CASE STUDY #2

The Setting

This study involved two components. One was the description of a corporate ergonomics program and assessment of this program's effectiveness. The second part was a demonstration project that examined the activities and performance of two ergonomics teams in a single plant of the corporation.

The Corporation: The corporation and its subsidiaries manufacture, market, and distribute thousands of products, principally fresh, frozen, smoked, cooked, and canned processed meats. These products include sausages, hams, wieners, bacon, canned luncheon meats, shelf-stable microwavable entrees, stews, chilies, hash, meat spreads, and frozen processed products. The corporation's meat and food products manufacturing facilities are located in Iowa, Minnesota, Wisconsin, Texas, Oklahoma, California, Georgia, and Kansas. Internationally, the corporation has operations in the Philippines, Japan, Korea, England, and other European countries.

Corporation employees first organized as a union in 1933. The name of the union changed over the years as a result of affiliations and mergers, but since the late 1970s, the plant workers have been represented by the United Food and Commercial Workers Union (UFCW), AFL-CIO.

In terms of employee benefits, the company established a guaranteed annual wage for its production workers in 1933. This program guarantees all workers a minimum annual wage based on 36 hours per week, even if the actual number of hours worked is less. This plan also guarantees that workers will receive these wages for the 52 weeks following notification of a plant closing. The company established a Joint Earnings Plan, a profit sharing plan for all employees, in 1938. This plan is guaranteed and allows workers with 30 years of seniority, regardless of age, to retire with no reduction in benefits. For years, an incentive system was used to determine worker wages, but in 1978, the corporation and the UFCW reached agreement that led to the ultimate discontinuance of the incentive pay system that had been in effect for 41 years for union workers.

The Plant: The corporation purchased this plant in 1947. At that time, the plant slaughtered and processed beef. The following year, the operations expanded to include pork. In 1977, the plant discontinued its beef operations and since then, the plant operations only include the slaughtering and processing of pork.

This plant has experienced two notices of plant closings (Local Secretary-Treasurer, UFCW, 1993). The first occurred in 1981, shortly after another, newly renovated corporate facility opened. The plant operations were continued when it was agreed to phase out the incentive wage system over the next three years. The plant received another notification of closing in 1988. The closing was limited to the Kill and Cut departments and would have affected 325 production workers. This closing was avoided when a split wage system (one wage scale for slaughterhouse workers and another for the processing workers) was accepted for the slaughtering operations workers.

There are currently approximately 930 workers of whom 830 are production workers. Approximately 778 of these production workers are represented by the United Food and Commercial Workers (UFCW) (Local Secretary-Treasurer, UFCW, 1993). Since the plant has recently hired new workers, not all are currently eligible to join the union. Aside from wages and the wage guarantee plan, union workers at the corporation also receive a full package of health care benefits, the guaranteed pension plan, sick leave benefits, long-term disability benefits, and are covered by a transfer agreement. There have been no strikes at this plant.

This plant is in the midst of a major renovation project. The Kill Department started installing new lines in September 1993. Its renovation should be completed by late 1994. Renovation work related to the Cut Department is scheduled to start in 1994 and to continue into 1995. Many changes related to the ergonomics teams' activities, especially design and layout changes, are scheduled for implementation during the renovation.

In 1985, the line speed of this plant was 625 hogs per hour. The line speed increased to 685 in August 1987, followed by another increase to 711 in April 1988. The speed increased again in September 1988 to 726, then to 741 in September 1990, and increased to 747 in August 1991 before reaching its current rate, 762, in November 1991. Post-renovation, the plant hopes to have the ability to process 1,000 hogs per hour, but no timeline for reaching this goal has been established.

PRE-EXISTING LEVEL OF ERGONOMIC CONCERNS/ EFFORTS

The Corporate Ergonomics Program

The corporation began development and implementation of its ergonomics program in 1986. OSHA citations of other red meatpackers and the resulting media attention, as well as a corporate evaluation of workers' compensation costs contributed to the company's awareness of the need for an ergonomics program.

The proposed goal of the program was to: "Establish a company-wide employee-involved continuing program to: reduce the amount of physical stress in the workplace; prevent internal damage to the body; and reduce the cost of work-related injuries and illnesses."

This program was developed primarily by a Corporate Ergonomics Coordinator, an industrial engineer with more than 45 years experience in meatpacking and the processing of pork. Organizationally, he is in the Corporate Operations and Engineering Group. He gained knowledge about ergonomics primarily through industrial engineering methods and layout work, short courses (including the OSHA five-day ergonomics course), and readings. Even though the corporation started developing their program in the mid-1980s, the OSHA Ergonomics Program Management Guidelines for Meatpacking Plants was used as a template for the formal written corporate program. The major reason for this latter choice was the desire to parallel OSHA's format.

In terms of structure, the corporation uses a Corporate Steering Committee to authorize, guide, and support all ergonomics-related activities. The members of this committee include the Vice President for Engineering, the Corporate Counsel, the Vice President of Beef and Pork Operations, the Director of Industrial Engineering, Corporate Safety and Security Manager, the Group Vice President for Operations, and the Corporate Ergonomics Coordinator. The Corporate Steering Committee communicates to individual ergonomics committees within each plant through plant managers. This is done to ensure supervisory as well as employee participation.

The corporation cites four advantages of corporate coordination:

1. It ensures the placement of proper priorities;
2. It facilitates the authorization of resources;
3. It provides a source of motivation for compliance; and
4. It facilitates the sharing of ideas and solutions.

Even though the Corporate Ergonomics Program started in 1986, the written program was not completed, approved, printed, and distributed until July 21, 1992. This written program was communicated to all company personnel.

The following sections summarize the highlights of the corporation's ergonomics program. This information was primarily obtained by review of the written program and discussions with the Corporate Ergonomics Coordinator.

Management Commitment

In 1986, the Chairman, the President, and the Chief Executive Officer of the corporation formalized the company's policy on the issues of safety, health, and ergonomics. This Safety, Health, and Ergonomics Policy focuses on four key elements:

1. Concern about employees' continued health and safety;
2. Commitment to the implementation and maintenance of effective safety, health, and ergonomics programs

and to the promotion of these programs through employee participation, awareness and education;
3. Through each plant's established committees and programs on safety, health, and ergonomics, the employees are encouraged to participate and provide input to develop and maintain a safe and effective workplace; and
4. The safety, health, and ergonomics programs are, and must continue to be, an integral part of all of the corporations operations.

Employee Involvement

The corporation's methods to achieve employee involvement include:

- the use of employee surveys, questionnaires, and suggestion procedures in a spirit of cooperation and mutual benefit;
- the use of procedures that endorse prompt and accurate reporting of signs and symptoms (use of an educational videotape and booklet about signs and symptoms, ergonomics, and participation; an encouraging letter from the Corporate Steering Committee; and re-emphasis during the training program);
- interaction with other quality, safety, and health committees; and
- training for all members of each ergonomics committee to develop ergonomic skills (this training is coordinated and given by the Corporate Ergonomics Coordinator).

Program Elements

The corporation's Ergonomics Program closely parallels the OSHA Meatpacking Guidelines. There are four major sections: Workplace analysis; Hazard correction, prevention, and control; Medical management; and Training and education.

Workplace Analysis: The corporation uses its own forms and checklists, injury/illness data, and workers' compensation expense data to target jobs for more detailed analysis. Aside from identifying existing problems (retrospective intervention), this method also allows the ergonomics committees to become involved in planned changes, such as new facilities, processes, materials, and/or equipment (prospective intervention and design). This analysis method also helps the committees identify potential light duty jobs and jobs without apparent hazard. Analysis of these latter jobs (those without apparent hazard) can be deferred to a later time (assigned low priority for committee effort).

