# A SAFETY AND HEALTH ASSESSMENT
# OF TWO CHICKEN PROCESSING PLANTS

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## SUMMARY

A detailed ergonomics and industrial hygiene assessment of two poultry processing plants was conducted by research scientists with the Georgia Institute of Technology over a six month period under a grant by the National Broiler Council. The principle objective of the study was to determine the extent of ergonomic and occupational health problems and to identify the types of available control technologies for medium-sized processing companies.

The results of this study are consistent with findings at other poultry operations of similar size. A summary of those results follows:

Cumulative Trauma Disorders (CTDs) are under-reported. This seems to be due to misinterpretation or lack of knowledge of the Bureau of Labor Statistics (BLS) recordkeeping requirements.

Jobs in the Evisceration Department and after-the-chiller "rehanging" jobs seem to have a high prevalence of these disorders. However, it was not possible to determine the actual prevalence due to the recordkeeping deficiencies noted above.

Employees who draw and present the viscera ("draw hands") in the Evisceration Department have the highest upper-extremity discomfort level and every person interviewed from this job reported frequent pain and numbness in the hands at night.

Because many positions in the Evisceration Department are machine back-up positions or are extensions of the machinery in use, equipment maintenance and the man/woman-machine relationship are important issues with respect to work load.

Employees who handle 70 pound cartons or tubs during palletizing and depalletizing operations in Shipping and Aging are at high risk of sustaining a back injury.

Work height incompatibilities (e.g., too high or too low) cause workers to assume stressful postures producing upper extremity and back pain and discomfort.

Carbon dioxide, noise, and dust exposures exceed the respective Permissible Exposure Limits in some cases.

Worker training efforts required under OSHA's Hazard Communication Program need improvement.

Substantial differences in the level of ergonomics, safety, and health program activity between the sites were noted. The advantage of having an engineer with a grasp of

ergonomics and ventilation design was demonstrated at Plant B. Although individuals at both sites have heard of the Medical, Ergonomics, and Training Program (MET), key individuals have not seen or read the document.

## BACKGROUND AND INTRODUCTION

Historically, the poultry industry has not only been labor intensive but also a hand intensive industry. As with all such industries (including apparel and electronics), it is common to see cumulative trauma disorders (CTDs) among the workers. Over the past few years this industry ranks second only to the meatpacking industry in the prevalence of these disorders. Because of this, the industry set out to address the problem and created an ergonomics task force comprised of safety, health, and ergonomic professionals to develop a repetitive motion disorder intervention and prevention strategy. The end result of their effort was the highly regarded Medical, Ergonomics, and Training Program (a.k.a., MET) that provides a three-pronged approach to workplace CTDs.

Unlike many other task forces of its kind, this group chose not to remain one dimensional or static and is continuing to address those safety and health issues important to the poultry industry. This proactive approach resulted in a grant to the Georgia Institute of Technology to help determine the extent of MET activity in two representative plants as well as to determine the emerging or heretofore unrecognized health and ergonomic problems associated with the poultry processing work environment.

Over the past five years more and more advanced manufacturing equipment has appeared on the market that could impact those "high risk" jobs by alleviating or eliminating the problem. The other side of the coin is that some equipment may introduce new yet similar problems (e.g., instead of a cutting activity there is a machine feeding activity). Further, with the introduction of machinery in some areas of the plant, many positions are now back-up positions (i.e., employees at these positions process the product that is missed or inadequately processed by the machinery). Therefore, the relationship between the human and machine becomes even more closely entwined since machine efficiency can affect employee work load. This relationship is explored, where appropriate, in the report.

Finally, since the industry uses carbon dioxide, chlorine, ammonia, and formaldehyde (in the hatchery) and other hazardous chemicals, an assessment of current exposure levels, control technologies, and management programs was made. Other hazardous agents such as dust, silica, and noise were also examined. Standard industrial hygiene protocols were used to help the industry recognize, evaluate, and control these health hazards.

The two plants selected for this study are representative of the industry as medium-sized producers. Both sites were nonunion and located within the Southeastern United States. They have between 350 to 650 processing employees producing approximately two million pounds of product each week. Plant A is primarily slaughter and first processing, producing whole birds and cut-up parts. Plant B is a slaughter and further processing operation. The annual turn-over at both sites exceeds 100 percent. Management appeared to be sincerely concerned about the health, safety and welfare of their respective employees. Both are to be commended for providing in-plant resources on short notice and for their open-door approach to the research scientists involved in this study.

## WORKER DEMOGRAPHICS

The average age of the population that participated in the interview (N=100) was 36 years. Sixty-nine percent were female and thirty percent male, with most men occupying the material handling intensive jobs (e.g., stack-off, live hang). Plant B had a slightly greater male population. As expected, ninety percent were right-handed. The average worker height was 65 inches with a 56 to 78 inch range.

The average worker in both plants had 43 months of experience at each site with 26 months at their present job. Plant B interviewees, however, had substantially less experience in the industry than Plant A interviewees. This is demonstrated by the fact that Plant B interviewees had only 3 months prior poultry experience which is almost 15 times less than the average plant A prior experience level (43 months). This experience difference could be due to the fact that Plant A is located in an area with a greater density of poultry companies that would compete for the same labor force than the Plant B location.

## METHODS

### INTERVIEW

One hundred employees were randomly selected from both sites on a strictly voluntary basis. The 47 individuals from Plant A were selected from the high risk departments as determined from a review of the OSHA 200 logs. Plant B (N=53) employees were selected from departments with a known history of musculoskeletal problems. All interviewees were assured that their responses would be confidential and their names were not recorded anywhere on the forms. The interview covered:

1. Demographic information
2. Medical history
3. Body-part discomfort
4. Workstation and environmental characteristics
5. Training

Most of the interview questions consisted of YES/NO, multiple choice, or short answer questions. Interview participants were asked to rate 16 different body parts on a 1 to 4 scale where 1 represents no discomfort and 4 represents constant discomfort. Open-ended questions were also used to collect more detailed information on interesting responses or suggestions on how jobs might be improved. The interviews were conducted in isolated rooms to help ensure confidentiality. We were not able to interview the Spanish-speaking population at Plant A but were able to at Plant B because of the availability of a translator.

## SAFETY AND HEALTH PROGRAM

Management and medical staff were interviewed to assess the breadth and depth of their safety and health programs at both locations. The structured form in Appendix A was used as the format. Management support, hazard identification and control, and medical surveillance activities were measured. The available OSHA 200 logs were also analyzed for calendar years 1988 and 1989. It was decided to go back to 1987 for the purpose of establishing if CTDs were ever a problem at one location. Existing safety hazards were noted during the health and ergonomic assessments.

## ERGONOMIC TASK ANALYSIS

Jobs were selected for detailed video analysis if they had an established history of cumulative trauma disorders or back injuries based on a review of the OSHA 200 logs or based on our experience with the industry. Where possible, back, side and hand views were taken with a Panosonic camcorder. Workstation measurements were taken with a standard metal tape measure.

The video was reviewed in slow motion and the stressful postures documented. Some of the postures that contribute to muscle fatigue and are associated with CTDs are listed below. Since hand repetition and forceful exertion are risk factors associated with Carpal Tunnel Syndrome, hand activity (a departure from the neutral hand posture of at least 15 degrees in any direction was recorded) was quantified and is given in this report as right or left hand motions per minute (HMPM). A comparison of the level of hand activity produced by each of the jobs selected for this study was made using this method. Interestingly, in one study, jobs were classified as "high repetitive" if the cycle time was less than 30 seconds or if more than 50 percent of the cycle time involved the use of the same fundamental cycle. Based on these criteria, almost all of the jobs examined in this report would fall within the "high repetitive" category. Force was not directly measured, but jobs were subjectively categorized, when applicable, into a low, moderate, or high force category based on the interview results and researcher inference.

| **Body Part** | **Posture** |
|---|---|
| hand | ulnar deviation |

| | |
|---|---|
| | radial deviation<br>flexion/extension<br>forceful pinching |
| arm | excessive forward reaching<br>reaching behind<br>forearm rotation |
| shoulders | elbows raised away from body<br>reaches at shoulder height |
| Back/neck | forward stooping more than 20 degrees |

Material handling analyses of the "carton stack-off" job in the Shipping Department and the "front half cone-line supply" job in the Aging Department were conducted using the National Institute for Occupational Safety and Health's Work Practices Guide for Manual Materials Lifting. The load weight handled by employees at each position is compared to the calculated Maximum Permissible Limit (MPL) and Action Limit (AL) for lifting. Employees who lift loads at the MPL are at high risk of sustaining a back injury. Jobs that create loads between the AL and MPL are classified as moderate risk from the standpoint of back injury. Obviously, under the guideline jobs that are less than or equal to the AL present a low risk of injury to employees.

## INDUSTRIAL HYGIENE

The methods used to investigate health hazards follow standard industrial hygiene protocols. Interviews were conducted to document employee complaints possibly related to exposure to harmful physical and chemical hazards, and to aid in the determination of when and where to collect samples. Investigation of the adequacy of existing control measures, which included alarm systems, containment systems, exhaust ventilation, administrative controls (i.e. employee rotation in and out of hazardous areas to reduce full-shift exposures), employee training programs, personal protective equipment, and respirators, was also completed. Management programs involving hazard communication, hearing conservation, respirator usage, confined space entry, and general safety were also briefly reviewed.

### Noise

Noise exposures were measured using DuPont MK-II noise dosimeters, which were worn by workers for the duration of the workshift. The microphone was attached to the employee's shoulder so that it was within a two-foot radius of the head. Each dosimeter was calibrated before and after each use according to the manufacturer's instructions. For nearly all employees, the lunch period was not included in the monitoring period, since it is often more difficult to control behavior during this time period. Each employee was questioned at the end of the work shift to help determine whether the exposures measured were indeed representative of normal or "worst-case" conditions. Data from the dosimeters were collected on site at the end of the sampling period, and recorded in field notes.

Noise levels were also measured inside each employee's hearing zone using a GenRad Precision Sound Level Meter (Model 1982) to provide supporting documentation of the levels recorded by the dosimeters. Octave band analyses were not performed, since it proved to be difficult to isolate individual noise sources adequately. However, the following report does contain recommendations with regard to improved noise control measures, although it will not be possible to specify noise absorbing materials without knowledge of the frequency distribution of noise energy.

**Dust**

Measurements of airborne dust were completed using personal air sampling pumps worn by employees. For total dust analysis, the pumps were operated at a nominal flowrate of 2 liters/minute for the duration of the workshift. Polyvinyl chloride filters with a pore size of 5.0 microns were housed in 37 mm filter cassettes and attached to the pumps with the use of tubing. The filter cassette was typically attached to the worker's lapel so that air inside the personal breathing zone was collected. Airborne dust particles were drawn into the filter cassette (closed face) and collected on the filter. The pre-weighed filters were then submitted to a laboratory accredited by the American Industrial Hygiene Association (AIHA) for post-sampling weighing. The weight was reported in milligrams. The air sampling pumps were calibrated before and after each use using a Buck Calibrator in accordance with the manufacturer's instructions. Based on the sampling time and the flowrate, a total volume of air sampled was calculated. By dividing the milligrams of dust collected on the filter by the total volume of air sampled, a time-weighted average concentration in milligrams per cubic meter ($mg/m^3$) can be calculated. These values can be compared with the OSHA Permissible Exposure Limit for Total Dust (Particulates Not Otherwise Classified) of 15 $mg/m^3$ and the 1989 Threshold Limit Value of 10 $mg/m^3$.

Respirable dust samples were collected in a similar manner. A 10 mm nylon cyclone was used to separate respirable and total dust. Only respirable dust was collected on the PVC filter. The filters were subsequently weighed in the laboratory and analyzed by X-Ray Diffraction to measure the percentage of crystalline silica (quartz) in the dust. This was done by transferring the filters to a Petri Dish, where they were digested in an International Plasma low temperature asher. The residue was transferred to a 25-mm silver membrane filter and the free silica was determined by X-ray diffraction. These results were then compared with the OSHA Permissible Exposure Limit of 0.1 $mg/m^3$ as an eight hour time-weighted average for dusts containing more than 1% free silica. The OSHA Permissible Exposure Limit for Respirable Dust is 5 $mg/m^3$. Blank filters were submitted to the laboratory as a standard quality control measure to help ensure that the filters were not contaminated prior to sampling. Visual observation was also used to identify sources of exposure, and possible control measures.

**Carbon Dioxide**

Employee exposures to carbon dioxide, which is released as a gas from poultry packages containing dry ice as a refrigerant, were measured in two ways. First, short-term detector tubes manufactured by Bendix/Sensidyne were used to measure airborne levels in various areas and inside employee's breathing zones. Care was taken not to include exhaled breath, which is rich in carbon dioxide as a normal product of human respiration. The results represent "snap-shots" of the concentration at the time when the sample was taken. This form of grab sampling cannot be used to calculate full-shift time-weighted average exposures with reliability. However, it is useful in determining whether concentrations in certain areas, such as holding coolers, approach or exceed the Immediately Dangerous to Life and Health (IDLH) level established by the National Institute for Occupational Safety and Health, which is 50,000 ppm. Concentrations above the IDLH level have been documented in other poultry plants (see Appendix B). All detector tubes used in this study had expiration dates of 1991 or later. The detector tube pump was leak tested before and after each day of use, and was also calibrated using the standard soap bubble/buret method.

