to the water is not adjusted in response to a variation in chlorine demand of the water.[12] At the West Columbia water treatment plant, the amount of ammonia added to the treated water is a calculated dosage of 1 ppm, but no test procedure is used for monitoring the concentration of ammonia in the treated water. In addition, the concentration of nitrogen compounds in the river from where the water is drawn is not monitored. Nitrogen levels (from humic material) can cause variations in chlorine demand and influence the formation of chloramines.

b) Chloramines can form in water as a result of a reaction between hypochlorous acid and nitrogen compounds.[13] This means that chloramines could form in the water lines between the treatment plant and Columbia Farms.

c) At Columbia Farms, chloramines can also be formed when free ammonia in the city water comes in contact with the super-chlorinated water in the evisceration and reprocessing areas. Since ammonia is not removed by the activated carbon filter, chloramines can potentially be formed in these areas.

Since it is possible to have fluctuations in chlorine demand and concentrations of nitrogen containing materials in the water, these fluctuations might be causing the variation in free ammonia and chloramine levels. While there is no validated sampling method for the chloramines in air, present conditions at Columbia Farms presumably do favor its formation in the water. From the three surveys, it can be concluded that ammonia and chloramines are present in the Columbia Farms water. Presently, the chloramines are considered a nuisance and are not known to be a health hazard.[2,6,12,13,14,15]

VII. RECOMMENDATIONS

I) A change by the West Columbia water treatment plant from post-ammoniation to pre-ammoniation may eliminate some of the free (unbound) ammonia which is present in the water going to Columbia Farms. This could potentially reduce the formation of chloramines later in the disinfection process, thus leaving very little free ammonia in the distribution system.

2) If the West Columbia treatment plant can not make any changes in it's present treatment process, then Columbia Farms will have to consult with a water treatment expert to see what alternative water treatment procedures are available, such as: (1) a mini-package water treatment plant that would draw water from a deep well or the nearby river, or (2) treatment of the incoming water with sulfur dioxide to remove the chloramines.

VIII. REFERENCES

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X. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45526. 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 NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. NIOSH Reg, IV
2. OSHA Reg. IV
3. Columbia Farms, Jim Mabe
   P.O. Box 738
   West Columbia, S.C. 29171

4. South Carolina Department of Health and Environmental Control
   J.Marion Sims Building
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   2600 Bull St.
   Columbia, S.C. 29201

5. United States Department of Agriculture, Pat Forslind
   Room 3823, South Agriculture Bldg.
   14th and Independence Ave.,S.W.
   Washington, D.C. 20250

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

Table I
Columbia Farms Poultry Plant
Columbia, SC
February 17-20, 1987
MHETA 87-110

HCl (acid mist)

Sample		Flow (cc)	Liters	Wt.(ug)	Results (ppm)*	Date
1	R	500	54.5	1.91	.06	2/17
3	I	501	49	1.49	.05	2/17
4	E	498	53	6.76	.20	2/17
8	I	501	36	1.08	.05	2/17
10	I	493	42	1.28	.05	2/18
11	E	500	36	1.75	.08	2/18
18	I	500	100	1.28	.02	2/19
19	I	500	100	1.70	.03	2/19

R - Reprocessing

I - Inspection

E - Eviscerator

* - Current OSHA standard is a ceiling value of 5.0 ppm.

Table II

Columbia Farms Poultry Plant
Columbia, SC
November 02-13, 1987
MHETA 87-110

Eye and/or Nose Irritation Reported By Six United States Department of Agriculture Inspectors working each day from 2/17-2/19/87 in the Inspection Area.

Severity of Eye and/or Nose Irritation	Number of Inspectors on 2/17/87	Number of Inspectors on 2/18/87	Number of Inspectors on 2/19/87
None	-	-	1
Mild	2	3	2
Moderate	4	3	2
Severe	-	-	1
Total Number of Inspectors	6	6	6