Hazard Correction, Prevention, and Control: The corporation uses the following procedure for hazard correction:

1. Targeted corrections are listed;
2. Priorities for corrections are established;
3. Individual assignments are made (*e.g.*, the industrial engineer is to contact a manufacturer to obtain some equipment within one week);
4. Action is initiated;
5. Progress is monitored;
6. Problems that arise are solved;
7. Accomplishments are recorded;
8. Corrected status is maintained; and
9. Successes are shared with other corporate plants.

In terms of prevention and control, the corporation relies on the four traditional techniques of exposure control: engineering techniques, work practice controls, personal protective equipment, and administrative controls. The corporation prefers engineering solutions and believes that engineering techniques are best done during design or modification of work stations, work methods, or tools. Work practice controls include items such as appropriate employee training on work technique, tool care (*e.g.*, knife sharpening), proper body mechanics, proper use and maintenance of power tools, and correct use of ergonomically designed and/or adjustable work stations. Included under the category of personal protective equipment are safety glasses, helmets, ear protection, gloves, guards, shields, shoes, harnesses, tethers, aprons, scabbards, etc. The corporation has struggled with the issue of personal protective equipment in the context of ergonomics. At this time, it does not mandate the use of back belts or hand/wrist supports as personal protective equipment unless prescribed by medical authorities or specifically requested by an employee. In terms of administrative controls, the corporation applies the following techniques:

- monitoring of machine use and line speed to determine if job demands are compatible with current staffing;
- making and checking for provisions for scheduled rest pauses;
- balancing manpower to expected production;
- ensuring proper job rotation;
- developing and implementing job enlargement;
- ensuring preventive and regular maintenance of equipment;
- a knife sharpening program;
- effective housekeeping and cleanup; and
- avoiding negative environmental factors.

Medical Management: The medical management component of the corporation's Ergonomics Program is defined or summarized as:

> *"a conscientious attempt to eliminate the risk of development of cumulative trauma disorder signs and symptoms through early identification and treatment and to the prevention of future problems."*

This provision of their ergonomics program includes the availability of first aid and nearby physician and emergency medical care. In terms of specific medical management issues, the following items are specifically addressed:

- accurate record keeping;
- facilitated early recognition and reporting;
- systematic evaluation, treatment, and referral;
- preference for conservative treatment;
- pre-surgical second opinions;
- conservative return-to-work plans;
- systematic monitoring of affected workers (*e.g.*, break-in time and/or work hardening);
- adequate staffing, training, and facilities for medical care; and
- no standardized treatment procedures.

Training and Education: The purpose of the corporation's training and education efforts are to ensure that employees are sufficiently informed about ergonomics principles and injury prevention to be able to actively participate in the corporation's ergonomics efforts. In addition, the training incorporates topics about how employees can participate in the program. The training audience includes all hourly employees (plant and office), engineering and maintenance personnel, supervision, management, and health care providers in all plants. The training is presented in language at an appropriate level of understanding for the target audience. Topics include proper and safe work methods, the physiology and symptoms of cumulative trauma disorders, and means of prevention, coping, or treatment. The training program also includes some measures of training effectiveness (interviews, testing, and observation). Most training topics are generic, but some job-specific training is also incorporated.

Implementation

Since the corporation's ergonomics program has been operating for several years, a certain methodological pattern has emerged in terms of implementation. In general, the Corporate Ergonomics Coordinator first examines the injury investigation reports for a plant or a specific department within a plant. These reports are used to target specific jobs for evaluation. The next step is a Safety and Ergonomics Survey. This survey, completed by all workers performing all jobs in the plant, asks about the presence of symptoms (lasting aches or sore spots), the perceived cause of these symptoms, the comfort of the workstation, the comfort of tools (if any), miscellaneous questions related to the way the job is performed (*e.g.*, lifting, lighting, pushing, pulling, posture, footing, noise, reach envelope) and other safety-related issues. The responses for each Safety and Ergonomics Survey are reviewed by the industrial engineer assigned to the department. Obvious hazards are addressed immediately. Other identified or suggested problems, such as the presence of musculoskeletal risk factors, are marked for special study. The results of the survey and any corrective actions are communicated to the Corporate Ergonomics Coordinator.

The next step in the methodology is to prepare supervisors and workers at the plant for upcoming study of the ergonomics-related problems identified in the survey. These activities are done by ergonomics teams composed of representatives from production workers, clerical workers, management, supervision, mechanics, and engineers. In general, the production and clerical workers are volunteers that, if represented by a union, would either be selected or endorsed by the union. The committees are structured so that the number of worker and management representatives are balanced. All members of the ergonomics teams are trained by the Corporate Ergonomics Coordinator. This training includes information related to musculoskeletal risk factors, musculoskeletal disorders, and teamwork. Training materials include some didactic material plus a variety of videotapes, booklets, and prepared educational materials that are selected according to the needs of the target audience. Upon completion, each member of the team receives a membership card listing the goals of the program on one side and summarizing a brief list of ergonomic "rules of thumb" on the other. To date, this training has been given to over 5,000 plant employees participating on ergonomics teams. This includes office ergonomics training for over 45 quality groups in the corporation's offices (over 600 people).

Each ergonomics team studies each job in its department using assessment tools developed by the corporation, *i.e.*, a Cumulative Trauma Disorder (CTD) Risk Factor Checklist and a Job Analysis Checklist. The CTD Risk Factor Checklist inquires about the presence of generic risk factors for upper extremity disorders as well as postural stability, unaccustomed activity, work pace, and selected personal characteristics. The Job Analysis Checklist is a one-page checklist that asks about risk factors related to the torso, the hands, the wrists, and the environment in general. This checklist is also being developed so it can be matched to a worker capability assessment, completed by health care providers, to optimize matching of worker capabilities to job demands, especially for workers returning after injury with limited capabilities.

In addition to the assimilation of data from the Safety and Ergonomics Survey, the CTD Risk Factor Checklist, and the Job Analysis Checklist, the ergonomics teams also meet with the workers performing the jobs. One result of this project has been the development of a new worker feedback form. Using the worker feedback form as a guide, one or more team members discuss an individual job and its effects on each worker individually. Following this data collection process, the ergonomic teams summarize their findings, brainstorm possible solutions (*e.g.*, new ideas, new opportunities to apply old ideas or interventions from other facilities), and discuss potential problems associated with the proposed solutions. After the teams reach consensus on the recommended interventions, implementation is discussed with supervisors and their findings documented in writing.

Prior to submitting a recommendation for change to management, the ergonomics teams use a checklist for ergonomic safety and efficiency as an additional level of assessment of the intervention. The topics of this checklist include assessment of effects on the following:

- efficiency and/or productivity;
- future productivity potential;
- job simplification;
- safety;

- improved morale;
- proper environmental parameters; and
- consistency with existing ergonomic recommendations for job design.

The checklist also includes spaces for reviewer recommendations and comments. The checklist is presented to the plant manager and, when approved, referred to the Corporate Engineering Group for consideration. The Corporate Engineering Group reviews the ergonomics team's findings, obtains clarification of any obscure or confusing findings, and prioritizes the recommended interventions. The team leader of each ergonomics committee, usually an industrial engineer, works with the Corporate Engineering Group to sort, assign, and schedule follow-up evaluation. As needed, the teams and/or the Corporate Engineering Group obtains assistance related to design, drafting, ordering, and/or installing new equipment. They may also need assistance in obtaining appropriate approvals (*e.g.*, from the United States Department of Agriculture) and obtaining appropriated funds. All negative comments related to this checklist must be addressed before the plans for intervention are considered acceptable.

When necessary, an ergonomics team can use a task force approach that incorporates a larger scope of human resources at the plant. The ergonomics teams also revisit prior interventions to follow-up on their effectiveness and review new or proposed workstations or operations. The teams also assess and/or monitor all new installations or modifications at the plant to ensure "ergonomic correctness." This may involve administration of one or more of the checklists. Finally, the teams provide information and success stories to corporate headquarters for distribution to other plants.