A second method was used to determine full-shift time-weighted average exposures to carbon dioxide. Backpacks containing a five-layered 3-liter Tedlar gas sampling bag and a personal air sampling pump were worn by selected workers. Tubing was used to attach the bags to personal air sampling pump exhaust ports. An additional length of tubing was attached to the pump inlet to collect air from the tip of the employee's shoulder. This location is still within the employee's breathing zone, but minimizes the possibility of including exhaled breath in the sampling bag. Pumps were operated at a nominal flow rate of 20 cc/minute, and were calibrated before and after each survey. At the conclusion of the workshift, the bags were sealed and the pumps turned off. A short piece of tubing was then attached to the bag nipple and flushed thoroughly with bag air. A short-term detector tube and pump were then attached to the hose and the concentration of carbon dioxide inside the bag was determined. This value represents the full-shift time-weighted average exposure experienced by the employee, and can be compared with the OSHA Permissible Exposure Limit of 10,000 ppm and the 1989-90 Threshold Limit Value of 5,000 ppm. This technique has been validated previously with a more sensitive laboratory-based analytical technique employing gas chromatography (see Appendix B).

**Chlorine and Ammonia**

Airborne concentrations of chlorine and ammonia were measured using Sensidyne/Bendix short-term detector tubes. The sampling procedure is similar to that described above for carbon dioxide.

**Formaldehyde**

Levels of formaldehyde inside the poultry hatchery at Plant B were measured using impingers filled with approximately 10 ml of a 1% solution of sodium bisulfite. The impingers were attached to air sampling pumps operating at a nominal flowrate of 1 liter/minute using tubing. The apparatus was placed either in certain areas or worn by an employee thought to have the greatest exposure. The air was then bubbled through the liquid for a measured time period. The solution was placed in a nalgene bottle for shipment to the laboratory, where it was analyzed colorimetrically using the standard chromotropic acid method.

The degree of containment afforded by the hatchers was also investigated qualitatively by videotaping a smoke test. A smoke generator was installed inside a test hatcher; the door was then closed, and the generator turned on. Leakage points were identified by the appearance of smoke. This rather simple technique is invaluable in specifying cost-effective control measures.

**Ventilation Measurements**

Attempts were made to measure the volumetric airflow rate for each of the machines which deliver dry ice to the poultry packages. Since small holes could not be drilled into the ductwork to permit pitot tube traverse measurements (both plant managements indicated this could contaminate food products), an alternative method was used. This involved slipping the flexible duct(s) off of the machines, and then taking centerline velocity measurements at the face of the duct opening. This is likely to produce some error due to hood entry turbulence, but since the same method was used in both plants, the resulting data should provide a useful comparison. Ideally, pitot tube measurements should be taken in straight lengths of ductwork to obtain more accurate readings. An Alnor Velometer with the pitot tube attachment was used to measure the velocities described above.

## RESULTS AND OBSERVATIONS

### INTERVIEW

Improper job design and badly designed workplaces can often create discomfort and pain to the joints and muscles of the production worker. This can result from sustained awkward working postures, reaches outside the normal reach envelope, repetitive hand and tool manipulation, excessive force and muscle endurance requirements, or combinations of these factors. It is possible, therefore, to obtain clues about possible worker-workplace incompatibilities (i.e., mismatches) by exploring the patterns of musculoskeletal discomfort experienced by the workers.

In addition, data on musculoskeletal discomfort can provide information useful in establishing priorities for redesign or automation of particular operations . Chronic work-related pain and discomfort is one possible reason for worker attrition as well as a potential cause of absenteeism and lowered productivity. If operations that are particularly stressful to the musculoskeletal system can be successfully automated, or if the conventional workplace can be modified to promote comfort and efficiency, it might be easier to retain experienced skilled workers and to maintain or boost their productivity.

The overall results of the comfort interview data are summarized in Figure 1 in Appendix C.

Approximately half of the hundred interviewees reported discomfort at least sometimes to the right hand (47%) and right shoulder (48%). Fewer than one-third of the workers reported discomfort to the left arm (27%), right foot (30%), left foot (28%), right knee (18%), left knee (11%), right leg (26%), left leg (28%), and middle back (31%). Reports of discomfort were most prevalent among workers with more than 37 months experience and between the ages of 26 and 35 years. Workers over the age of 55 had the lowest frequency of complaints. It is difficult to explain the age and experience results. The relatively small sample size of the over 55 and under 26 year age categories might be a contributing factor. Perhaps older and younger, inexperienced workers are less likely to report complaints fearing management retribution.

Plant A had a higher frequency of musculoskeletal complaints possibly due to the fact that more evisceration workers participated in the study at this location. Hand complaints were more prevalent at Plant A and shoulder discomfort was more prevalent at Plant B. Even so, a correlation coefficient of r = .596 demonstrated a reasonable degree of similarity in the frequency of discomfort experienced by the workers at both sites.

To gain a better understanding of the prevalence of discomfort, the job categories listed below were established and are based on the primary work activities observed by the study team. Quality assurance jobs at Plant A were not included if they were laboratory jobs.

| **Tool User (N=40)** | **Hand Manipulation (N=37)** | **Material Handling (N=20)** |
|---|---|---|
| A. Knife Only (N=17) | A. Involving Pinch Grip (N=17) | Stack-off |
| First Wing Cut | Draw Hands | Packing |
| Second Wing Cut | Wing Machine Feeder | Scaling |
| USDA Trimmer | Tender Lay-on | Line Supplier |
| Cut-up Utility | Filet Pull Down | |
| Salvage | | |
| | | |
| B. Scissors Only (N=12) | B. Power Grip (N=20) | |
| Vent Cutter | Saw Hands | |
| Breast Filet Trimmer | Hangers | |
| Liver Trimmer | Cone Loader | |
| | | |
| C. Both (N=11) | | |
| House Trimmer | | |
| Evisceration Utility | | |
| Debone Filet Inspector | | |

The body maps in Appendices D, E, and F give the results for the three major categories and the five sub-categories. While examining the body maps keep in mind that they are back views. "Manual material handlers" clearly had the lowest overall complaint level even with respect to the back region. This may suggest that a self-selection process is operating where those who cannot adapt to heavy or frequent lifting quit soon after they are hired. "Tool users" have a higher complaint frequency with regard to the left hand and upper and lower back than "non-tool users" (i.e., "hand manipulation" category). Workers in the "hand manipulation" category (non-tool users) reported a higher prevalence of right arm and right knee pain. In both categories, right hand, right shoulder, left shoulder, upper back, and neck pain were reported by more than 45% of the interviewees.

Employees who use knives reported the highest frequency of left hand discomfort (71%) possibly due to sustained holding and positioning activities by the nondominant hand. The surprising finding was that one-third or fewer of the scissor-only population reported hand pain or discomfort. Much of their discomfort focused on the shoulders, legs, upper and lower back, and neck. Interviewees who used both tools and interviewees who grasp and pull down with a pinch grip (e.g., "draw hands", tender pullers) reported substantially higher levels of discomfort to the right hand than any other work category ( 73 and 78 percent, respectively).

Of those jobs in the "power grip" subcategory, "rehanger" complaints of discomfort focused on the right side. This polarization might be due to work methods that involve transfer of the bird from left hand to the right hand for shackling or simply grasping and hanging with the right hand. "Saw hands" did not exhibit as great a right versus left side difference. This is perhaps due to the more balanced use of both hands (symmetry) during much of the sawing operation.

It is important to be aware of the validity of these body part discomfort data. Self-reports of work-related pain are subject to many biases. First, there are significant individual differences in what is perceived as pain and differences in what kinds of pain are attributed to work-related difficulties. Recent experiences with discomfort will likely be over-reported while experiences in the more distant past may be over-reported or under-reported. Finally, there may be a reluctance to report discomfort because of fear of retribution by supervisors (even though workers were assured that interviews were confidential) or out of a sense of loyalty to the organization. Spanish-speaking interviewees at Plant B were subject to many biases including loss of information during the translation process. This problem could account for at least some of the discomfort level differences noted between the sites.

## SAFETY AND HEALTH PROGRAM

The level of safety training at Plant B was greater than Plant A. Seventy-four percent of the interviewees at Site B indicated they have received training in safety. This compares to seventeen percent at the other site. As expected, much of the training received at both locations is in the form of on-the-job-training (OJT). Sixty-six and twenty-three percent of the interviewees reported receiving OJT on topics other than safety at Plants B and A, respectively. The growing trend towards ergonomics education of management and supervision was evident. Company representatives from both sites have received training from outside sources. However, based on the interview results, as you go below this level to the hourly line employee, the awareness level drops to practically zero.

These differences in training reflect the relative strength of both safety programs. Plant B is clearly further along than most plants of its size but still is only part of the way towards developing a complete program. Based on the size and level of production, Plant A is more representative of the industry than Plant B.

Management at both locations is committed to developing an ergonomics program. Plant B has the resources of an engineering staff that is well educated in ergonomics and plays a leadership role on the ergonomics committee, one of five committees devoted to safety and performance-relatedissues. Although serious resources are committed, there is not a full time equivalent of time invested in the program at either site. Presently, a formal written ergonomics and safety program is in the developmental phase at Plant B.

One site is planning many changes that include workstation modification and mechanization of operations where problems could or do exist. These proposed changes are in writing and are included in the engineering diagrams. Expansion and long term plans also have ergonomic considerationstaken into account.

Inspections are conducted monthly but are basically informal from a documentation and scheduling standpoint. A computerized Injury/illness surveillance system is under development at one location. But presently it consists of a periodic review of loss information and/or incidence rates. Job rotation as a means to prevent CTDs is not in effect at either site.

**Medical Surveillance and Recordkeeping**
In 1988 and 1989 (January through September) Cumulative Trauma Disorders (CTDs) represented approximately 25 percent of the lost work days and 23 percent of the restricted work days at Plant A. This is an incomplete picture, however, since we did not have all the injury and illness data for 1989. Approximately eight carpal tunnel release surgeries were reported to have occurred in 1989 by the plant nurse. Evidently, all cases that show a positive electromyograph are recommended for surgical release. The distribution of CTD cases and incidence rates by department are summarized in the following table.

**Table A. CTD Incidence Distribution at Plant A**

| | | | | |
|---|---|---|---|---|

| DEPARTMENT | 1988 CASES | 1988 IR* | 1989 CASES | 1989 IR |
|---|---|---|---|---|
| Evisceration | 3 | 4.22 | 12 | 22.87 |
| Cut-up | 3 | 12.30 | 4 | 16.40 |
| Giblets | 0 | 0.00 | 4 | 29.67 |
| Ice Pack | 3 | 8.55 | 2 | 5.70 |
| Plant A | 14 | 3.69 | 23 | 6.04 |

* Incidence rate (IR) = cases per 200,000 work hours.

Overall, the recorded incidence of CTDs increased substantially from 1988 to September, 1989 with the sharpest rise in the Evisceration and Giblet Packing Departments. In 1988, half the CTD cases involved "rehangers" (a total of 4 cases) in the Cut-up and Ice Pack Departments and "trimmers" (3) in the Evisceration Department. Over eighty percent of the year-to-survey date 1989 cases involved "draw hands" (6), "vent cutters" (2), and "trimmers" (3) in the Evisceration Department; "giblet parts box weighers" (3) in the Giblets Department; "packers" (3) and "cut-up parts box weighers" (1) in the Cut-up Department; and "rehangers" (2) in the Ice Pack Department. Most, but not all of the Carpal Tunnel Syndrome (CTS) cases were female. In the Evisceration Department (using 1989 data) there were two more cases from the NELS lines than the SIS lines. Plant personnel indicated that no major labor or process changes occurred over this period (1988 to September, 1989) that could account for the increased incidence of CTDs at this location. Even so, two NELS lines were introduced into production in 1988.

The Plant B profile is much different. In 1988 there were only four cases of CTDs recorded on the OSHA 200 log ( two in the Evisceration and one each in the Cut-up and Debone Departments). This translates to an estimated incidence rate of 0.67 cases per 200,000 work hours. There were no reported cases in 1989 from the processing side. The two cases on the log involved "debeak/vaccination" workers in the hatchery. This relatively low incidence contrasts sharply with the incidence of cumulative trauma disorders reported in 1987. According to the log, over 50 CTDs were reported with at least two-thirds of these resulting in loss time or restricted work duty and at least one-third of the cases coming from the Breast Debone Department. The addition of medical and human resource personnel with knowledge in the field of occupational safety and health and the addition of an industrial engineer with a strong ergonomics background, probably contribute to but cannot completely explain this favorable trend. This is supported by the fact that in 1989 as many as ten employees per month were treated by the plant nurse for hand pain or swelling with most coming from the Debone Department ("skin" and "tender pulling" were cited as problem jobs). As will be discussed in the next section, recordkeeping poses a problem for both locations.

An individual with hand pain or swelling is likely to be treated in a similar manner at both locations. Hand problems will be attended by the "plant nurse" with the use of heat, cold, and/or splinting depending on the nature of the problem. Multiple treatments might be given to the same individual before referral to a physician. A light duty program was in effect at Plant A. The jobs on this program are outside the production area and do not involve the use of hand tools. Assignment to a light duty position, however, did not constitute a recordable event on the OSHA log. Usually the case becomes a log entry only when the individual sees a physician. Moreover, one site was misclassifying the CTDs as an injury and not an illness. Therefore, using the Bureau of Labor Statistics guidelines, both plants are probably under-reporting CTDs. This is mainly due to a lack of understanding or knowledge of the recordkeeping requirements. Phalen and Tinel's tests for symptoms of Carpal Tunnel Syndrome have been added at both sites in the last eight months to the medical screening programs.