TABLE III

CHARACTERISTICS OF WORK FORCE AT COLUMBIA FARMS BY WORK AREA

COLUMBIA FARMS

WEST COLUMBIA, SOUTH CAROLINA

MHETA 87-110

	INSPECTORS n=12	PRODUCTION n=73	PACKING n=71	CLEAN-UP n=14	OVERALL n=170
AGE					
≤29	1(8%)	21(29%)	35(49%)	7(50%)	64(38%)
30-49	6(50%)	39(53%)	33(47%)	7(50%)	80(50%)
≥50	5(42%)	13(18%)	3(4%)	---	21(12%)
SEX					
MALE	8(67%)	8(11%)	36(51%)	7(50%)	59(35%)
FEMALE	4(33%)	65(89%)	35(49%)	7(50%)	111(65%)
RACE					
WHITE	7(58%)	4(6%)	3(4%)	1(7%)	15(9%)
BLACK	5(42%)	69(95%)	67(94%)	13(93%)	154(91%)
ASIAN	----	1(1%)	----	----	1(1%)
TENURE					
<1 yr	4(33%)	27(37%)	19(27%)	10(71%)	60(35%)
1-2 yrs	3(25%)	9(12%)	26(37%)	3(21%)	41(24%)
3-5 yrs	3(25%)	2(3%)	6(9%)	1(7%)	12(7%)
>5 yrs	2(17%)	35(48%)	20(28%)	----	57(34%)

TABLE IV

SYMPTOMS OF IRRITATION AT COLUMBIA FARMS BY WORK AREA

COLUMBIA FARMS
WEST COLUMBIA , SOUTH CAROLINA
MHETA 87-110

	INSPECTORS n=12	PRODUCTION n=73	PACKING n=71	CLEAN-UP n=14	OVERALL n=170
EYES					
STINGING	11(92%)	60(82%)	26(37%)	12(86%)	109(64%)
TEARING	9(75%)	52(71%)	29(41%)	10(71%)	100(59%)
BLURRED VISION	6(50%)	23(32%)	14(20%)	7(50%)	50(29%)
DIFFICULTY OPENING	8(67%)	23(32%)	11(16%)	4(29%)	46(27%)
LIGHT SENSITIVITY	5(42%)	18(25%)	9(13%)	7(50%)	39(23%)
OTHERS					
EXCESS SNEEZING	10(83%)	68(93%)	27(38%)	12(86%)	117(69%)
RUNNY NOSE	10(83%)	58(80%)	23(32%)	13(93%)	104(61%)
COUGH	9(75%)	48(66%)	19(27%)	6(43%)	82(48%)
HEADACHE	8(67%)	31(43%)	17(24%)	5(36%)	61(36%)
SORE THROAT	7(58%)	29(40%)	12(17%)	4(29%)	52(31%)

TABLE V

SYMPTOMS OF IRRITATION AT COLUMBIA FARMS AMONG PRODUCTION WORKERS BY SHIFT

COLUMBIA FARMS
WEST COLUMBIA, SOUTH CAROLINA

MHETA 87-110

	FIRST SHIFT n=47	SECOND SHIFT n=26
EYES		
STINGING	38 (81%)	22 (85%)
TEARING	35 (75%)	17 (65%)
DIFFICULTY OPENING	20 (43%)	3 (12%)
BLURRED VISION	18 (38%)	5 (19%)
LIGHT SENSITIVITY	12 (26%)	6 (23%)
OTHERS		
EXCESS SNEEZING	46 (98%)	22 (85%)
RUNNY NOSE	40 (85%)	18 (69%)
COUGH	35 (75%)	13 (50%)
SORE THROAT	24 (51%)	5 (19%)
HEADACHE	25 (53%)	6 (23%)

Table VI
Columbia Farms Poultry Plant
Columbia, SC
November 02-13, 1987
MHETA 87-110

Severity of Eye/Nose Irritation
Among Employees and Inspectors

		M	T	W	Th	F	M	T	W	Th	F
Employees (24)	None	8	11	14	15	14	10	13	16	22	11
	Mild	11	9	10	9	10	14	10	7	2	0
	Moderate	3	0	0	0	0	0	0	0	0	0
	Severe	0	0	0	0	0	0	0	0	0	0
		22	20	24	24	24	24	23	23	24	11
Inspectors (11)	None	3	1	2	1	2	2	2	2	6	2
	Mild	2	2	2	5	5	1	5	7	2	7
	Moderate	6	8	7	5	4	5	4	2	3	2
	Severe	0	0	0	0	0	3	0	0	0	0
		11	11	11	11	11	11	11	11	11	11

Note: None---did not have irritation
Mild---slight irritation, but did not interfere with job
Moderate---definite irritation, slightly interfered with work
Severe---extreme irritation that markedly affected work