Communication

Each ergonomics team submits a monthly status report. This report is organized as a standardized agenda to be used for an ergonomics team's monthly meeting. The agenda includes the following items:

- a review of the previous month's injuries, their implications, and related action plans;
- a review of ergonomically-related workers' compensation and medical costs;
- an update of corporate audit progress;
- old plant recommendations;
- new plant recommendations;
- ideas and successes that should be shared with other facilities;
- special topics;
- a review of ergonomic checklists associated with changes that need to be made or have been proposed;
- a review and forwarding of any Safety/Ergonomics Surveys that have been filled out by employees who have performed a new job after three months; and
- any listed suggestions to improve the Ergonomics Program.

At the corporate level, these monthly reports (from all ergonomics teams in all plants within the corporation) are reviewed by the Industrial Engineering Manager and the Corporate Ergonomics Coordinator. This allows them to monitor each plant's or team's activity and progress. Since 1988, the corporation has published a quarterly newsletter entitled "What's New in Ergonomics." The purpose of this newsletter is to communicate news related to ergonomics, report on the status of the ergonomics program, serve as a reminder so that heightened awareness is maintained, and share the experiences of individual ergonomics teams. The newsletter is distributed to all plant managers and all plant ergonomics teams, and team leaders. In general, the plant managers route the newsletter to all superintendents. The list of topics can be quite varied.

Summary

The corporation implemented their Ergonomics Program in 1986. The structure of the program is consistent with the OSHA guidelines for this industry. A Corporate Ergonomics Coordinator oversees, tracks, and audits the activities of ergonomics teams within each plant. A variety of forms and checklists are utilized to identify musculoskeletal and safety-related risk factors for injury. Parts of these forms also serve as a source of information on employee symptoms. Overall, the ergonomics program of the corporation is characterized by comprehensive scope, structure, and communication.

ERGONOMICS AT THE PLANT

This plant was one of the first sites to implement the corporation's ergonomics program. Activities started around 1986-1987. Organizationally, there is one ergonomics committee that oversees ergonomics activities at the entire plant though each department may have its own ergonomics team that is accountable to the

Department	Number of Job Changes
Bacon Slice	15
Bacon Slice/PFLM	1
Edible Rendering	1
Fresh Sausage	1
G.P.Can Meat	5
Ham Bone	7
Hog Cut	30
Hog Kill	37
Inedible Rendering	1
Market Ship	2
Office	7
Plant	7
Preparation Sausage Manufacturing	6
Quality Control	5
Sliced Smoked Meat	2
Smoked Meats Packing	6
Smokehouse	3
Smokehouse/Cure	1
Storeroom	2
Vat/Trolley Wash	2
Total	141

Table 1. Number of ergonomics interventions made by the plants ergonomics committee according to department.

plant's ergonomics committee. The current ergonomics committee meets twice a month using the corporate program's agenda. The eleven-member committee includes: one production worker, one office worker, one union steward, two maintenance engineers, three industrial engineers, one production supervisor, the personnel/safety coordinator, and the nurse.

Year	Number of Job Changes
1986	2
1987	1
1988	1
1989	7
1990	20
1991	24
1992	54
1993	26
ongoing	3
no completion date	3
Total	141

Table 2. Number of ergonomics interventions made by the plant's ergonomics committee by year of completion.

The ergonomics committee and teams at this plant have been quite active. Tables 1 and 2 summarize the number of projects completed or in progress by department and year, respectively.

SCOPE/OBJECTIVES OF DEMONSTRATION PROJECT

The demonstration project involved working with two ergonomics teams at the plant, a Kill Department team and a Cut Department team, to analyze targeted jobs. The targeted jobs were selected based on previous Safety and Ergonomics Surveys and other analyses (*e.g.*, expensive compensable injuries or high turnover rates) that suggested they were problematic. In addition, none of these jobs had obvious solutions. Both ergonomics teams were charged to analyze these jobs, identify the source(s) of the problems, and develop, recommend, and implement appropriate interventions.

METHODS AND OPERATIONAL PROCEDURES

Team Formation/Member Selection

The Kill Department ergonomics team consisted of three production workers, a supervisor, one of the industrial engineers assigned to the Kill Department, the Corporate Ergonomics Coordinator, and the investigators. The Cut Department's ergonomics team was similar to the Kill Department's team except that the Cut Department had two production workers instead of three. The plant's Manager of Industrial Engineering, the plant Maintenance Engineer, and the most senior industrial engineer of the department also often attended the teams' meetings.

Team Training

The project started with a meeting at the plant. The purpose of the meeting was to clarify the scope and purpose of the project from all perspectives — the management, the union, and the investigators. This was followed by a training session for the ergonomics team members. The training curriculum, delivered by the investigators, included an overview of the demonstration project; the epidemiology, etiology, and development of low-back pain; the epidemiology, etiology, and development of upper extremity disorders; and an approach to solving ergonomics-related problems, including participatory problem-solving techniques. The audience included production workers, supervisors, maintenance personnel, engineers, and management personnel. There was no specific assessment of training effectiveness.

Team Activities re Defining/Solving Problems

Meetings and Their Assessment: After training, the investigators met with the two individual teams, Kill and Cut, to address the targeted jobs in their departments. During the calendar year 1993, there were five such meetings. It should be noted, however, that both committees occasionally met on their own in the interim. In addition, the industrial engineering members of each committee often met with the renovation project consulting firm to discuss incorporation and implementation of their committee's recommendations. Since the members of both committees had worked together prior to this project and team dynamics were not considered pathological, little time was required for team-building activities.

Meetings were structured according to an agenda. In general, each meeting started with a review of the prior meeting's minutes. The committee's prior work on each targeted job was summarized, new data or ideas discussed, and remaining work identified and assigned.

At the conclusion of the meetings, the participants and the investigators completed meeting assessment forms adapted from Scholtes (1988). These were reviewed by the investigators to determine if changes in committee procedures or politics were necessary. In addition, one of investigators attending the meeting completed a group dynamics checklist, also adapted from Scholtes, (1988) to subjectively assess the functional dynamics of the team and its members. This information was used solely for observational purposes and, in this project, not applied as a means to manage a team member's behavior. At the end of the project, another questionnaire was given to the participants to determine their overall impressions of the meetings.

The Problem-Solving Process

The problem-solving process applied to the targeted jobs during the demonstration project was developed and recommended by the investigators. It was, to a large extent, adapted from problem-solving principles and processes related to quality management (Scholtes, 1988; Deming, 1986; Walton, 1986; Swezey, 1992). The major principles underlying the process include participation, structure, a scientific approach, and decision by consensus. The process involved five phases: problem identification, problem evaluation, solution development, solution implementation, and solution evaluation.

Problem Identification: To a large extent, the problems had been identified through the plant's previous ergonomics committee activities, such as the Safety and Ergonomics Surveys. The targeted jobs represented jobs associated with a large number of injuries, one or more particularly severe injuries, or relatively high workers' compensation expenses. In addition, they were jobs for which the company had no solutions.

Problem Evaluation: The problem evaluation process was particularly structured and emphasized a scientific approach to data collection and analysis. Following a structured method was considered important since some people have a tendency to jump immediately to solution brainstorming or even implementation without full understanding of the job and task requirements or a clear definition of the job's problems. In this project, the selected method involved the following steps: data collection; data analysis; and assessment of the problem(s). Data elements used to describe the job were grouped into background data, exposure data, and effects data.

Background data included a one sentence statement of the purpose of the job, a summary of the associated tasks, the weights or sizes of objects lifted or handled, and a description of the job's work organization (number of exposed workers, job rotation, location on the line, etc.).

Exposure data represented descriptors of the forces or movements to which the workers were exposed. One component was a summary of time-related information. This included data on the production rate (pieces per worker per hour), standard times (allowed man-minutes per piece per worker, job load and calculated cycle time), observed times (cycle time, duration of exertion per cycle, percentage of time of exertion per cycle, and frequency of exertion), and duration per day (hours). Another component of the exposure data collection was a summary of motion- and exertion-related information. This included a Therblig description of the tasks and an estimation of required intensities of exertion using a five point scale.