The other problem seen at both locations is that the workers do not know or understand the signs and symptoms of CTDs. Only five percent of the interviewees reported any knowledge and awareness of these types of disorders. Also, thirty-six percent reported pain and numbness in the hands and wrists at night (see Table B). Plant A had a much higher "symptom" frequency than Plant B (47% to 26%). Complaints of pain and discomfort were most prevalent among Evisceration Department workers (57%), women (49%), individuals in the "hand manipulation" job category using primarily a pinch grip (53%), and "knife users" (53%). Every one of the "draw hand" employees interviewed at both sites (N=7) reported this problem as well. The prevalence of this symptom of carpal tunnel syndrome (CTS) supports the theory that the records do not accurately reflect the true prevalence of CTS in the workplace and that the lack of employee education is part of the problem. To confirm this finding will of course require diagnostic measures and medical interpretation.

**Table B. CTS Symptom Distribution**

| POPULATION | PERCENT WITH SYMPTOM |
|---|---|
| Overall | 36 |
| Evisceration | 57 |
| Debone | 17 |
| Cut-up | 20 |
| Females | 49 |

| | |
|---|---|
| Males | 6 |

Table C summarizes the injury data for both locations. The percent of the total lost time plus restricted work days is given by injury type. The number of cases is given in parenthesis. Both plants experienced a decrease in the incidence of injuries from 1988 to 1989. This positive trend could very well be attributed to management's efforts in safety. The difference in severity and frequency of lacerations between locations could be due to the glove policy in place at Plant B. Employee strains and sprains involved the back, ankles, upper extremities, and shoulders and occurred in the Shipping, Cut-up, Debone, and Evisceration Departments. Practically all the cases were associated with manual materials handling (e.g., lifting, lowering, pushing, pulling, carrying various objects and materials). The frequency of slips and falls was surprisingly low but a few were associated with back injuries.

A large percentage of the lost and restricted work days were also due to unknown causes suggesting a need for additional training in making log entries for the purpose of tracking injury and illness trends.

**Table C. Injury Distribution**

| INJURY TYPE | PLANT A 1988 | PLANT A 1989 | PLANT B 1988 | PLANT B 1989 |
|---|---|---|---|---|
| Lacerations | 27% (40) | * (27) | 11% (18) | 4% (14) |
| Strains and Sprains | 22% (12) | * (3) | 34% (19) | 45% (16) |

| | | | | |
|---|---|---|---|---|
| Contusions | 9% (10) | * (10) | 1% (2) | <1% (2) |
| Falls | 0 | 0 | 11% (7) | 3% (3) |
| IR** | 22.07 | 19.70 | 15.5 | 10.17 |

* Lost time data not available for 1989 at time of evaluation.
** Incidence rate (IR) is number of recordable injuries per 200,000 work hours.

**Safety Hazards**
Both plants had a number of safety hazards. Many of these could result in serious injury to employees if they are left uncontrolled. Examples of the types of safety hazards found are described below. A common machine hazard in the industry continues to be the nip point created by the gizzard peeler in-running rolls and shackle conveyor system. Electrical hazards are also a major concern made worse by the wet/damp work environment in many departments. Confined space and lock-out/tag-out programs were not reviewed in this study.

Plant A
The water ice house configuration requires an employee to climb a pile of ice cubes about 20 feet high to dislodge ice blockages. It was reported that one employee had suffered a broken neck when he attempted to shovel ice out through an "ice tunnel" which subsequently collapsed on top of him. Employees reported that this practice has been discontinued, but that falls and slips were still quite common. Plant B has automated this process to the point where employees are not required to enter the ice storage area.

Wet floors can contribute to slips and falls. This problem was reported in both plants.

The washout area was not equipped with an eyewash station, even though an acid-based cleaner was used.

The live hang area had large fans (about 3 or four feet in diameter) which had the blades and fan belts exposed. This is especially hazardous considering the low lighting present in

the area. Employees could be drawn into the fans by loose clothing coming into contact with moving parts.

No eyewash was present in the battery charging area, where sulfuric acid is used.
Fan belts used to operate the water washer were not guarded.

Plant B
KFC and cut-up saws were missing the adjustable side guards.

Power transmission equipment was not completely enclosed in some cases.

A grinder in the machine shop had a missing shield.

Hydrochloric acid and potassium cyanide were stored in close proximity to each other in the laboratory. Accidental mixing of these two substances results in the formation of hydrogen cyanide gas, which acts very rapidly and without warning. These two substances should be separated.

An organic vapor cartridge respirator was stored in the laboratory where it is exposed to organic vapors. This is likely to render it ineffective when actually used. It should be stored in a gas-tight ziplock baggie in an area free of organic vapors.

About 150 gallons of perchloroethylene was stored in an inadequately ventilated closet. Some of this material is probably hazardous waste, but was not labeled as such.

The eyewash in the laboratory consisted of a squeeze bottle. These are not recommended, since they cannot provide a full 15-minute flushing of the eyes. This eyewashing must be done before transporting an injured worker to a hospital for medical treatment. Damage to the eyes can occur enroute if thorough flushing has not been accomplished.

The laboratory hood did not have sufficient airflow and the sash could not be lowered. The average face velocity was found to be about 35 feet per minute, well below the recommended value of 100 fpm. There was no program of regular laboratory safety inspections.

## ERGONOMIC JOB ANALYSIS

### Evisceration Department

The interview results and medical records establish " viscera drawing (or presentation)", "vent machine back-up" and "trimming" as high risk jobs in the Evisceration Department. It was not possible to compare this department with the Debone Department because of the lack of accurate medical information. Even so, the reported discomfort level was greater in Evisceration then any other Department analyzed in this study. As mentioned in previous sections, there were only slight differences between SIS and NELS operators with respect to the prevalence of body part pain and CTDs. It is anticipated that problems will arise when converting to the faster NELS line speed at jobs where the labor and machine efficiency will not change. With the similarity in hand activity between the "gizzard puller back-up" and "viscera drawing" jobs, and the "liver trimmers" and "vent cutters" these two jobs are also categorized as high risk.

Both plants made use of individual platforms or stands at each task location along the evisceration lines creating work heights from 42 to 44 inches. Plant A seemed to have made better use of the platforms since most workers were at the right height for the observed tasks. The problem at Plant B was that the height adjustable platforms were not always adjusted for the individual. "Liver trimmers" share the same platform and use stands to bring themselves up to the right level. An interesting finding where more than one worker is doing the same job is that the work load is not always evenly distributed among the workers. Those individuals who are working harder and faster probably have a relatively higher risk of developing CTDs than those who work at a slower pace.

Based on the findings of this study, employees who draw the viscera (i.e., "draw hands") are at high risk of developing CTDs. "Draw hands" reach down into the bird vent opening with right or left hand flexion and then, with a pinch grip, grasp and position the viscera, with forearm rotation, for presentation to the USDA inspector. Two and three "draw hands" were used on SIS lines at Plants A and Plant B, respectively. Plant A uses three employees on NELS which will also be the configuration used when Plant B converts to the faster line speed. This job seems also to be dependant on the efficiency of the upstream evisceration machine. If the machine does not properly remove the viscera it will force the employee to reach further into the vent opening with a severely flexed hand. The "nondrawing" hand removes the skin flap with considerable pinching and forearm rotation. Table D summarizes the hand activity for this job.

**Table D. Draw Hand Task Analysis**

| SYSTEM | LEFT HAND HMPM | RIGHT HAND HMPM |
|---|---|---|
| SIS (2) | 125 | 120 |
| SIS (3) | 78 | 70 |
| NELS (3) | 96 | 109 |

"Vent cutter" employees back-up the vent opening machine. The industry trend at this position is to use one person per line regardless of the inspection configuration (i.e., SIS or NELS) or line speed. Openings that are inadequate or missed by the machine are cut with

scissors in the dominant hand. The number of cuts per minute ranged from 78 to 87 for NELs and 15 to 70 for SIS. This wide range of cutting activity is due to machine misses and/or the use of a work method where the line worker cuts every bird whether it is needed or not. Machine problems may be due to the lack of adjustment for a particular run, a lack of uniformity in bird size, and equipment malfunction. The potentially stressful work method might be an adaptation assumed to ease the defect detection process. That is, it might be easier to develop a rhythm and cut every bird then it is to visually examine each bird. The right hand is deviated toward the ulnus while the scissors are in use. The left hand checks every bird (180 HMPM for SIS and 260 HMPM for NELS) with flexion, pinching, and forearm rotation.

The inspection tasks on the Evisceration line are conducted by the "house and USDA trimmers" (also called "USDA helper"). The most stressful job based on probable work load is the "house or mirror trimmer". This is because there is generally one individual per line doing this task regardless of the line speed. Obviously, the amount of trimming activity is dependant on the quality of the run. The more defects or contamination the greater the hanging back, salvage, and trimming activities. "USDA trimmers" made from 2 to 8 knife cuts per minute (5 cut average) with the right hand in ulnar deviation. The "house trimmers" had approximately double the tool (knife) activity. The left hand is used primarily for support. Transferring contaminated birds to the salvage line (i.e., hanging back) occurred at a very low frequency (less than 3 birds per minute). Plant B installed a salvage line that has right angle turns to allow each "trimmer" to hang to the side at or just below shoulder height rather than hang back. The small salvage work area in front of many trim stations was from 22 to 33 inches from the platform. This location causes all but the shortest individuals to stoop forward during off-line trimming activities.

Three liver trimming or harvesting employees are usually found on SIS lines and four on NELS. With three basic cuts made per person per bird, this translates to approximately 66 right hands movements per minute (HMPM) for NELS and 69 right HMPM for SIS. The nondominant hand reaches and grasps the viscera, than supports it for cutting. This activity results in approximately 66 left hand motions per minute (HMPM). During the evaluation it was not unusual to find less than a full complement of labor at this location adding to the work load of the remaining workers. Interestingly, the liver trimming work population was generally older and expressed a very low upper extremity discomfort level. Not surprisingly, their complaints of discomfort focused on the back and leg regions.

There is generally one individual who backs-up the gizzard pulling machine per line. As mentioned before, the hand activity is very similar to the "draw hand" job where the right, left, or both hands are inserted with moderate to severe flexion into the vent opening to check for gizzards that are missed by the machine (34 to 36 right and left HMPM). A tremendous amount of reaching and bending due to the location and size of the water trough directly in front of the employees was also observed.

**Breast Debone Operation**

The cone line (front half conveyor system) speed is set between 34 to 46 birds per minute and is under the control of the department manager. Two platforms were in use along the length of the line that elevated the workers 27 and 20 inches above floor level. The first section put the work height at 43 inches (top of cone from platform surface) and the second section put the work height at 49 inches. These work heights would be elbow height for statures of 68 and 78 inches, respectively and are therefore going to cause mismatches without the use of stands. This indeed is what was observed where some tall individuals were stooping and some short individuals were working well above elbow height. Most of the "high force" positions are occupied by male workers.

A potentially dangerous work practice was observed along one of the debone lines where at least three individuals were sitting on the top rail along the first platform section. Since this section is 27 inches above the floor a serious injury could result if someone falls backward. Very few individuals were observed using the eleven inch footrail at any time. Moreover, when the line was full, there was less than adequate space between workers.

Table E (below) summarizes the results of the video analysis for the eleven observed jobs along the breast debone line . All positions along the line are highly repetitive with low to high force requirements. When employees in this department were asked which job they felt was the most difficult, most of those who responded identified the "fillet pull" and "second wing cut" jobs.

As expected, almost all the cutting activities involve wrist flexion and ulnar deviation with the use of a standard straight handled knife and scissors. The one exception was the "back trim" operation where the worker maintains a straight wrist while cutting with scissors. Mouse trap sharpeners were available at most task locations and they were frequently used by the line workers. Their location was, however, less than optimal causing employees to reach with partially extended arms.

Individual differences in the method used to accomplish the job were also noted. An important case in point is the second wing cut where the right handed individual used more than twice the hand motions as a left handed individual doing the same job. The second person doing the first wing cut used significantly fewer hand motions than the first person observed. A double blade tender scoring knife was in use that requires half the number of strokes of a standard knife. The wing cutters and breast pull down workers tend to throw or toss the meat to the central belt conveyor. This activity would contribute to the overall work load since it is often done with wrist flexion.

**Table E. Breast Debone Task Analysis**

| JOB | LEFT HMPM | RIGHT HMPM | CUTS PER MINUTE* | FORCE |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1-Wing cut | 109 | 65 | 44 | M |
| 2-wing cut | 104 | 191 | 35 | H |
| Back skinner | 133 | 133 | 89 | M |
| Breast Skinner | 160 | 100 | NA | H |
| Pull down Breast | 35 | 59 | NA | M |
| Tender Scorer | 82 | 41 | 42 | M |
| Tender Prep | 166 | 166 | NA | L |
| Detendonizer | 160 | 0 | 80 | M |
| Tender Pull | 229 | 229 | NA | M |

*A cut is recorded when there is a pause and change in direction.

The left hand is used primarily for positioning and supporting the meat during cutting activities using both a pinch and power grip. For the more forceful pull down operations (e.g., tender, skin, and breast pull) it is used like the right hand, grasping, pinching and pulling.

**Packing Operations**

The manual insertion of parts into cartons in the Cut-up Department at Plant A is a high risk job based on the fact that there were three reported cases of CTDs in this area. In general, an employee will grasp and insert cut-up parts from a central belt conveyor and place them in lined boxes located on a roller conveyor. The grasping activity is very repetitive and can cause the worker to reach more than thirty inches in front of the body. The left and right hand activity produces about 67 hand motions per minute (HMPM) and there is considerable grasping with pinch and power grip, forearm rotation, and wrist flexion to complete the task. The activity varies depending on the amount of product produced. Employees were also observed rehandling boxes between a stand and a roller conveyor located near-by (finished product conveyor). This activity could increase their exposure to back injury.