Associated body postures were qualitatively described. The investigators also characterized the jobs according to their Strain Index rating (Moore & Garg, in-press).

Effects data represented information that reflected the potential effects of the exposures on the workers. Recordable injuries and illnesses were ascertained by review of the OSHA 200 logs for the years 1988 through 1993 (data prior to 1988 was not available). Disorders were clustered into three categories according to anatomical body part: the distal upper extremity (elbow, forearm, wrist, and hand); the shoulder; and the lower back. Days restricted or lost, if any, were noted. Some workers on the teams had performed some of the target jobs and could offer some anecdotal insights into sites where they developed soreness or discomfort. Turnover was also used as an indicator of a potential exposure effect and, by consensus of the committee, was considered a useful indicator of problems associated with the job. A third source of effects data was worker feedback. Members of the ergonomics teams interviewed workers who currently or recently performed the targeted job. The interview followed a consistent and structured format by using a worker feedback survey. This survey incorporated some background information on the worker's affected body part, perceived problems with the job, and any recommended solutions or changes for the job. Once the data were collected, the teams reviewed and discussed the findings and determined the parts of the job that were of most concern.

Solution Development: Solutions were developed to solve the identified problems. A brainstorming technique was used to ascertain ideas, regardless of feasibility, practicality, or other such concerns. Once a list was completed, the group used informal discussion to modify, delete, and prioritize the listed ideas. Eventually, the group reached consensus on the most desirable and reasonable interventions. No formal process, such as voting, was necessary for either team.

Solution Implementation: Implementation of the recommended solutions was primarily the responsibility of the industrial engineer for the area. The engineer initiated and tracked the corporate intervention evaluation form, contacted product manufacturers to obtain equipment, arranged simulations, and coordinated communications with supervision, maintenance, the renovation consulting firm, and others. The engineer reported on the progress of each job at each meeting.

Solution Evaluation: Given the time frame of this project, there was no opportunity for meaningful post-intervention evaluation for changes developed and implemented by the ergonomics teams. Based on discussion with the committees, however, there are plans to re-evaluate all interventions. It is planned to repeat the Worker Feedback Survey approximately three months post-intervention. This time interval was selected to minimize the potential for the Hawthorne effect — i.e., it was believed that the novelty of the intervention would have largely dissipated by then.

TEAM ACCOMPLISHMENTS

The Kill Department targeted nine jobs for evaluation. The Cut Department targeted twelve. These are listed in Table 3.

Kill Department	Cut Department
Pulling leaf lard	Lifting neckbones
Fleshing hides	Pulling ribs
Snatching guts	Skinning picnics
Tonguing and impaling heads	Scribing loins
Chiseling cheek meat	Hooking sides
Splitting hogs	Pulling loins
Positioning hogs on the Gambrel table and cutting cords	Packing loins
Shackling hogs	Palletizing loin boxes
Removing toe jam	Hooking bellies
	Trimming bellies
	Pulling butts
	Palletizing fresh pork boxes

Table 3. Jobs targeted for the Kill and Cut ergonomics teams.

The Kill Department ergonomics team addressed all nine targeted jobs; however, the team did not feel it necessary to subject all analyses to the entire formal problem-solving process. One intervention was partially installed in September 1993 and the installation of one of the renovated lines began during November of 1993. The Cut Department ergonomics team addressed eight of its twelve targeted jobs. Some were started near the end of the project period and have not completed the problem evaluation phase. No interventions were installed during the project since most involve revised layouts to be implemented with the renovation, but selected components of some intervention plans are in process. There have been no post-intervention evaluations for either team to date.

Results of the analysis of six targeted jobs (three from each department) have been summarized in report form and presented in Exhibits 1-6. Each exhibit attempts to concisely communicate the team's work.

EXHIBIT 1

Job Data

Job Name: Pulling Leaf Lard

Purpose: Remove leaf lard from the inner aspect of the abdominal cavity - improves quality of exposure to ribs - useful for rendering.

Tasks: Pull leaf lard, trim belly with a Whizard Knife, remove the kidneys.

Work Organization: The three tasks are arranged sequentially. The first worker in the line removes kidneys, the next three pull leaf lards, and the final worker uses the Whizard knife to trim the bellies. There are five workers that advance one workstation every 15 minutes.

Exposure Data

Analysis of Time:

Production Data

12.5 seconds per hog (two leaf lards per hog)

18.75 seconds per worker per leaf lard

9 leaf lards per minute

Standard Time Data
0.2133 minutes per hog
Job load = 88%
Recovery = 12%

Observed Time
Cycle time = 6.7 seconds per leaf lard
Duration of exertion = 3.0 seconds
% Exertion per cycle = 45%
Exertions per minute = 18 (two per leaf lard)

Duration per Day
9.5 hours per shift
5.7 hours pulling leaf lard per day

Analysis of Motion:

Grasp and tear loose the lower end of the leaf lard
⇓
Regrasp and pull leaf lard from the diaphragm and abdominal wall
⇓
Set aside

The workers grasp the lower end of the leaf lard with one hand. It is grasped forcefully with a tightly closed fist because of the low coefficient of friction (they also wear cotton mesh gloves). Stresses to the fingernails and back of the distal interphalangeal joints are significant. Most of these workers have lost parts of their fingernails and one had ulcers on the back side of these finger joints. The workers then supinate the forearm and pull upward to initiate the tear. Two hands are usually used when regrasping and pulling upward to remove the leaf lard. Near completion of the task, the workers hands are at approximately head height. The shoulders are almost flexed to 90°. The tissue is easier to tear during this phase of the task. When torn free, the leaf lard is dropped into a chute below.

Other Observations:

Intensity of exertion	= Hard
Posture	= Fair
Speed of work	= Fair

The Strain Index (Moore & Garg, in-press)

Exposure Factor	Rating	Multiplier
Intensity of Exertion	3	6.0
% Exertion per Cycle	3	1.5
Exertions per Minute	4	2.0
Posture	3	1.5
Speed of Work	3	1.0
Duration of Task per Day	4	1.0
STRAIN INDEX		27.0

Effects Data

Distal Upper Extremity Disorders

Year	Condition	Days Restricted	Days Lost
1988	CTS (right wrist)	13	18
	CTS and epicondylitis (both wrists and lateral elbows)	8	0
1989	None reported	0	0
1990	Tendinitis (right elbow and wrist)	0	0
1991	Flexor tenosynovitis (both hands)	0	23
1992	Discomfort (left wrist)	0	47
	Discomfort (left hand)	0	0
1993	None reported	0	0

Shoulder Disorders

{None reported}

Low-Back Disorders

Year	Condition	Days Restricted	Days Lost
1988	None reported	0	0
1989	Disc syndrome	0	106
	Lumbago	0	0
1990	None reported	0	0
1991	Strain	4	0
1992	None reported	0	0
1993	None reported	0	0

Average Rates (1988 - 1993)

Body Part	Incidence Rate	Severity Rate
Distal Upper Extremity	20	363
Shoulder	0	0
Lower Back	10	367

Other Injury / Illness Data: One worker developed dermatitis of the left hand in 1991 (restricted for 3 days). Two workers strained their lower extremities. One was off work for 147 days; the other 2 days. Seven workers had lacerations or burns, primarily affecting the right hand. These traumatic injuries were associated with 15 restricted days.

Turnover Data: 10 individuals filled 5 positions in the last 2 years (100% turnover every year).

Worker Feedback Data (n=7)

Perceived problems	Total
Gripping the leaf lard	5
Breaking the leaf lard free	2
Pulling the leaf lard	1
Tearing the leaf lard	1
Rolling the leaf lard	1

Affected Body Part	Right	Left	Bilateral	Total
Neck				2
Shoulders	1	1	3	5
Elbows	1	0	0	1
Forearms	0	1	4	5
Wrists	2	0	2	4
Hands	0	0	6	6
Upper back				0
Lower back				5

Recommended Improvements

{None reported}

The Team's Assessment

- It is difficult to grasp the leaf lard because of its size, consistency, and it is slippery.
- The tight and forceful grasp creates high compression and shear forces on fingers and fingernails when grasping.
- Pulling up the leaf lard stresses the hands, wrists, and low-back.

Solution Brainstorming

- Use an automatic leaf lard puller manufactured by Durand International
- Use a leaf lard starter and/or roller manufactured by SELO
- Use a vacuum with a cutting nozzle
- Cut the lower end of the leaf lard with a knife, then pull manually
- Start at the top of the leaf lard, then pull down
- Cut the leaf lard in the middle, then pull out the halves
- Inject air behind the leaf lard to "loosen" it, then pull out
- Freeze the leaf lard, then break it out
- Use a hand-held skinner to remove it

The Proposed Solution

The plant had previously tried a single SELO unit to tear loose the leaf lard on each side of the hog. This did not work well. As an alternative, it was recommended to use two SELO units — one for right sides and one for left sides. The other solutions were considered less effective or less feasible.

Implementation Status

Two SELO Leaf Lard Starter units were obtained for trial in August 1993. A cylinder malfunction delayed the trial until September 1993. Once implemented, informal worker feedback was favorable. There were no evident adverse impacts on quality or productivity. Both units are scheduled for final installation by the end of the year.

EXHIBIT 2

Job Data

Job Name: Fleshing Hides

Purpose: Remove excess fat from hides so they can be properly salt-cured.

Tasks: Flesh hides

Work Organization: There are two workers that flesh hides regularly plus one relief person that performs this task less than half-time. The work was designed by the industrial engineers so the fleshers would not keep up with the skinners (the source of the hides). The relief person would catch up by working while the regular fleshers took their scheduled breaks. In reality, the fleshers work fast to stay up with the skinners. As a result, they can take more and longer breaks.

Exposure Data

Weight of One Hide: One hide weighs approximately 6 pounds. Its shape is irregular.

Analysis of Time

Production Data
700 hides per hour
350 hides per worker per hour
7.5 hides per minute

Standard Time Data
0.071 minutes per skin per worker
Job load = 86%
Recovery = 14%

Observed Time
Cycle time = 8.0 seconds per hide
Duration of exertion = 4.0 seconds
% Exertion per cycle = 50%
Exertions per minute = 22.5 (three per hide)

Duration per Day
9.5 hours per shift

Analysis of Motion

Grasp, lift, and move one hide from a table to the machine
⇓
Lay the hides on the roller, fat side up
⇓
Activate the machine
⇓
After the cycle, step on a pedal to open the machine
⇓
Grasp, turn, and replace the hide on the roller
⇓
Repeat machine activation and opening
⇓
Catch hide and set aside on a conveyor

The first action by the Flesher is to grasp one hide from an adjacent table, lift it up, then move it to the fleshing machine. The hides are slippery and amorphous. The Flesher places the hide on the machine. The roller is at approximately waist height. The Flesher reaches up to approximately head height to activate the machine by pressing two buttons. The location of the buttons was determined on the basis of safety concerns. A counting switch is next to the right button. The Fleshers usually reach over to hit the lever right after hitting the button once per cycle. After the machine has cycled once, the Flesher grasps, lifts, turns, and replaces the hide on the roller to remove fat from the other half of the hide. After the hide is in place, the Flesher activates the machine a second time. At the end of the cycle, the Flesher catches the hide and sets or guides it onto a conveyor.

Other Observations

Intensity of exertion	= Somewhat Hard
Posture	= Good
Speed of work	= Fast

The Strain Index

Exposure Factor	Rating	Multiplier
Intensity of Exertion	2	3.0
% Exertion per Cycle	4	2.0
Exertions per Minute	5	3.0
Posture	2	1.0
Speed of Work	4	1.5
Duration of Task per Day	4	1.0
STRAIN INDEX		27.0

Effects Data

Distal Upper Extremity Disorders

Year	Condition	Days Restricted	Days Lost
1988	None reported	0	0
1989	None reported	0	0
1990	None reported	0	0
1991	None reported	0	0
1992	Discomfort and numbness (both wrists)	25	43
1993	None reported	0	0

Shoulder Disorders

Year	Condition	Days Restricted	Days Lost
1988	None reported	0	0
1989	None reported	0	0
1990	None reported	0	0
1991	None reported	0	0
1992	Discomfort (right shoulder)	4	0
1993	Overuse syndrome (bilateral)	54	176

Low-Back Disorders {None reported}

Average Rates (1988 - 1993)

Body Part	Incidence Rate	Severity Rate
Distal Upper Extremity	8.3	567
Shoulder	16.7	1,950
Lower Back	0.0	0

Other Injury / Illness Data: In 1992, one worker suffered multiple fractures and lacerations of the right hand when the hand was caught in the roller portion of the machine. This injury was associated with 236 lost days.

One worker with bilateral wrist discomfort and numbness, recorded in 1992, underwent surgery for bilateral CTS in 1993

medical costs = $5672
disability costs = $1733

One worker with the shoulder problem recorded in 1993 as "overuse syndrome" actually had diagnoses of right partial rotator cuff tear, bilateral biceps tendinitis, and bilateral impingement syndromes

medical costs = $ 1708
disability costs = $ 1809

In 1993, there have been 424 restricted hours among 5 Fleshers

cost of light duty work = $4952.

Total cost of 1993 injuries (as of September) = $15,874.

Turnover Data: Ten individuals filled two positions in the last six months

1,000% turnover per year
7 of the 10 (70%) had injuries

A Quality Issue: The company's customer notified them of problems related to the quality of the hides. Apparently there was either too much retained fat or the skins were too thin. It was suspected that this was related to the workers working too fast.

Worker Feedback Data (n=3)

Affected Body Part	Right	Left	Bilateral	Total
Neck				0
Shoulders	1	0	1	2
Elbows	0	0	0	0
Forearms	1	0	0	1
Wrists	1	0	0	1
Hands	1	0	1	2
Upper back				1
Lower back				1

Perceived problems	Total
Lifting hides from the tables	2
Gripping hides	1
Turning and twisting	1

Recommended Improvements

{None reported}

Previous Interventions

- The aside conveyor was modified so workers only dropped the hides at the end of the second machine cycle. This eliminated one lift plus carrying the hide.
- They tried rubber gloves to improve friction, but the gloves got stiff and cracked.
- They installed light-activated switches, rather than palm buttons, to activate machines.
- They installed distribution conveyors from the skinners that equitably distribute hides to the two fleshing machines.

The Team's Assessment

- Handling the hides requires forceful grasping.
- Lifting and manipulating hides requires significant strength and non-neutral shoulder postures.
- The work area is very restricted in terms of space.

Solution Brainstorming

- Get out of the business (not feasible – too profitable)
- Add a third machine (there are space limitations, the productions rate will eventually increase to 1,000 hides per hour
- Redesign layout in a manner analogous to the beef industry (space limitations)
- Use no-cut or leaf lard gloves (worked well, but filled with fat and became slippery)

The Proposed Solution

It was possible to redesign the layout and add a third machine:

- hides will be conveyed to one area, then to individual machines
- hides will be presented to workers at the work surface height of machine, this will eliminate the first lift
- install light touch buttons on all machines and place them below shoulder height
- after the last cycle, the hides will drop onto a conveyor (eliminates the last lift)

EXHIBIT 3

Job Data

Job Name: Snatching Guts

Purpose: Remove the internal organs (viscera) from the hog's body cavities.

Tasks: Remove guts, then set aside.

Work Organization: There are three workers that perform this job without rotation.

Exposure Data

Weight of One Set of Guts: One set of guts weighs approximately 26 pounds.