After the bags and boxes are filled in the Giblets and Cut-up Departments they go to a weigh station. As mentioned before these activities are associated with CTDs. Employees in the Giblets Department receive bagged gizzards, place them on a scale and add or subtract parts to achieve the desired weight. The bags are than manually tied and placed in a box. When full (40 pounds), the box is off-loaded to a table near-by. There are approximately 79 left HMPM and 54 right HMPM per bag. The most hand intensive activity is the bag closure process that involves wrist flexion/extension and deviation , forearm rotation, and finger manipulation. These employees must also lift the bags to or from a intermediary box with a 10 inch side that causes their arms to be raised above elbow or shoulder height.

With the cut-up parts carton weighing operation there was much less hand activity and materials rehandling. Boxes containing parts are simply pushed along a roller conveyor from upstream packing to the scale and onto either an ice or carbon dioxide dump station. Bags are sealed one of two ways depending on whether they are going to the ice or carbon dioxide dump. Those destined for the carbon dioxide station are vacuum-sealed. Those destined to be ice packed are taped closed with a tape gun. It is this latter activity that may create the greatest stress on the dominant hand. The use of the tape gun causes the worker to use a bent wrist (ulnar deviation). Moreover the bags that are going to be vacuum-sealed are raised to the point of operation with right and left hand dorsiflexion. Using the same posture the employees raise their hands to the two hand control at or above shoulder height to actuate the machine. One final observation is the use of forceful shoving or pushing to move boxes between locations. This activity could also add to the total stress acting on the upper extremities (hands, arms, and shoulders).

**Rehang and Live Hang Manual Transfer Operations**
Hanging at the various locations in both plants is as expected very similar. Birds, alive or processed are manually transferred from one location, usually a conveyor or bin,to a shackle. Table F below summarizes our results for three different hanging locations.

**Table F. Rehang Task Analysis**

| POSITION | AVERAGE BPM* PER PERSON | RIGHT HMPM | LEFT HMPM |
|---|---|---|---|
| Cut-up | 15 | 90 | 90 |
| After Chiller (Ice Pack) | 40 | 180 | 72 |
| Evisceration NELS | 45 | 270 | 225 |
| Evisceration SIS | 35 | 210 | 175 |
| Live | 32 | ** | ** |

* BPM is birds per minute.
**Did not conduct videoanalysis at this location.

All "rehang" and "live hang" jobs are repetitive and involve a high degree of nonneutral wrist activity and forearm rotation. The effort is also significant since the job invariably requires the worker to raise the bird (i.e., working against gravity) to the shackle. The other potential incompatibility is the location of the birds either in a bin or on a flat belt conveyor. More often than not the origin of the lift forces the worker to stoop and reach to acquire the bird (average height from floor or platform was 31 inches) and raise the arms well above elbow height to place it on the shackle (average height of shackle was 55 inches). For most of this time the individual conducting the transfer is also visually inspecting the bird.

Four "rehang" methods were observed at both sites. The first involves simply grasping and raising the bird to the shackle with the dominant hand alone. The second method involves grasping the bird with the nondominant hand and transferring it to the dominant hand for shackling. Thirdly, a two hand hang is used where a single bird is grasped by both hands. The last method noted involved grasping two birds, one in each hand. The interview data supports the use of the first two as the predominant methods as most of the reported discomfort is focused on the right side. Some rehanging operations (primarily for cut-up machines) involved an additional step, where prior to hanging the thighs are manually dislocated or the wings are broken. Both components substantially increase the force requirement of the task.

**Cut-up Department Saw Operations**
Nine piece and leg quarters saw operations were evaluated. Plant A was more automated in this area with one nine piece Simon Johnson, Automated Packaging System (APS), and Foodcraft leg and thigh and breast processing machines. Plant B also has an APS machine that has replaced ten "saw tenders". They plan to install one more in the next year.

These positions were examined because of the complaints of discomfort to the upper extremities and back and the fact that other sites have reported these jobs to be a source of CTDs. The results of our analysis are summarized in Table G. Both jobs are repetitive requiring a tremendous amount of arm, hand and back activity. Although the overall activity is classified as heavy, during the on-site evaluations they were only done intermittently throughout the work-day. As with most jobs examined in this study with multiple operators, some were working harder and faster than others (work load imbalance) and there was a tremendous amount of individual variation. These findings demonstrate a need for training and the development of standard operating procedures.

**Table G. Cut-up Task Analysis**

| JOB | LEFT HMPM | RIGHT HMPM |
|---|---|---|
| 9 Piece Cut | 70 - 106 | 86 - 104 |
| Leg Quarters | 237 - 404 | 143 - 242 |

The lateral reach to shackle ranged from 19 inches to as much as 30 inches depending on the orientation of the saw. The shackle location also required the workers to reach at or above shoulder height (shackle height from work surface ranged from 48 to 60 inches).
These activities help explain the reported frequency of shoulder pain and discomfort among "saw tenders".

The most hazardous activity that was observed was the cut-up part bag handling task component. The bags are located anywhere from 30 to 36 inches from floor or platform below the machine point-of-operation. This location causes the saw tenders to stoop to remove a full bag and stoop again to insert a new bag. The upper body flexion (i.e.,
bending) ranged from 30 to 50 degrees depending on the operator. Severe flexion of the back is associated with muscle fatigue and can reduce work tolerance as well as increase the risk to injury. Ergonomics aside, however, this work practice brings the head of the operator dangerously close to the saw point of operation. Only one operator was observed bending the legs instead of the back to reduce their exposure to this safety hazard.

**Material Handling**
Employees in the Breast Aging Department supply the breast debone cone lines with meat (front-halves). Tubs containing the front-halves weigh approximately 70 pounds and are stacked on pallets up to five high. Employees lift/lower the tubs from the pallets to a "dump" station located near-by. The "stack-off" operation in the Shipping Department requires employees to lift/lower cartons which weigh 40 to 100 pounds from a conveyor to floor level pallets. The lifting frequency in both cases ranged from two to four lifts per minute per individual.

Table H summarizes the results of the lifting analysis. For the two jobs, lifting units that are 70 pounds or more exceeds the NIOSH maximum permissible limit for lifting. Therefore, both palletizing and depalletizing jobs are classified as high risk from the standpoint of back injury. The action limit was exceeded for all box and tub types handled in both areas. According to NIOSH, jobs that equal or exceed the MPL are acceptable to only 25 percent of the male and less than 1 percent of the female population and intervention should be in the form of engineering controls. As a minimum, administrative controls should be instituted for jobs that are between the AL and MPL. Keep in mind that the values in the table below probably underestimate the risk to injury since they do not consider posture (e.g., bending and twisting) and other material handling task components that would add to the effort (e.g., load carriage).

**Table H. Material Handling Task Analysis**

| JOB | AL (pounds) | MPL (Pounds) | LOAD (Pounds) |
|---|---|---|---|
| Stack-off A | 20 | 60 | 40 to 70 |
| Stack-off B | 23 | 69 | 40 to 75 |
| Debone Tub Supply | 23 | 69 | 70 |

## INDUSTRIAL HYGIENE

### Air Contaminant Standard

The Occupational Safety and Health Administration's Permissible Exposure Limits (PELs) are legal standards with which all employers must comply. Many of the standards were adopted from the 1986-87 American Conference of Governmental Industrial Hygienists Threshold Limit Values (TLVs). Other air contaminant standards have been promulgated directly by OSHA throughout the past twenty years, and have other specific requirements. Generally, the TLVs are based on more current toxicological information; many companies have adopted them as internal standards to provide their employees with a recognized level of protection. It is worth emphasizing that neither the PELs nor the TLVs will protect all individuals; some will experience adverse health effects below these limits due to differences in metabolism, genetic makeup, current medical status, etc. In short, the limits must not be viewed as a sharp dividing line between "safe" and "unsafe" conditions; they are better viewed as guidelines.

The newly-adopted OSHA PELs became effective March 1, 1989. Employers were required to comply with the new OSHA standards through any combination of engineering controls, work practices and personal protective equipment (e.g. respirators) by September 1, 1989. By December 31, 1992, feasible engineering controls must be implemented to achieve compliance with the new limits.

The employee exposures described in this report are referenced to the current OSHA PELs and the ACGIH TLVs for 1989-90.

### The OSHA Noise Standard

The OSHA Noise Standard requires employers to determine two types of noise exposure levels. Both are time-weighted averages (TWAs) measured over an 8-hour work shift. One consists of an average of all noise energy above 80 decibels measured on the A-scale (DBA), and is compared with the OSHA "action level" of 85 DBA. The other consists of an average of all noise energy greater than 90 dBA and is compared with the OSHA Permissible Exposure Limit (PEL) of 90 dBA.

From major research studies, OSHA has decided that at the "action level," the risk of hearing impairment becomes significant. At 80, 85 and 90 dBA, the percentage of the working population suffering hearing loss is 0-5%, 10-15%, and 21-29%, respectively.

**Noise**

Noise levels appear to be above the OSHA Permissible Exposure Limit of 90 dBA in most areas of Plant A, and slightly below 90 dBA in Plant B. The individual exposure results for Plant A and Plant B are presented in Appendix G in Tables 1A - 2A and Tables 1B - 2B, respectively. Many employees who were exposed to noise levels greater than 90 dBA did not wear proper hearing protection, which OSHA would classify as a serious hazard. Eight out of twelve workers in Plant A were exposed to time-weighted average noise levels greater than that permitted. Only one of the eleven workers in Plant B was overexposed to noise. However, all workers monitored in both plants were above 85 dBA, which represents a significant risk of hearing loss (10% of the working population).

Even employees monitored in a relatively quiet area in Plant B (the Debone Department) were exposed to noise levels slightly greater than the OSHA Action Level of 85 dBA. These results indicate that plant-wide hearing conservation programs are necessary unless noise exposures can be reduced (see recommendations below). Plant A included all employees in the hearing conservation program, while Plant B did not include employees in certain job categories. Nurses in both plants were responsible for operating the hearing conservation programs, in consultation with nearby physicians. A cursory review of the programs indicated that several cases of hearing loss (standard threshold shift) had been identified in both plants; it was reported that the relatively high turnover rate in both plants militates against easy identification of hearing losses.

Why were noise exposures in Plant A higher than in Plant B? One possible reason is that Plant B had not yet installed automated final control machines, which were a major noise source in the Evisceration Department in Plant A. Management in Plant B admitted that their noise levels were likely to increase with the installation of final control machines in their plant. Plant A did have thin plastic sheeting around its final control machines, but it was reported that this was for water spray control, not noise attenuation.

Another possible reason involved preventive maintenance. Machinery which is not properly maintained tends to be noisier. For example, a large fan in the live hang department in Plant A had a bad bearing on the day of the survey. Simple lubrication and repair of the bearing during the lunch break reduced noise levels by approximately 3 dBA (since decibels are a logarithmic scale, this means the noise energy inside the employees' hearing zones was reduced by about half). Lighting in both plant live hang areas was dimmed, which may contribute to less noise from the birds.

Noise levels in the Debone Department averaged about 80-83 dBA until the ice chute was activated. The impact of noise on the conveyor and the motor noise combined to produce levels of about 95 dBA, which explains why the average noise exposure was above 85 dBA.
Finally, some of the variation may have been due to differences in work schedule. For example, the emulsifier machine in the Blending Department was not operating on the day of the survey in Plant B.

OSHA would regard the failure to enforce the use of hearing protectors in areas above 90 dBA as a serious hazard and reference 29 CFR 1910.95(b) of the General Industry Health and Safety Standards. Further, OSHA may regard the absence of a formal noise abatement program (see recommendations) as an "other than serious" hazard.

**Dust Exposures**
Individual dust exposure results from both plants are presented in Appendix G, Tables 3A and 3B. Dust exposures in the Live Hang area of Plant A were roughly twice as high as the Permissible Exposure Limit, while exposures in Plant B were below the limits. However, the dust in Plant B was found to contain a significant percentage of crystalline silica (quartz), while Plant A had no detectable levels. Several workers in Plant B had exposures which exceed the limit for crystalline silica (0.1 $mg/m^3$). The absence of quartz in Plant A is probably related to the type of dirt on the chickens as they are brought in from farms. Both plants had exhaust ventilation systems in place, but neither was in operating order on the days of the surveys. In both cases, the exhaust vent opening was at least 5 feet above employees heads. Thus, the opening was not placed as close as possible to the source of the dust generation.

Some workers in both plants wore unapproved single strap dust masks, and there was no formal respirator program in place in either plant. OSHA requires that a respirator program be implemented whenever dust masks or respirators are used. The agency would classify this as an other than serious hazard and reference 29 CFR 1910.134.

Large floor fans were used in the Live Hang area of Plant A to keep employees cool. However, these fans greatly increased the air turbulence in the room, stirring up a significant quantity of dust. Proper engineering controls could help avoid the dilemma of trying to decide whether heat stress or dust exposures present the greatest hazard. Several employees complained that heat and humidity levels were extreme, especially during the summer months. Measurement of heat stress was not performed for this study, but should be done during a hot day later this year. Additionally, all employees in both plants used compressed air to blow the dust off of their clothing before leaving for lunch and at the end of the workshift. This practice also creates a dust cloud, and is easily rectified by changing work practices. OSHA would classify the total dust exposures in Plant A, and the respirable silica dust exposures in Plant B as serious hazards, referencing 29 CFR 1910.1000.