Analysis of Time

Production Data
742 hogs per hour
247 sets of hog guts per worker per hour
14.6 seconds per set of hog guts

Observed Time
Cycle time = 13.3 seconds per hog
Duration of exertion = 4.0 seconds (guts hand)
% Exertion per cycle = 30% (guts hand); 100% (knife hand)
Exertions per minute = 4.5 (once per set of guts)

Duration per Day
9.5 hours per shift

Analysis of Motion:

Grasp and wrap bung around one hand
⇓
Apply traction to the bung and cut to free the rectum
⇓
Regrasp near the stomach
⇓
Cut the diaphragm to free remaining viscera
⇓
Cut the laryngeal tissue
⇓
Hold, turn, and carry the guts to the pan

The first two elements of this job require little effort, but the hand that holds the knife is exposed to static, relatively low-force muscular work. The left shoulder is abducted to approximately 90° and internally rotated to wrap the rectum around the hand. Grasping near the stomach the diaphragm is cut and the guts are lifted and transferred to a pan located behind the worker. The pans are approximately at knee height.

Other Observations:

Intensity of exertion	= Very hard (guts hand);
	= Light (knife hand)
Posture	= Good
Speed of work	= Fair

The Strain Index (Guts Hand)

Exposure Factor	Rating	Multiplier
Intensity of Exertion	4	9.0
% Exertion per Cycle	3	1.5
Exertions per Minute	3	1.5
Posture	2	1.0
Speed of Work	3	1.0
Duration of Task per Day	5	1.5
STRAIN INDEX		30.4

The Strain Index (Knife Hand)

Exposure Factor	Rating	Multiplier
Intensity of Exertion	1	1.0
% Exertion per Cycle	5	3.0
Exertions per Minute	5	3.0
Posture	2	1.0
Speed of Work	3	1.0
Duration of Task per Day	5	1.5
STRAIN INDEX		13.5

Effects Data

Distal Upper Extremity Disorders

Year	Condition	Days Restricted	Days Lost
1988	CTS (left)	2	1
1989	CTS (bilateral)	25	71
1990	None reported	0	0
1991	CTS (bilateral)	53	13
1992	None reported	0	0
1993	CTS (left)	53	22

Shoulder Disorders

Year	Condition	Days Restricted	Days Lost
1988	None reported	0	0
1989	None reported	0	0
1990	Rotator cuff (right shoulder)	52	8
1991	Pain (right shoulder)	0	0
	Strain (left shoulder)	0	24
1992	None reported	0	0
1993	None reported	0	0

Low-Back Disorders

Year	Condition	Days Restricted	Days Lost
1988	None reported	0	0
1989	None reported	0	0
1990	None reported	0	0
1991	None reported	0	0
1992	None reported	0	0
1993	Strain	0	3

Body Part	Incidence Rate	Severity Rate
Distal Upper Extremity	22.0	1,333
Shoulder	16.7	467
Lower Back	5.6	17

Turnover Data: Eight individuals filled three positions in the last two years (133% turnover per year)

Worker Feedback Data (n=4)

Affected Body Part	Right	Left	Bilateral	Total
Neck				1
Shoulders	0	4	0	4
Elbows	0	1	0	1
Forearms	0	0	0	0
Wrists	0	1	3	4
Hands	0	0	4	4
Upper back				0
Lower back				2

Perceived problems	Total
Inadequate room	1
Difficult to pull bungs out correctly	1

Recommended Improvements	Total
Open the H-bone	2
More room	1
Pull bungs out correctly	1
Develop a new method	1

The Team's Assessment

- Handling the guts requires forceful grasping of a slippery amorphous object.
- Lifting and carrying the viscera with one hand requires significant strength.
- The pan is located behind the worker.
- It is necessary to lift the viscera into the pan.

Solution Brainstorming

The industrial engineers had been working on a proposed solution prior to the ergonomics team's review of this job. The team agreed with the proposed intervention. As a result, there was no solution brainstorming for this targeted job.

The Proposed Solution

The renovated design involves breaking the gut-snatching job into three tasks. The first worker frees the abdominal organs, the second cuts the diaphragm to free the thoracic organs, and the third performs the final cut to free the entire guts from the laryngeal area. The viscera will fall passively into a pan riding on a conveyor below the carcass. This new design and layout eliminates all forceful grasping and lifting. A simulation was arranged and worked well.

There was one major obstacle – the United States Department of Agriculture. The USDA was concerned about the possibility of contamination of the viscera by debris falling from the workers' shoes. In addition, the viscera must stay with the carcass through the inspection process. Both obstacles were eventually overcome and the company has USDA approval to proceed with the renovation.

Implementaion Status

The revised layout is scheduled for installation during 1994 as part of the renovation project.

EXHIBIT 4

Job Data

Job Name: Pulling Ribs

Purpose: Remove ribs from the belly.

Tasks: Pull the rib and set it on the aside conveyor, pack the ribs.

Work Organization: Three workers rotate among these two tasks every 15 - 30 minutes. Two workers pull ribs (using a special knife that requires two hands) while the third packs the ribs (materials handling).

Exposure Data

Rib Data

The average weight of one rib = 3.13 lbs.
The average length of one rib = 15 in.

Analysis of Time

Production Data
765 hogs per hour
765 bellies per worker per hour
4.76 seconds per rib

Standard Time Data
0.0794 minutes per rib per worker
job load = 98.9%
recovery = 1.1%

Observed Time
Cycle time = 4.6 seconds per rib
Duration of exertion = 0.75 seconds
Percent exertion per cycle = 16%
Exertions per minute = 26 (two per rib)

Duration per Day
9.5 hours per shift
5.7 hours pulling ribs per day

Analysis of Motion

Grasp the knife
⇓
Reach forward to begin cut
⇓
Pull the knife to cut
⇓
Grasp the cut rib
⇓
Lift, turn, and place the rib on the aside conveyor

The knife is held with two hands. Its design requires that the workers extend and abduct their thumbs to place them on the handle. The thumbs press against the upper part of the handle to provide torque to oppose torque created by the knife blade (cutting through the meat below the little fingers). The forward reach requires some trunk and shoulder flexion. After the cut, the workers grasp the end of the rib with a pinch grasp with the forearm supinated, then lift it to approximately head height, reach forward, turn the rib over, and place it into a trough on the aside conveyor.

Other Observations:

Intensity of exertion	= Somewhat Hard
Posture	= Bad (thumbs abduction and extension)
Speed of work	= Fair

The Strain Index

Exposure Factor	Rating	Multiplier
Intensity of Exertion	2	3.0
% Exertion per Cycle	2	1.0
Exertions per Minute	5	3.0
Posture	4	2.0
Speed of Work	3	1.0
Duration of Task per Day	4	1.0
STRAIN INDEX		18.0

Effects Data

Distal Upper Extremity Disorders

Year	Condition	Days Restricted	Days Lost
1988	Possible CTS	0	0
1989	None reported	0	0
1990	CTS (right)	7	0
1991	None reported	0	0
1992	Tenosynovitis (left fifth finger)	11	0
1993	Pain (right hand, wrist, and arm)	3	0

Shoulder Disorders

Year	Condition	Days Restricted	Days Lost
1988	None reported	0	0
1989	None reported	0	0
1990	Strain (right shoulder)	42	0
1991	Strain (left AC joint)	31	0
1992	None reported	0	0
1993	None reported	0	0

Low-Back Disorders

Year	Condition	Days Restricted	Days Lost
1988	None reported	0	0
1989	None reported	0	0
1990	None reported	0	0
1991	Strain	7	0
1992	None reported	0	0
1993	None reported	0	0

Average Rates (1988 - 1993)

Body Part	Incidence Rate	Severity Rate
Distal Upper Extremity	22.2	117
Shoulder	11.1	406
Lower Back	5.6	39

Other Injury / Illness Data: One team member had performed this job and experienced bilateral radial wrist soreness (suggestive of DeQuervain's tenosynovitis). This job was associated with 68 restricted days in last 12 months.