**Carbon Dioxide ($CO_2$) Exposures**

Individual time-weighted average exposure results are presented in Appendix G, Tables 4A and 4B. Short-term detector tube readings, which can be viewed as supporting data for the time-weighted average exposures, are presented in Tables 5A and 5B. The results show that all employees monitored in Plant A had exposures above the new OSHA PEL of 10,000 ppm (the bag for Worker 21 probably leaked, since the detector tube samples in this area indicated an average concentration of about 16,000); workers in Plant B had exposures between 5,000 and 10,000 ppm, except for Worker 39, who was exposed to 12,000 ppm. Workers in both plants reported frequent episodes of headaches, nausea, an inability to "catch" one's breath, and fatigue. Workers in Plant B indicated that the frequency of these episodes has declined substantially after improvements in ventilation were made in the stack-off cooler and on the packing lines. Both management personnel and hourly employees reported that these symptoms were much worse on warm rainy days, and that the carbon dioxide does not dissipate as well in humid air. Repeated attempts were made to collect air samples on a day with high humidity and when relatively large quantities of dry ice could be expected to be used. This proved to be nearly impossible to predict in both plants. At the conclusion of the sampling on the days of the surveys, workers in both plants indicated that they thought exposures were lower than what one would see in a "worst-case" scenario. In short, the results reported here are likely to underestimate representative exposures. Sampling on one occasion was done on a day when little carbon dioxide was used.

There also remains some controversy regarding an acceptable exposure. For many years, the OSHA Permissible Exposure Limit and the Threshold Limit Value for carbon dioxide stood at 5,000 ppm. The limit was set to prevent various adverse health effects. The common wisdom is that carbon dioxide is a simple asphyxiant (that is, it displaces oxygen), which is erroneous. Carbon dioxide produces a number of toxic effects beyond simple asphyxiation; its exposure limit is based on its toxic properties other than asphyxiation.

In a recent controversial move, OSHA raised its Permissible Exposure Limit to 10,000 ppm (1%), while the recommended TLV remains at 5,000 ppm (0.5%). The rationale for this move rests largely with studies conducted during the mid-1970's, many of which focus on high short term exposures. Those individuals with existing respiratory system ailments may not be sufficiently protected by the new PEL. Since employees have reported various health problems in the poultry plants studied here, we believe that the recommended TLV of 5,000 ppm is a more prudent course of action. The rationale for both the OSHA PEL and the 1989-90 TLV are provided in Appendix H.

A previous study of four poultry processing plants found that exposures in holding coolers can exceed the Immediately Dangerous to Life and Health (IDLH) limit of 50,000 ppm. The holding cooler in Plant A reached a maximum of 34,000 ppm, while the level in Plant B peaked at 22,000 ppm. Neither holding cooler was equipped with exhaust ventilation, except for the normal dilution ventilation which occurs through the doorways. The concentration of carbon dioxide in the holding coolers is related to the length of time packages are stored, how many packages are present, how much carbon dioxide is administered to each package, and temperature and humidity levels. This study shows that exceeding the IDLH level inside holding coolers cannot be ruled out. On the other hand, time-weighted average exposures for jack drivers who entered the holding coolers frequently but briefly were not significantly elevated above those of other workers. In short, these results show that workers who spend long periods of time inside the holding coolers (for example, maintenance workers performing repairs) can be expected to experience extremely high levels of exposure. The hazard would be magnified for those individuals working alone.

Plant B had a carbon dioxide alarm system installed in the stack-off room, together with a mechanical exhaust ventilation system. The alarm had no record of being calibrated, and no individual in the plant appeared to have responsibility for maintaining the accuracy of the system. If the concentration at the sensor in the stack-off room exceeded 10,000 ppm, a red warning light would be activated in the shipping department foreman's office. Plant B had no alarm system in place. Both plants practiced an informal rotation system, which allowed workers to leave the stack-off room whenever they felt that levels were excessive. The foreman in Plant B reported that when the alarm did go off, he made certain that workers were rotated on a more frequent basis. Workers in Plant B reported that they had experienced fewer episodes of high exposure to carbon dioxide since the exhaust ventilation and alarm systems had been installed.

The stack-off room exhaust ventilation system in Plant B consisted of a simple duct opening near the conveyor belt. The circular opening was 8 inches in diameter, and was found to have an average face velocity of 3800 feet per minute (fpm). The volumetric airflow rate (cubic feet per minute--cfm) can be calculated as follows:

$$\text{cfm} = 0.349 \text{ ft2} \times 3800 \text{ fpm} = 1325 \text{ cfm}$$

Plant A had no exhaust ventilation system in the stack-off room, perhaps explaining the higher exposures encountered there.

The machines responsible for delivering dry ice to the poultry packages were equipped with exhaust ventilation systems in both plants, reportedly specified by the manufacturers of the machines in both cases. In both plants, simple visual observation showed that substantial amounts of carbon dioxide, which appears as smoke, escaped into the plant atmosphere before being captured by the exhaust systems. In Plant A, the exhaust system employed two fans aligned in a "T" configuration directly above the machine. The fans were located so that air moved in opposite directions, which is clearly an inefficient design. In Plant B, the exhaust fans were mounted on the roof, but no one could explain how the fan capacity had been selected. Both plants had relatively poor hood enclosure designs.

Table I provides the volumetric airflow rates for each of the carbon dioxide machines in both plants, based on the face velocity measurements at the flexible duct openings for each machine.

**Table I.**
**Volumetric Airflow Rates for CO2 Delivery Machines**

| Location | Average Face Velocity at Duct Openings (fpm) | Total Estimated Airflow (cfm) |
|---|---|---|
| **Plant A** | | |
| Military Line Machine | 1620, 1620 | 635 |
| Cutup Line Machine | 2160, 1890 | 793 |
| Multicut Line Machine 1 | 2250, 2430 | 917 |
| Multicut Line Machine 2 | 1620, 1800 | 670 |
| AP line Machine | 1980, 1980 | 776 |
| **Plant B** | | |
| KFC Line Machine | 3420 | 670 |
| Saw Line Machine | 1620 | 317 |
| Cutup Machine | 2880 (bottom), 1200 (top) | 1800 |

**Note: Measurements taken on Feb. 2, 1990 using an Alnor Velometer. Centerline velocities are multiplied by 0.9 to obtain average face velocity.**

In comparing the two plants, Plant B clearly had a greater amount of exhaust ventilation for the machine it used most frequently for delivery of dry ice to poultry packages (the Cut-up Machine), which may explain why exposures were higher in Plant A $CO_2$ than in Plant B machines. In the one case where exhaust ventilation rates in Plant B were lower (Saw Line Machine) exposures were elevated (see Appendix G, Table 4B, worker 39, who had an exposure of 12,000 ppm). In short, these results suggest that a total volumetric airflow rate of about 2000 cfm (measured at the hood, not the fan), together with a well-designed enclosure, should be sufficient to keep exposures below the OSHA PEL.

Neither plant could be considered to have a hood design which had a sufficient degree of enclosure. This is a relatively simple matter to correct, and could dramatically boost exhaust ventilation efficiency (see recommendations).

The exposures in Plant A would be considered to be a serious hazard by OSHA, since they are above 10,000 ppm. OSHA would regard the exposure in the vicinity of the saw line in Plant B to also be a serious hazard. In both instances, the violation would be referenced to 29 CFR 1910.1000.

**Ammonia**

Ammonia refrigeration systems were in use in both plants, and in both cases, maintenance and management personnel reported that leaks were commonplace. In the loading dock area of Plant B, a routine maintenance operation (cleaning oil pots) resulted in an exposure of 50 ppm on the day of the survey (see Table 5B in Appendix G, which is above the 8 hour time-weighted average PEL of 25 ppm. Significant concentrations of ammonia were also discovered in freezers in both plants (see Tables 5A and 5B), supporting the claim that leaks are commonplace.

Since the freezers can be considered to be confined spaces with limited means of egress and natural ventilation, the risk of contacting an extremely high concentration of ammonia, with the potential to immediately incapacitate an employee, is likely. Ammonia has good warning properties, so employees may be able to escape in many situations. However, neither plant had any means of testing the air inside the freezers prior to entry, or determining whether a significant leak of ammonia had occurred. The prevalence of such leaks should be a major source of concern for the industry.

To understand the possibility of a contracting a lethal dose of ammonia, consider the following example:

A freezer measuring 20 feet x 20 feet x 10 feet, or 4000 cubic feet, leaks 1 pound of ammonia. The concentration of ammonia inside the freezer can be calculated as follows:

1 pound = 454 g (grams)
4000 cubic feet = 113,000 L (liters)
1 mole of gas occupies about 22 liters at zero degrees F
Molecular weight of ammonia = 17 g/mole
1 ppm = 1 microliter/mole

$$\frac{1 \text{ lb.} \times 454 \text{ g/lb.} \times 22 \text{ L/mole} \times 1{,}000{,}000 \text{ microliter/L}}{17 \text{ grams/mole} \times 113{,}000 \text{ liters}} = 5{,}200 \text{ microliter/liter}$$

5,200 microliters/liter = 5,200 ppm

The Immediately Dangerous to Life and Health level for ammonia established by the National Institute for Occupational Safety and Health is 500 ppm. Therefore, a small 1 pound leak inside a typical freezer unit can result in an exposure 10 times greater than can be tolerated; even a brief exposure to such a level may cause lasting injury.

A maintenance supervisor in Plant B reported that it is not unusual for workers to work alone when servicing the ammonia refrigeration system. He also reported that respirators are not normally used when ammonia is released into the air. He indicated that some workers wear dust masks, even though these would provide absolutely no protection against ammonia vapors. Since the servicing involves bleeding off a significant quantity of ammonia, this is typically performed on an off-shift, when fewer employees are likely to be exposed. If the maintenance employee were to be exposed to a concentration greater than 500 ppm, unaided escape may not be possible. Plant B reportedly had an SCBA unit available for rescue, while Plant A had a full-face canister respirator located in the dock area. As noted earlier, neither plant has a respirator program. Inspection of the canister respirators had apparently not been performed for some time; no one could determine when the canisters had last been changed, how they could be tested, or how effective they might be an emergency. No one had received a fit test for the ammonia respirators.
OSHA would probably classify the absence of an emergency rescue plan for maintenance workers overcome by ammonia gas as a "serious hazard" under the General Duty Clause of the Act (paragraph 5 (a) (1)). Further, it would classify the absence of a respirator program and respirator training as an "other than serious" hazard, unless an overexposure were to occur, in which case it might be considered to be a "serious hazard" under 29 CFR 1910.134.

**Chlorine and Soap Mixing Operations (Chemical Hazard Communication Program)**
Chlorine levels in the washout area of Plant A and in the soap mixing room in Plant B were only at trace levels, and under normal operating conditions, are unlikely to pose a significant hazard. The employee involved in the soap mixing operation poured various solutions from buckets and stirred the mixture in a tank with a stick. This practice results in a significant splash potential. However, no face shields, goggles, or gloves were worn by the worker.

In addition, alkaline materials (specifically "Delex") were stored in close proximity to chlorine bleach compounds. The Delex label says that this material should not be stored near chlorine compounds, due to the potential release of chlorine gas. The individual in the soap mixing operation was not aware of the hazards involving in mixing these two incompatible substances. OSHA would require that these two compounds be stored in separate areas, and the hazard communication program include employee training on proper chemical segregation and handling procedures. Neither plant had a written hazard communication program, although management in both plants reported that this process was well underway. Finally, the sprayer tanks which were filled with the sanitizer solution were not labelled with either the contents or an appropriate hazard warning. These conditions would be classified as a serious hazard by OSHA and referenced to 29 CFR 1910.1200).

**Formaldehyde and Ozone**

Formaldehyde and ozone levels were measured in the hatchery at Plant B. Plant A did not have a hatchery on site. Individual results are provided in Table 7B in Appendix G. Previous studies have shown that exposures to formaldehyde can be quite high in hatcheries, often due to the absence of air-tight hatchers. The individual monitored wore a full-face air-purifying respirator specifically approved for formaldehyde.

The results show that the individual was exposed to a level below the OSHA PEL, but above the 1989-90 proposed TLV. The OSHA Short Term Exposure Limit, which is 2 ppm, was very nearly exceeded (see sample 20B in Table 7B, which was 1.77 ppm). OSHA regulates formaldehyde as a carcinogen (cancer-causing substance) under 29 CFR 1910.1048. This standard requires companies to implement feasible engineering controls. The courts have recently ordered OSHA to reconsider its PEL, and it seems likely that the allowable exposure limit will decrease. The Threshold Limit Value of 0.3 ppm is a ceiling value (not a time-weighted average) which is not to be exceeded even for short periods of time.

The area samples show that levels inside the room where the hatchers are located reach about 3 ppm, and then decline over time. Formaldehyde was administered at 6 p.m. on January 9 and again at 4 a.m. on January 10, 1990. Area samples collected at about 8:30 a.m. on January 10 indicated that levels were between 0.09 ppm and 0.24 ppm. The variation is probably due to differences in room ventilation. Since these levels are not greatly below the proposed TLV of 0.3 ppm, additional control measures are needed (see recommendations).

The exhaust stacks for the hatchers in this study were physically separated from the work area. In one room, a direct connection existed between the hatcher exhaust stack and an exhaust duct leading to the building roof. In the other room, the exhaust stacks opened into a "dust corridor," which was equipped with a wall fan to maintain negative pressure with respect to the work room.

The smoke generator test videotape showed that containment offered by these hatchers was generally superior to other hatchers investigated previously. Area concentrationsin two other plants reach as much as 30 ppm of formaldehyde. The hatchers in these other plants exhibit a much higher degree of leakage than found in Plant B of this study. However, there was still some degree of leakage, primarily from gaps between the floor and the gasket on the hatcher door, which can be rectified easily.

Ozone was also measured with short-term detector tubes inside one hatcher or incubator equipped with an experimental "ozonator." No measurable levels could be detected inside the hatcher, although levels greater than 10 ppm were found at the ozonator hose opening inside the incubator. It is not clear why ozone could not be detected inside the hatcher or the workroom. Possible explanations include interferences from high humidity, the highly reactive nature of ozone, and rapid dissipation by the hatcher ventilation system. More sensitive analytical techniques are available, and should be used to document employee exposure if this experimental method gains more widespread use. The OSHA Permissible Exposure Limit for ozone is quite low (0.1 ppm). Since ozone is not regulated as a carcinogen, it represents a possible substitute for formaldehyde. Whether this actually improves working conditions depends upon the exposures encountered.

## CONCLUSIONS AND RECOMMENDATIONS

### SAFETY, HEALTH, AND ERGONOMICS PROGRAM

Neither plant in this study had a complete safety and health program or all the elements of an effective ergonomics program. Both are however, working towards achieving this goal with one plant further along than the other. Clearly, the existence of a formal safety and health program will make the development and implementation of an ergonomics effort much easier than if such a program does not exist at all. The identification and control of ergonomic hazards requires an interactive approach involving management, engineers, and human resource, safety, and medical personnel as well as hourly employees. As with any successful safety and health program, an effective ergonomics program must include the following elements: Management support and commitment, a mechanism to identify hazards, resources and commitment to control the hazards, and employee education. If the resources are not available, a company should consider using their insurance carrier's loss prevention service, if provided, or an outside consultant. If a company has a CTD problem it is very important that they document all efforts in ergonomics and develop an effective written program using the Meatpacking Guideline and MET Program as models. Further, to administer such a program will probably require a full time effort by someone who understands the process flow, ergonomics, and safety.

#### Training

If a plant has an Engineering Department it is recommended that at least one individual receive formal training in ergonomics. The individual selected should be closely involved in process matters and be familiar with equipment and facility layout. It is recommended that as a minimum this person attend a one to two week course from the University of Michigan's Center for Ergonomics, the Harvard School of Public Health, or similar program.

A few instances were noted where stress was introduced on the line or job because of the absence of a coworker. Therefore, it is important that adequately trained utility workers be available to take up the slack caused by absenteeism (without creating deficiencies elsewhere).

Training in the early detection of the signs and symptoms of CTDs is needed to help ensure that affected individuals receive prompt treatment to reduce the likelihood of surgery or disability. All employees should be instructed to report to the medical department when problems occur.

Hourly employees receive on-the-job training but only rarely do they receive training on postural safety and ergonomics. Therefore, as a minimum, the points described below should be covered in a training session at the time of employment and repeated periodically. It is strongly recommend that all new employees be brought up to speed gradually using a training line with restricted on-line duty. Moreover, videotape could be used to reinforce the use of proper methods to accomplish the task.

**Training Points**

Discuss with all employees the importance of maintaining a neutral wrist as much as the job permits. Not only is it important from the standpoint of disease prevention but it allows the hand to operate at an advantage. Also, new employees should receive training on how to do the job to minimize their exposure to CTDs. Based on the results of this study, many individuals were wasting motion (using more than the required strokes or motions). Methods training on motion and strength conservation in conjunction with posture avoidance is highly recommended.

Discuss the importance of getting within the 14 to 16 inch reach envelope to help reduce the stress on the arms and shoulders. Some individuals were observed standing further away from the job than was actually necessary.

Discuss the hazards associated with the equipment or methods they will be using.

Many of the "material handlers" that were interviewed were aware of sound back biomechanics. Proper back posture should also be a training topic for all line workers.

When employees identify an ergonomics or safety problem they should be encouraged to report it immediately to their supervisor for corrective action.

When new equipment or tools are introduced in the workplace employees should be properly trained in their use. It is well known that many employees resist change. That is why it is important to involve the employee as much as possible concerning any proposed change in their workplace. For example, an explanation of why a biocurved tool is superior to a straight handled tool or the purpose of using an available footrail to promote a stable back configuration should be provided in an off-

line 5 to 10 minute training session.
Sharpening procedures should be outlined in writing and carefully reviewed with each new employee involved in "cutting" and "trimming" operations.

A formal training program should have a mechanism for retraining current employees. Retraining is necessary to bring people up-to-date on important issues and reinforce policy. A training plan should be developed each year and incorporated into the written ergonomics program.

Adequately trained maintenance personnel are also needed to address the day to day problems associated with some of the processing equipment. When a problem arises there should be someone available to respond in a timely manner. All equipment should be on a preventive maintenance program as well.

One site has videotaped almost all the processing jobs for engineering and ergonomic analysis. All problem jobs should be carefully analyzed and written work practices generated so they can be reviewed with employees. This may require the use of an consultant (insurance or private). For each job, the basic job elements should be listed along with the corresponding high risk motion and postures and possible control strategies (job safety analysis format). Videoanalysis is not only important in the identification of hazards but it may also reveal a better, safer way to do the job.

A committee of people involved in the ergonomics effort should meet monthly to review all program activities.

Finally, as a key component of the hazard detection process, it is important to regularly recruit employee feedback concerning their work environment and perceived level of comfort. This concept could easily be incorporated into the "monthly" safety inspection program. The results of the "interview" should be documented for review by the ergonomics team. A structured questionnaire with a body-part discomfort section could be designed and used to assist this effort.

**Surveillance and Recordkeeping**

The recordkeeping problems noted in this report are commonplace in industry. The main problem is one of misinterpretation and lack of awareness. Heretofore, the Bureau of Labor Statistics (BLS) has not been clear as to what is specifically required concerning CTDs. Many people believed that a positive diagnosis (i.e., physical finding) by a physician was the only requirement for recordability. With the proposed Meatpacking Guideline, however, BLS takes the tact that a subjective finding such as hand pain or numbness in addition to treatment (e.g., hot wax, compresses, splinting) is a recordable event as long as the pain persists beyond a single shift (i.e., one day) and the job is hand intensive. A positive physical finding using established diagnostic measures is recordable and a light duty assignment must appear on the log as a restricted duty case. It is also a BLS and OSHA requirement that all CTDs be classified as an occupational illness (column 7(f) on the OSHA 200 log).

Whoever is responsible for recordkeeping should be familiar with the requirements. The Bureau of Labor Statistics (BLS) has a publication that should help and there are some short courses that cover the topic in some detail. First aid logs should also be maintained for the purpose of tracking problems that could become severe if left unattended. When an injury, illness occurs, whether recordable or not, the following basic data should be collected:

1. Department
2. Shift
3. Age
4. Gender
5. Job at time of injury (e.g., draw hand, thigh skinner, liver trimmer)
6. Date and time of injury
7. Injury classification (never enter "not elsewhere classified")
8. Body parts involved (right versus left)
9. Machine and/or line involvement

With the volume of injuries and illnesses at most locations an effective way of tracking would be by computer. A data management system could easily be developed using Lotus, Symphony, Dbase, Rbase or any number of software packages that are commercially available. "Ready to use " software packages designed specifically for tracking injuries and illnesses are also commercially available.

The accident data should be evaluated on a monthly basis by the safety, health, and ergonomics committee. All injuries should be thoroughly investigated within twenty-four hours of the event to help protect against loss of vital information. A common deficiency on the "supervisor's accident investigation report" is many people put only single causes frequently citing "employee carelessness". Carelessness is almost never the only cause of the event since most accidents have multiple components involving the worker, workplace, and environment. Like other events, CTDs should also be investigated in a similar fashion.

Phalen and Tinel's or other noninvasive methods for testing employees for carpal tunnel syndrome could be used as part of the medical screening program. Retesting of employees should be conducted at least annually for the purpose of detecting any deterioration that could be symptomatic of carpal tunnel syndrome. Plant nurses will most likely need to be trained to use this methodology and this training should probably be conducted by a knowledgeable physician.

Inspections should be conducted on a regular basis (at least monthly) with a special focus on ergonomics. The results should be recorded and presented during the monthly committee meeting for control strategy development. Documentation is also important for follow-up purposes. Outstanding recommendations should be discussed each month until they have been completed to the satisfaction of the committee members. Many of the safety hazards identified in this report would have been detected if a formal inspection program was in place.

**Written Program and Policies**

The foundation of any safety program is a strong policy statement signed and distributed by the top management of the facility. Without clearly-identified support at the highest levels, the best safety efforts will be only marginally effective, and may be regarded by many as a mere nuisance. All employees must understand that unsafe acts or failure to adhere to existing policies will not be tolerated. More importantly, they should understand the reasoning behind the adoption of safety rules.

Operationally, this means that employee performance reviews at all levels should include a review of safety performance, both personally and for areas under an individual's supervision. Poor safety audits in a department and failure to correct deficiencies should be addressed promptly. Department heads and supervisors should be held responsible for safety performance in their areas.

Standard Operating Procedures, safety procedures, and safety rules should be uniformly enforced. For example, visitors and supervisors entering a laboratory where protective eye-wear is required should don safety glasses (or goggles), even if the time spent in the lab is relatively brief.

In order to be most effective, safety policies, rules, and procedures should be maintained in a single document. This short general statement should reference safety requirements in specific standard operating procedures.

All activities concerning ergonomics and the prevention of CTDs should be documented and readily available for review. Written standard work practices, short term intervention and prevention plans (e.g., special knives, platforms, minor workstation adjustments) and long term plans (e.g., automation and major equipment purchases) should be a part of the written program.

## ERGONOMICS

To different degrees both plants were addressing potential worker-workplace mismatches. Examples include the use of adjustable platforms and stands. Plant B is, however, ahead of many plants within the industry due to the presence of an engineer who is actively involved in the ergonomics effort. Numerous changes have been made to help improve worker comfort and productivity. Included was a change at the wing machines to reduce the reach distance to the raw material conveyor. This simple change resulted in a savings of several thousand dollars. The other sound idea that was implemented was discussed in an earlier section and that was the installation of right angled turns so "trimmers" in the Evisceration Department can hang to the side and not back. Also on the drawing board is the almost total automation of the "breast debone" operation. On the evisceration lines an automatic transfer machine was installed at the end of our study. This machine eliminated the need to manually rehang birds except as a back-up position. A liver trimming or liver harvesting machine is also under consideration.

What follows are recommendations that focus on the jobs that continue to be a problem at these sites as well as those plants evaluated in the past. Under the present atmosphere it is a certainty that if a problem exists with regard to musculoskeletal disorders and nothing is done to address it, the company is assuming a significant risk and liability. Tough decisions must be made concerning the problem jobs. The first choice in eliminating the problem is automation and with more systems on the market than ever before this is a real possibility for some jobs. Justification of new machinery is easy when it can match or out-perform the labor force from a quality and productivity standpoint and the workers compensation losses are significant. Before a purchase is made, however, it is important to evaluate the potential safety or ergonomics hazards that may be introduced by a new piece of equipment. Addressing the CTD problem becomes more difficult and less clear with less efficient machinery. Where equipment is not presently available or infeasible, job and/or tool redesign is the next choice. Can the work be repositioned to improve work tolerance and endurance? Can the job be done both seated and standing? Can a tool be used to reduce or eliminate the use of a bent wrist? Often the answer is yes. In the event that the answer is no or the changes do not impact the problem then all that remains in the decision-making process is how to administratively reduce the exposure (force and repetition). If there is a more effective less stressful way of working, job restructuring or methods training are possibilities but require vigilance by management and supervision. The least desirable yet often unavoidable option is to add individuals or decrease line speed to reduce repetition and the job work load.

**General Workstation Guidelines**

Table height and work height can cause workers to assume hunched posture or work with arms raised and extended. Trim tables and lay-on conveyors or the position of the work in general (e.g., gizzard pull back-up) should be configured to allow each individual to work with their elbows down close to the body. The most important recommendation here is that the work be arranged for elbow height for the tallest worker so that shorter individuals can be raised to the proper height with adjustable stands or platforms.

In the absence of specific anthropometric data, elbow height can be estimated using the approximation that it is sixty-three percent of stature. According to a 1971-1974 HEW civilian study, a tall male (95th percentile) is about 74 inches (in this study the tallest individual interviewed was 78 inches). Elbow height for this 95th percentile male is
.63 x 74 which is about 47 inches. In this example, work heights should be set within plus or minus two inches of this value (plus or minus four inches is used by many researchers). For precise work that is visually demanding, the upper value of 49 inches could be used (47 + 2). For most work the lower value of 45 inches could be used (47-2). If adjustable stands are to be designed, the

appropriate range of adjustability could be determined by comparing the elbow height of a small individual with our 95th percentile male. Elbow height for a 5th percentile female is approximately (.63 x 60) 38 inches. Therefore, the range of platform adjustability to accommodate 90 percent of the work population should be 9 inches (47 - 38) with one (not more than two) inch increments. A more exact method would be to go out into the plant and physically measure elbow height for the work population.

The other recommendation to help protect workers from stooping and reaching is to locate the work within 14 to 16 inches of the worker. Conveyors that are 42 inches wide are probably going to cause workers to reach outside this work envelope creating discomfort and pain to the back and shoulders of some individuals.

Jobs such as "breast filet trimming", "inspecting", and "filet lay-on" are prime candidates for sit-stand if forward reaches can be limited to the suggested range. There is also very littlereason why sit-stand should not be considered for many of the jobs along the evisceration line. Sit- stand will not only allow workers to alternate muscle groups creating a work-rest cycle but it could help to improve employee morale. Evisceration Department workers are reminded daily that chairs can be used in this environment. All they have to do is look at the USDA inspection stations.