Total medical costs for 1993 (to date) = $2400.

Turnover Data:
Ten individuals filled 3 positions in last 12 months (333% turnover per year).

Workers often post in for higher pay.

Worker Feedback Data (n=9)

Affected Body Part	Right	Left	Bilateral	Total
Neck				2
Shoulders	5	0	3	8
Elbows	3	0	0	3
Forearms	2	1	1	4
Wrists	0	2	5	7
Hands	0	0	5	5
Upper back				1
Lower back				3

Perceived problems	Total
Dull knife	6
Pulling the knife	5
Setting the rib on the aside conveyor	4
Thumb pressure	3
Grasping the rib	3
Grasping the knife	2
Bellies pull off the spike conveyor	2
Bone cuts	1

Recommended improvements	Total
Improve the knife handle	5
Change the spike conveyor	5
Change floor stands	3
Get a better knife	2
Lengthen the table	1
Lower the aside conveyor	1
Add a person to the packing task	1
Try gloves	1

The Team's Assessment

- The floor stand is irregular because the ends of the existing mats do not match.
- The existing conveyor designs contribute to the difficulty of the pulling task.
- The ribs are put into the roller with their long axis parallel to the axis of the roller drum. They may be flattened better (thus easier to cut) if rolled the other way.
- The existing knife places the user at a mechanical disadvantage, especially regarding the thumbs (loaded and extended).
- The existing system requires the spike conveyor operator to align the bellies by sight alone. As a result, some bellies come to the pullers with the ribs impaled by the spikes on the conveyor.
- The current technique of setting the ribs aside requires use of pinch grasp combined with poor mechanical advantage (it is held at the end of the rib) and forearm pronation.
- The aside conveyor is located up and away from the worker, thus requiring an extended forward reach, trunk flexion, and lifting to approximately shoulder height.

Solution Brainstorming

- Upgrade the flooring material.
- Design the spike conveyor for a taller worker and install adjustable stands for shorter workers.
- Consider hooking the bellies instead of spiking them.
- Roll the ribs lengthwise.
- Use a light to consistently align bellies on spike conveyor.
  Knives (sharpness is very individualized, consider a means to keep the blade warm, reduces friction, consider a new design to eliminate pressure with the thumbs).
- Leave the pulled ribs on the bellies and install some device to push them off
- Place the ribs in a chute next to the puller so it drops to a conveyor
- Add a third worker: two pull ribs and one sets the ribs on the conveyor (2 hands)
- Lower the aside conveyor (not feasible to move it closer)

Implementation Status

- Layout changes have been incorporated into the renovation design plans.
- New flooring material has been installed.

- Work practice changes will be incorporated into the renovation plans.
- A revised knife handle has been designed and a prototype built. Workers recently tried it on the line (November 1993). Overall, the new design addresses the biomechanical issues, but its dimensions need to be changed so the end of the knife does not hit the conveyor during the pull. It is undergoing further modifications.

EXHIBIT 5

Job Data

Job Name: Lifting Neckbones

Purpose: Remove neckbones from the shoulder.

Tasks: Get one shoulder, then remove the neckbone

Work Organization: There are five workers that rotate every 30 to 60 minutes among three tasks: three neckbone pullers, one foot saw operator, one trims front feet. Only one person lifts neckbones for one continuous hour per day. For all others, the maximum continuous duration is 30 minutes. The other two tasks are not considered to be as significant as the neckbone task in terms of musculoskeletal risk factors.

Exposure Data

Weight of One Shoulder:

Average weight of shoulder = 17.4 lbs.
Average weight of one neckbone = 1.7 lbs.

Analysis of Time

Production Data
1,532 shoulders per hour
511 shoulders per worker per hour

Standard Time
0.1166 minutes per shoulder per worker
Job load is 98.7%
Recovery is 1.3%
7.0 seconds per shoulder

Observed Time
Cycle time (per shoulder) = 6.6 seconds
Duration of exertion per cycle = 3.3 seconds
% Exertion per cycle = 50%
Exertions per minute = 9

Duration per Day
9.5 hours per shift
4.5 hours lifting neckbones per day

Analysis of Motion:

Orient shoulder on conveyor
⇓
Preliminary cut to allow grasp
⇓
Continue cut around neckbone
⇓
Aside neckbone

Orienting the shoulder on the conveyor may involve pushing and/or pulling with one hand. Sometimes, the shoulders are stacked, requiring the worker to lift, push, or pull to get to them. The knife is used in one hand. The other hand is sometimes used to provide traction to the neckbone. The workers' posture is generally favorable for the preliminary cut; however, the final cut requires the worker to cut under the neckbone and up the opposite side. This maneuver requires wrist flexion. The neckbones are dropped into a chute.

The Strain Index

Exposure Factor	Rating	Multiplier
Intensity of Exertion	2	3.0
% Exertion per Cycle	4	2.0
Exertions per Minute	3	1.5
Posture	4	2.0
Speed of Work	4	1.5
Duration of Task per Day	4	1.0
STRAIN INDEX		27.0

Effects Data

Distal Upper Extremity Disorders

Year	Condition	Days Restricted	Days Lost
1988	CTS (right)	3	0
1989	Epicondylitis (both elbows)	0	9
	Tendinitis (right elbow)	0	18
1990	None reported	0	0
1991	Discomfort (right wrist)	2	0
1992	Discomfort (right elbow)	22	0
	Pain and numbness (right hand)	1	0
1993	Discomfort (right wrist)	37	0

Shoulder Disorders

Year	Condition	Days Lost	Days Restricted
1988	Bicipital tendinitis (right shoulder)	90	109
1989	Impingement (right shoulder)	40	25
1990	None reported	0	0
1991	None reported	0	0
1992	Tendinitis (right shoulder)	116	61
	Strain (periscapular area)	0	0
1993	None reported	0	0

Low-Back Disorders {None reported}

Average Rates (1988 -1993)

Body Part	Incidence Rate	Severity Rate
Distal Upper Extremity	23.3	307
Shoulder	13.3	1,470
Lower Back	0.0	0

Turnover Data: 10 individuals posted for 5 positions in last 2 years (100% turnover per year).

Worker Feedback Data (n=10)

Affected Body Part	Right	Left	Bilateral	Total
Neck				3
Shoulders	3	1	2	6
Elbows	3	1	1	5
Forearms	1	0	1	2
Wrists	3	1	4	8
Hands	3	1	4	8
Upper back				2
Lower back				4

Perceived problems	Total
Turning the shoulders	3
Dull knife	3
Too crowded	2
Problems related to the Kill Department	2
Conveyor moves too slow	1
Tables are too low	1
Workstation #1 is bad	1
Duration on the job is too long	1
Difficulty putting neckbones into the chute	1

Recommended improvements	Total
Rotate more frequently	3
Adjust the table height	2
Fix the flooring	2
More space	2
Better quality control from Kill	1
Slow down the line speed	1
Better steeling of knives	1

The Team's Assessment

- This is a skilled task requiring a sharp knife plus good technique.
- The continuous conveyor is part of the problem. If the cut is missed, the worker must follow the shoulder down the conveyor.

Solution Brainstorming

- Knives/Steeling (improve worker education, improve communication with the skilled sharpeners).
- Repositioning shoulders (increase the space between shoulders)
- Uneven floor (install a single mat of new flooring).
- Work surface height (install adjustable work stands).
- Line speed (add a sixth worker, 4 lifters and 2 foot saw operators. this should reduce production rate to 500 shoulders per worker per hour).

Implementation Status

- New flooring has been installed.
- Adjustable work stands and conveyor modifications are being incorporated into the renovation design. The new design should also reduce crowding.
- A sixth worker has been added.
- Knife/steeling education started.

EXHIBIT 6

Job Data

Job Name: Skinning Picnics

Purpose: Remove skin from the picnic.