**Job Rotation**

Based on the evaluation of the jobs in the Evisceration, Debone, and Cut-up Departments, an effective job rotation program to reduce exposure to the risk factors (force, repetition, posture) associated with cumulative trauma disorders will be difficult to design "within Department". The reasoning behind this assertion is that most jobs are highly repetitive and without knowing what a safe level is or what the force requirements of each job are, they must be classified in the same risk category. Going from jobs like "skin pull" to off-line "inspection" or conveyor "lay-on" operations would probably be an effective strategy if these less forceful jobs did not require the use of hand flexion, extension, or deviation. If a rotation scheme is developed it is important to document the jobs and include a justification of why the jobs were selected (this will require task analysis of each job).

One advantage of a structured rotation program is that if done frequently enough it could help minimize static loads on the leg muscles thereby increasing worker comfort and endurance. Further, if done at least once an hour it would provide a brief break from the hand intensive work (Eastman Kodak recommends a minimum of 5 minutes for each hour of repetitive work).

**Tool Sharpening**

The interview data shows that individuals who have their tool (knife and scissor) sharpened three times or less per day were more likely to classify the condition of the tool as "poor". Individuals with sharpeners at the workstation (e.g., mouse trap) and who use them regularly (average use at Plant B was 26 times per day per individual) were more likely to classify their tool in the "fair" or "good" categories. To fine tune the sharpening schedule for a particular tool will require regular feedback from the user population. If most perceive a particular schedule as less than adequate, then it should be increased. It is recommended that a new set of tools be provided to each workstation more than three times per day or shift. Individual sharpeners (e.g., steel or mouse trap) could be provided at each workstation as long as sufficient time is allowed for the sharpening process (i.e, the worker doe not get behind). The blades on pneumatic trimmers and neck cutters (as well as the saw blades),if in use, should also be put on a regular sharpening schedule.

In a few plants that have been evaluated in the past, many of the reported lacerations were inflicted by a neighbor located nearby. Therefore, adequate workspace must also be provided to help reduce this potential exposure. One anthropometric source ("Humanscale 7") recommends a dynamic workspace of 42 inches for a large male. Many plants have water stations available to remove fat from the tool handle to minimize the cutting effort. This is a sound work practice.

**Evisceration Department**

As noted in the results section, all jobs examined are repetitive involving low to moderate force and stressful postures. The impact of automation is an important factor that can definitely affect the work load of the "vent cutting", "drawing", "gizzard pulling", and "neck breaking" tasks. Equipment that is out of adjustment for a particular run (e.g., bird size varies greatly) or malfunctioning can cause workers at these positions to work faster and harder thereby increasing their exposure to CTDs. Consequently, it is very important to have trained maintenance staff available to quickly respond to any crisis. Moreover, utility workers should be available to help reduce the load at any point along the shackle conveyor. Equipment should be placed on a preventive maintenance program to help ensure that all systems operate as designed and when a problem arises it should be documented.

"Drawing or viscera presentation" continues to be a problem in the industry. Alternate presentation of the bird is a possibility that might reduce the amount of hand flexion and help accommodate the visual inspection process. Instead of drawing with the vent hole facing up the bird could be forced by a guide bar to rotate 90 degrees so the vent hole is facing the worker. The less desirable alternative is to reduce the repetition by adding workers to the line. Methods training to train workers to use both hands (alternating from one to the other) may also have application.

Vent cutting is a serious problem particularly when the opening machine is not operating properly. Generally, if the machine is missing more than 10 percent of the birds it should be carefully examined by qualified staff. Employees should be aware of the importance and immediately report any problems to their supervisor for action. Trained workers should be available at all times as a contingency. The repetitive use of scissors could be eased with the use of spring-loaded varieties to assist the hand opening operation. Evidently, not all commercially available scissors are up to this task. Specifically, one tool has been reported to fail with repeated use at this job. Expect to see a light weight pneumatic tool (less than 2 pounds) on the market soon. Other vent cutting power tools that have been seen are heavy and should be counter-balanced and evaluated from the standpoint of safety and vibration. The main safety consideration is the cut or amputation exposure. Power tools will most likely require employees to wear protective gloves. The other issue that needs to be addressed is the use of the "cut every bird" work method adopted by some employees. This procedure should be stopped to help reduce the stress on the dominant hand. Once a procedural policy is developed it should be reinforced with pertinent employees in a training session.

When going from a SIS (two inspector) to a NELS (three inspectors) inspection system the faster line speed could impact jobs that maintain the same labor. Although slight differences in body-part discomfort and the prevalence of CTDs were noted, an increase in problems under the NELS system is anticipated at jobs where the number of employees remains the same unless the equipment in use will be more efficient and produce fewer misses. Examples of the jobs that may fall within this category include: the "vent cutting back-up", "gizzard pull back-up", "house trimmer", and "salvage" jobs.

The foregoing concepts on workstation design have application in the "house" and "USDA trimming" operations. The trim table or tray needs to be raised as close to elbow height (for each individual) as possible without interfering with bird transfer. Right angle turns in the "salvage" line at each "trim" workstation is preferable to the traditional "behind the worker" location. However, the lateral location of the line should comply with the elbow height recommendation to minimize the static loading of the shoulder muscles. The location of parts and waste receptacles should also be given the same consideration. Knives with biocurved or pistol-shaped handles might help reduce the ulnar deviation associated with vertical downward cutting activities, as well.

Automation is available for the liver trimming operation. However, there are conflicting reports concerning the efficiency of this equipment. With head, neck, and back problems reported by the interviewees, "liver trimmers" should have their arms properly supported for the off-line trimming activity (i.e., activity after the first cut) so they can raise the work closer to the eyes. This could be done by providing a stainless steel rounded bar across the work space. To help reduce the pace, management and engineers should consider the practicality of having the entrails cut and transferred automatically to off-line trim tables (possible contamination will be a major concern with this recommendation).

**Breast Debone Operation**

Automated Breast debone equipment is presently available that will also remove and cut the wings. The reported yield is evidently better than the manual operation and the labor is reduced to five individuals (cone loader, shoulder cutter, and tender pull). Further, a breast skinning machine has recently been put on the market that would eliminate perhaps the most stressful job in the further processing operation. Plant B plans to purchase and install this equipment in the near future.

Knives with handles that reduce the amount of ulnar deviation are still a viable option in the industry. There are a wide variety of knives available on the market, from L-shaped knives to the biocurved variety. Much of the wrist ulnar deviation associated with the "first wing cut" or any vertical downward cut could probably be substantially reduced with the use of a pistol or biocurved knife.

The design of the "breast debone" conveyor line at Plant B will make it very difficult to use individual stands. This line was raised to accommodate the "front half" cone-line supply operation which is raised above floor level in the adjoining Breast Aging Department. With the guard rails along the length of the "debone" line work platform the introduction of individual stands could create serious egress and trip hazards. Raising the top rail along the first section of this line to the standard 42 inches will make it inaccessible to employees for sitting.

In the absence of automation there presently appears to be only two choices to reduce the stress associated with the various "meat and skin pull down" operations " (e.g., breast and back skin pull and filet and breast meat removal) particularly if there is a serious problem with CTDs. The first is to add labor to the problem job to proportionately reduce the hand activity. The other accomplishes the same thing through line speed reduction.

**Packing Operations**

By applying concepts of motion economy, energy conservation, and workstation design, much of the stress associated with packing activities could be minimized. This is another reason why it is so important for individuals involved in process matters and equipment lay-out to receive training in ergonomics. To eliminate the hand repetition associated with cut-up parts packing in the Cut-up Department will require automation. The amount of stress could be reduced by arranging the boxes just below conveyor height so parts could be selectively swept into the carton using gravity, not opposing it. A roller or ball surface table between raw material and finished product conveyors should also be provided to eliminate the need to lift the full carton from table to conveyor (a method observed being used by some packers).

To reduce excessive reaching and bring the parts closer to the packer, a deflector bar could be installed upstream from the task location so when the parts come in contact with it they will be forced closer to the worker. The other more expensive alternative would be to use a smaller width conveyor. Methods training focusing on avoiding wrist flexion and deviation and conserving strength might also help (as with most jobs).

The practice of applying downward force to the bagged whole bird or fryer to get a better fit (some sites refer to this activity as "leg breaking" and it occurs prior to bag clipping) has been shown to be associated with CTDs at other sites. This procedure was not used routinely at the plants involved in this study. Elimination of this potentially stressful task component might be accomplished with the use of autobagging or autopackaging equipment (e.g., shrink bag technology).

Scaling and weighing operations at other locations were found to be problems particularly where the pacing and rehandling of material (e.g., tray pack boxing operations) was excessive. An example would be handling tray packs or whole birds from conveyor to scale to a carton situated elsewhere. This activity often requires employees to lift the units from the supply conveyor and then lower them to the scale. Subsequently, the "weighed" units are lifted from the scale and lowered to a transfer conveyor located near-by. As with all operations, the workstation should be configured to take advantage of gravity and conserve strength and motion.

The activities associated with weighing cut-up parts cartons appeared to be fairly enriched. Overall, based on the observed hand activity this job would not be classified as high risk, even though it was associated with CTDs. Even so, there were some job components that if done frequently could substantially increase the effort and stress on the hands. The tape gun handle for example could be redesigned to allow the workers to assume a neutral wrist. It should also be counter-balanced to reduce the stress on the forearm and shoulders.

Gravity conveyor rollers should be checked to see if the effort to set the boxes in motion can be reduced. Perhaps a belt driven conveyor section or better use of gravity would facilitate the transfer process.

**Rehang and Live Hang Manual Transfer Operations**
Research and development to eliminate the manual transfer of birds from one conveyor system to another is needed after the chiller. Before this point an automatic transfer machine is available for transferring birds from one shackle line to another (i.e., kill to evisceration). After the chiller "rehang" is due to the temperature reduction process equipment (chiller) that requires the birds to be "knocked-off" the shackle conveyor prior to entry. Solving this problem is further complicated by the visual inspection (grading) component that is required at many transfer stations. Consequently, to eliminate the human element will require the development of a vision system that can detect defects and withstand the harsh environment of a poultry plant. This technology is a few years away but is under development at some universities. Another important question that needs to be addressed is can a chiller system be developed that will allow the use of the shackle conveyor (i.e., in-line chiller).

With the recurring problems at the Ice Pack (after chiller) and Cut-up Department "rehang" operations, the bird transfer rate for each individual needs to be carefully evaluated. If there is a CTD problem at one rate then consideration must be given to reducing that rate possibly by adding labor to the line or by balancing the hand activity. Obviously, if a problem persists at the new level despite any ergonomic modifications, this level of activity should be further reduced.

The lifting distance to the shackle from the storage bin or conveyor should not exceed 10 to 11 inches for most rehang operations. For live hang this distance is increased to 15 inches to account for the bird head and neck. To reduce forward stooping, the location of the birds on the conveyor or bin should be at elbow height for the workers and the conveyor or bin be modified to restrict forward reaches to 14 to 16 inches.

**Cut-up Department Saw Operations**

As mentioned before, there are automated systems that can do the cut-up parts operations. But even these require at least one person to load the machine, an activity similar to rehang. A system needs to be designed that will transfer the bird directly from the shackle to machine.

It is recommended that the birds be delivered to the "saw tenders" off-shackle. Perhaps a knock-off could be installed that will drop or remove the appropriate number of birds from the shackle to evenly distribute the work load (balance the line). If the birds are delivered at the height of the work this could substantially reduce the amount of reaching and working against gravity.

According to Plant B personnel, an automatic pneumatic bagging system is available that would eliminate the dangerous work practice associated with the manual handling of the bags (empty and full) to and from the saws. Eliminating the stooping activity will definitely increase work tolerance and endurance at these jobs. Until a system can be identified workers should be encouraged to keep their backs straight and bend the knees to complete this task. It should also be possible to simply drop the bag to the conveyor instead of raising it than throwing or tossing it to the conveyor.

A similar job that was not evaluated due to the absence of CTDs (at the study sites) is the breast processing machine operation. This job requires the operator to grab the whole bird on the shackle and pull the "front half" across a stationary blade. The "front half" is then lowered to the feed section and the machine is actuated. Overall the work load and hand activity are high ( operators at other plants that have been examined handled between 15 to 25 bpm). A device is available for deshackling and feeding the "back half" (i.e., leg quarters) to the leg and thigh processing machine but not for this machine. Until the technology is developed, the feasibility of automatically cutting and delivering the "front halves" off-shackle should be explored by process management.

**Material Handling**

As discussed in the medical section, there were very few back injuries reported in the Shipping and Aging Departments perhaps due to a self-selection process (the high turn-over in both departments supports this theory). The "carton stack-off" job in the Shipping Department has been a problem for many companies. Only a few have installed scissors lifts to keep the work at the level of the conveyor or work area. Eliminating the lift/lower component by this means could significantly increase the acceptability of the jobs. Plant B has plans to install scissors lifts for this reason. Other mechanical aids that are available include pallet turn tables (so worker does not have to reach across pallet) and mechanical and vacuum hoists. Since the carton dimensions vary slightly many operations could be automated.

Limiting the stack height and locating the pallets at least twenty inches above floor level could also help improve the acceptability of these jobs. Employee training as prescribed by NIOSH in what postures to avoid is recommended but the use of back belts has not been proven effective in eliminating or reducing the risk to injury. Reducing container size and weight or instructing workers to use a two person could reduce employee exposure to back injuries. This information could also be applied to most line supply jobs that have similar task components (e.g., working to or from a pallet).

## INDUSTRIAL HYGIENE

### Noise

Both plants had existing hearing conservation programs for workers exposed to noise levels above 85 dBA. The data presented here indicate that the program needs to be extended to cover nearly all employees in Plant B, including specifically those employees in the Debone Department. The program appeared to work well in both plants in identifying those individuals who showed early signs of hearing loss. A deficiency in both plants involves the use of hearing protection, typically ear plugs. Enforcement of use of these devices was incomplete in both plants, and in some cases, employees wore them incorrectly. In short, further training and enforcement efforts are needed in both plants. This problem is present throughout not only the poultry industry, but many other high noise industries. Those plants with the most effective hearing conservation programs combine thorough educational programs on why hearing protectors are necessary with disciplinary procedures aimed at encouraging everyone to wear hearing protectors whenever they enter a high noise area.

Neither plant had a long-term noise abatement program, as required in the OSHA noise standard. Such a program includes an on-going effort to research and develop feasible engineering controls to reduce noise at its source. Further research in this area is needed. Implementation of these engineering measures can be phased in over a number of years in order to minimize the financial impact.

Examples of such measures in the poultry industry include greater use of heavy leaded vinyl curtains around final control machines in the eviscerating areas, use of vibration isolators and noise absorbing materials for fans, coating of vibrating metal surfaces (for example, water ice chutes in the debone departments) with water-proof vibration damping materials, and use of partial or full noise enclosures for compressors, and other noise-producing machinery.

The noise abatement plan should be in writing, and sufficient staff time should be allocated to examining the numerous materials and methods now on the market.

A sound preventive maintenance program will also help reduce noise exposures. The bad fan bearings and missing compressed air exhaust mufflers identified above could have been corrected by an aggressive preventive maintenance program. Obviously, machinery which is not properly maintained tends to produce high noise levels.

**Dust**
Dust exposures in the Live Hang areas obviously cannot be completely eliminated. However, the use of more local exhaust ventilation should reduce exposures dramatically. Such a system would consist of a slot hood design placed immediately behind the bird hanging hooks. If the capture velocity is chosen correctly, most of the dust could be pulled away from the workers' breathing zones. The existing dilution ventilation systems should be retained and repaired to augment this proposed local exhaust system. Further air sampling would be needed to determine how well the system works in reducing dust exposures.

Until further data are available, the cooling fans located in the work area should also be retained. The possibility of heat stress appears to be significant, and in spite of the fan's probable adverse affect on turbulence and exhaust system efficiency, a well-designed exhaust system should be able to overcome room air turbulence sufficiently to reduce exposures below exposure limits. Ideally, this room should be air-conditioned; this would reduce the heat stress and eliminated the use of turbulent fans. Since cool contaminated air is already exhausted from the stack-off room in Plant B, another option would be to use an air-to-air heat exchanger. This would allow cool, clean air extracted from the stack-off area to be supplied to the live hang area without paying for increased cooling capacity.

The extent of heat stress in this area should be measured during the hot summer months with device capable of measuring the Wet Bulb-Globe Temperature Index, which can be compared to the Threshold Limit Value for heat stress.

Another possible way to reduce dust exposures is by wetting down the birds before they are hung on the conveyor. This method has reduced dust exposures in many industries. It may have the disadvantage of making the birds more difficult to grasp.

**Carbon Dioxide**
Carbon dioxide exposures appear to be producing adverse health effects throughout the poultry industry. In many cases, this is due to the shift towards dry ice away from water ice. As the industry makes this change, control technology does not appear to have kept pace.

Additional research is needed to determine if other methods of achieving a deep rapid freeze can be substituted for dry ice. This may include blast tunnels using very cold air or liquid nitrogen, together with improved insulated packaging. The product could be frozen rapidly, and then held in a cold environment before being shipped. This will involve tighter control of freezer conditions, but the cost savings in reduced use of carbon dioxide, reduced energy costs caused by the need to ventilate coolers, and reduced costs in monitoring and installing alarm systems (not to mention the potentially severe costs incurred by worker injury from carbon dioxide poisoning), would appear to be substantial. Further research is needed to determine the feasibility of process substitution for dry ice use in the poultry processing industry.

Until these alternatives can be substantiated, additional exhaust ventilation and better containment measures will be necessary. The data reported here show that both top and bottom exhaust ventilation is needed for dry ice delivery machines. This makes sense when one considers the fact that carbon dioxide vapors will tend to settle towards the floor due to thermal effects.

Hanging plastic curtains from the sides of the machines would provide a simple means of providing a greater degree of enclosure, and would also boost the capture velocity of the existing systems. Of course, the plastic skirts would need to be capable of withstanding cold temperatures without cracking or deteriorating. These results suggest that fans capable of moving at least 2,000 cfm at the point of dry ice delivery are needed for each machine. Selection of the proper fan size would need to include static pressure drops resulting from the hood entry loss, length of ductwork, number and type of duct elbows, duct configuration, and exhaust stack design. Ideally, no visible emissions should be seen during charging of dry ice into poultry packages. The present level of ventilation in both plants is not sufficient to meet the TLV of 5,000 ppm. Specifications for the exhaust fan size should be developed by a qualified ventilation engineer or industrial hygienist.

In addition, the practice of using two exhaust fans mounted in a "T" configuration above the carbon dioxide machines is clearly an inefficient one. Essentially, the two fans work against each other. This should be replaced by a single fan mounted on the roof, so that all ductwork remains under negative pressure with respect to the workroom. Branch ducts entering main ducts should be tapered at 30 degree angles, and all duct connections should be airtight. Ductwork in both plants studied here had significant leaks.

Ventilation of stack-off areas and holding coolers will also be required. Since extremely high exposures remain a distinct possibility in both areas, alarm systems should be considered an essential piece of equipment. Proper periodic calibration of these air sampling devices is critical in ensuring reliable operation. Waiting for workers to complain means that we are essentially using people as detectors. In some sensitive individuals, this practice is unlikely to provide a sufficient margin of safety. Training of all workers is essential, and should be integrated into existing hazard communication programs. Workers should be able to recognize the early warning signs of carbon dioxide poisoning in themselves and in others. When such symptoms appear, management must take immediate steps to ventilate relatively confined spaces.

A comparison of the two plants shows that installing even a modest exhaust ventilation system for the stack-off area is successful in reducing exposures considerably. Depending upon production levels, slightly more than the 1300 cfm being exhausted in Plant B is needed to keep exposures below 5,000 ppm.

Repeated air sampling after improvements in existing exhaust ventilation systems should be performed to quantify the degree of improvement achieved.

**Ammonia**
Hazard communication training is a clear weakness throughout the industry. In particular, many workers did not appear to have a good grasp of how rapidly ammonia can overcome workers. Indeed, several supervisory and managerial personnel treated the subject of ammonia poisoning with a cavalier attitude, assuming that escape would always be possible. The same response can be seen in the understanding of carbon dioxide toxicity, which at least a few workers regarded as an "inert" substance. Training in toxic chemicals should emphasize not only the potential hazards associated with exposure, but also the importance of using proper control techniques, whether it be maintaining exhaust ventilation, or proper use of respirators.

All individuals who may be required to wear respirators into atmospheres with high levels of ammonia should be fit tested quantitatively several times each year. Additionally, someone should be assigned the responsibility of maintaining ammonia respirator canisters so that in the unfortunate event they are needed, they will operate as expected. A regular inspection program for respirators can be organized in much the same manner as routine checks of fire extinguishers are performed.

All ammonia leaks should be regarded as potentially serious events; they should be repaired promptly. Whenever maintenance personnel expect to release quantities of ammonia from enclosed refrigeration systems, they should don proper respirators to protect themselves from the possibility that a large leak (e.g. valve failure) should occur.

Finally, the feasibility of installing ammonia alarm systems in confined areas (such as closed door freezers) should be examined further. Such a system would warn of the presence of a large leak before a worker contacts an injurious and possibly fatal atmosphere.

Ammonia leaks represent one of the most difficult occupational health hazards to control; essentially, they are low probability/high risk events. Large leaks may be relatively rare, but the consequences can be especially severe.

Appendix I provides the essential elements of OSHA's respirator program. The program should include all types of respirators, from self-contained breathing apparatus to canister-type gas masks to dust masks.

**Storage of Chemicals**
This report identified several instances of storage of incompatible chemicals in close proximity to each other. Chlorine-containing products, such as disinfectants and bleach, must never be stored near caustic or basic chemicals. Cyanide salts should not be stored near acids. Formaldehyde should never be stored near hydrochloric acid. Large quantities of organic chemicals should be stored only in well-ventilated areas and hazardous wastes must be properly labelled. In most cases, proper storage and use directions can be found on either the label or the Material Safety Data Sheet for each

product.

A specific individual in each plant should be charged with the responsibility to ensure that all MSDSs are reviewed, that all containers on site are labelled properly, and that storage and use practices conform to those recommended.

**Formaldehyde Exposures in Hatcheries**

Better containment of formaldehyde can be achieved by using a more air-tight hatcher design. Doors should have gaskets which seal well, especially on the floor. Exhaust systems should not recirculate back into the work area.

The feasibility of using a remote delivery system should be examined. This rather simple method involves mounting a sealed gallon container of formaldehyde above each hatcher. The container is fitted with a hand pump and a hose which delivers a measured amount of formaldehyde into each hatcher. Another possibility involves a continuous feed of formaldehyde solution into the hatcher. In both systems, we have a fully-contained system, and if the hatchers are fully sealed, there should be virtually no human exposure. The necessity to pour formaldehyde solution into a measuring cup, and then pour it into an egg shell holder is completely eliminated. It would also greatly reduce the injury which may occur from spilling or splashing the chemical. Since formaldehyde is a cancer-causing substance, it is unlikely that any completely "safe" exposure level will ever be established.

Research into possible alternatives, such as ozone and quaternary ammonia compounds, is also needed. However, since these substances are biocides of one sort or another, they are all likely to exhibit varying degrees of toxicity in humans.

## FUTURE CONSIDERATIONS

Looking to the future, more research is clearly needed to establish the impact of ergonomic control technologies on the incidence of workplace CTDs. This should not, however, diminish the positive results of the industry case studies reported through the industry task force and from the experiences of researchers at Georgia Tech. Moreover, additional research is needed in the field of epidemiology to firmly establish cause and effect of the various CTDs in general and carpal tunnel syndrome specifically as well as to gain a valid assessment of the distribution of these disorders in industry.

Although only speculation at this point, there appears to be a susceptible population of individuals since some workers do not appear to develop Carpal Tunnel Syndrome (CTS) even though they occupy "high risk" jobs. Consequently, this points the research need in the direction of developing screening methods to help reliably identify this possible subpopulation. Nerve conductivity and electromyography (EMG) show promise but may require years of testing before their applicability and validity are determined.

Many of the middle-sized and small processors that have been evaluated in the past do not have the main components of an effective CTD prevention or intervention program in place. In most cases, the Medical, Ergonomics, and Training (MET) program has not reached the right individuals who might be able to create the organizational and administrative atmosphere to implement an effective program. The tact for many companies is to use consultants to address the problems. At best this is only a temporary solution unless the consultant is retained throughout the recognition, evaluation, and control process or there is someone within the organization who has a working knowledge of ergonomics. For the sake of continuity and efficiency it would be beneficial to send an engineer or someone else who understands the process flow to a week (or more) long training course modeled after the University of Michigan's Center for Ergonomics course. Since ergonomics is so closely tied to the process flow having someone knowledgeable in both areas will be a clear advantage in the prevention of CTDs.

The results of this study demonstrate the need for more directed research in developing automation that can reduce the use of labor that often acts as an extension of or back-up to a machine or as a transfer mechanism. While new equipment developments continue to surface in the areas of automatic transfer and deboning more work is needed in developing new flexible and intelligent automated systems. Research institutions and equipment manufacturers need to work together to develop and apply advanced manufacturing technology (e.g., vision, robotics, automated guided vehicle, computer technologies) to the poultry industry environment. With automatic feedback control more is possible with technology than has been accomplished thus far. Equipment manufacturers also need to become sensitive in the design and installation of their devises so they do not create a new or similar hazard not only at the point of operation, but up or down stream of the operation as well.

The issue of the human as a back-up or extension of new equipment has been one focus of this report. An additional human factors concern which did not receive the attention of the study team is the relationship between defect detection and line speed or machine-paced work. Even with adequate labor to minimize and optimize the work load and pace, individuals involved in the myriad of inspection activities must still visually scan the bird, identify defects, and make required modifications or decide on its removal. As the line speed increases what happens to the observation window? In theory at least, it becomes smaller. One symptom of the "reduced opportunity" phenomenon is the up-stream and down-stream reaching activity used by some employees to either stay ahead or catch-up. This possible incompatibility warrants investigation.

Debeak and vaccination operations within the Hatchery have been linked to CTDs in other studies. One possible contributing factor is the commonly used incentive based wage system that encourages employees to work at a fast pace. The possible relationship between CTDs and the payment system needs to be examined from an ergonomic and organizational standpoint. Furthermore, heat stress and the possible exposure to biological agents in the Live Hang area are also topics which need to be further addressed in the future.

In closing, the use of dry ice, ammonia ,and formaldehyde and the presence of silica dust and high noise could create serious and ,in some cases, life threatening exposures if they are not adequately addressed in a safety and health program. Hazard communication and emergency response are still important issues that should not take a back seat to ergonomic concerns. Instead, a total systems approach needs to be taken in the recognition, evaluation and control of all stressors and hazards.

# APPENDICES

Appendices not available in this electronic version of the report.