Tasks: Skinning picnics, Trimming neckbones

Work Organization: There are seven workers that rotate between skinning picnics and trimming neckbones every 2.5 hours (associated with breaks): two trim neckbones (using knives manually), five skin picnics (using skinning machines), three on the left side of the conveyor, two on right side of the conveyor

Exposure Data

Weight of one Picnic: The average weight of each picnic is 9.5 lbs.

Analysis of Time:

Production Data
306 picnics per worker per hour
14.1 seconds per picnic

Standard Time
0.1410 minutes per picnic per worker
Job load is 90.0%
Recovery is 10.0%

Observed Time
Cycle time = 13.1 seconds per picnic
Duration of exertion = 7.4 seconds per picnic
Percent exertion per cycle = 56%
Exertions per minute = 13.8 (three per picnic)

Duration per Day
9.5 hours per shift
usually 5.0 hours, but possibly up to 7.5 hours skinning picnics

Analysis of Motion:

Reach to the right or left side to grasp, lift, turn, and place one picnic on the skinning machine.

⇓

Rotate the picnic on the skinning machine.

⇓

Place the picnic back on the conveyor.

The skinning machine is located adjacent to the conveyor carrying the picnics. The workers reach to one side (right or left depending on the orientation of the workstation) to grasp, lift, and carry the picnic to the skinner. Once placed on the skinning machine, the worker primarily guides the picnic over the blades. There may be some additional lifting to reorient the picnic for reskinning. Once skinned, the picnic is placed back on the conveyor.

The Strain Index

Exposure Factor	Rating	Multiplier
Intensity of Effort	3	6.0
% Exertion per Cycle	4	2.0
Exertions per Minute	3	1.5
Posture	2	1.0
Speed of Work	3	1.0
Duration of Task per Day	4	1.0
STRAIN INDEX		18.0

Effects Data

Distal Upper Extremity Disorders

Year	Condition	Days Restricted	Days Lost
1988	Tendinitis (both wrists)	60	203
1989	Epicondylitis (right lateral elbow)	0	0
	"CTD" (both hands)	0	29
1990	Epicondylitis (right lateral elbow)	0	6
	Tendinitis (both wrists and hands)	5	8
1991	CTS (right) {underwent surgery}	32	19
1992	None reported	0	0
1993	None reported	0	0

Shoulder Disorders

Year	Condition	Days Restricted	Days Lost
1988	None reported	0	0
1989	None reported	0	0
1990	Subluxation (left)	0	22
1991	Strain (right)	23	0
	Strain (right)	53	0
1992	Tendinitis (right)	88	134
1993	None reported	0	0

Low-Back Disorders {None reported}

Average Rates (1988 - 1993)

Body Part	Incidence Rate	Severity Rate
Distal Upper Extremity	14.3	862
Shoulder	9.5	762
Lower Back	0.0	0

Turnover Data:

Estimated to be high

Worker Feedback Data (n=11)

Affected Body Part	Right	Left	Bilateral	Total
Neck				3
Shoulders	5	2	2	9
Elbows	0	0	0	0
Forearms	0	0	0	0
Wrists	3	1	0	4
Hands	1	0	5	6
Upper back				2
Lower back				3

Perceived problems	Total
Handling picnics	7
Difficult to adjust machines	1

Recommended improvements	Total
Improve handling of the picnics	6
Install adjustable workstations	5
Adjust the machinery	2
Increase job rotation	2
Decrease job rotation	1
Rotate the machine 180°	1
Improve communication	1

The Team's Assessment

- Improve the picnic handling. If possible, eliminate lifting.
- Allow for adjustable workstation heights.

Solution Brainstorming

Picnic handling

- eliminate the guard rail to reduce the vertical height of the lift
- use a trough instead of a flat conveyor so picnics will not fall off
- install angled workstations to pull picnics off, then push to return to conveyor

Adjustable workstations

- design for a taller worker and raise the shorter ones

Implementation Status

Conveyor modifications

- a prototype is being built
- if successful, it will be incorporated into the renovation design

Adjustable platforms have been incorporated into the renovation design.

EVALUATIONS OF TEAM PERFORMANCE AND PROGRAM OUTCOMES

Measures of Team Function/Effectiveness

One of the purposes of the project was to assess the effectiveness of the participatory approach to solving ergonomics-related problems. The following outcomes were considered to measure this effectiveness:

- Team productivity;
- Number of interventions; and
- Participant feedback.

Team productivity was determined by comparing the number of jobs analyzed by the teams to the number of targeted jobs. The number of successful interventions was considered as a measure of effectiveness; however, during the brief observation period by the investigators, interventions were installed for only a few jobs. Therefore, the number of successful interventions was not used as a yardstick of team effectiveness for this project.

To determine feedback from team participants, a self-administered questionnaire, called the "Participant Feedback Questionnaire," was completed anonymously. The questionnaire included five-point scales (where "1" is very unfavorable and "5" is very favorable) to assess participant ratings for team size, team balance, representation of interested parties, effectiveness of each phase of the problem-solving process, team productivity, team functioning, etc. Participants were also asked to identify obstacles to effective team functioning. It was distributed to all team members at the end of the project. Upon completion, the questionnaires were forwarded to the investigators for tabulation and analysis.

Twelve (eight from Hog Kill and four from Hog Cut) "Participant Feedback Questionnaires" were received. Eleven of the 12 (92%) participants felt that the sizes of the teams were about right and balanced in terms of management representatives versus worker representatives. All respondents felt that all interested parties were represented on the committees.

Participant ratings of effectiveness for different aspects of the problem-solving process and committee productivity (number of jobs studied) were highly favorable (Table 4). As expected, ratings for intervention implementation were relatively lower since few interventions were implemented during the project period. Regarding perceptions about team functioning, the mean ratings were 4.4 (range: 3 to 5) and 3.5 (range: 3 to 4) for the Hog Kill and Hog Cut teams, respectively.

	Hog Kill (n=8)		Hog Cut (n=4)	
	Mean	Range	Mean	Range
Problem Identification	4.3	4-5	4.0	4
Problem Evaluation	4.4	4-5	4.5	4-5
Intervention Development	3.9	3-5	3.0	2-4
Intervention Implementation	3.6	3-5	2.8	2-4
Intervention Evaluation	4.1	3-5	3.5	3-4
Number of Jobs Studied	3.8	2-5	3.8	3-4

Table 4. Participant ratings of the problem-solving process elements and number of jobs studied on a scale of 1 to 5 (1 = very unfavorable; 5 = very favorable).

Four of the eight Hog Kill team members felt there were obstacles to the team working well. The reasons and the number of individuals citing each reason (in parentheses) included:

- Lack of advanced notice of meetings (3);
- Inconvenient meeting times (2);
- Key people did not attend (1);
- Lack of meeting structure (1);
- People were too busy with other major projects at the same time (1);
- Finding a good meeting place was a problem (1); and

- People shortages made it difficult to get team members to the meetings (1).

Three of the four Hog Cut team members also felt there were obstacles. They cited:

- Poor participation (2);
- Team members were passive or reluctant (2);
- A lack of open discussion (1);
- Key people did not attend (1);
- Non-team members were reluctant to contribute (1);
- Team members were overworked because of conflict with another major project (1);
- A shortage of plant workers made it difficult for some members to attend all meetings (1); and
- A shortage of conference rooms (1).

Mean ratings and ranges for each team's meetings are summarized in Table 5. Overall, the ratings were highly favorable.

	Hog Kill (n=8)		Hog Cut (n=4)	
	Mean	Range	Mean	Range
Good vs. Bad	4.3	3-5	4.3	3-5
Focused vs. Rambling	4.3	4-5	4.5	3-5
Energetic vs. Lethargic	4.0	3-5	3.5	3-4
Satisfying vs. Not Satisfying	3.8	3-4	3.5	3-4
Scientific vs. Shooting from the hip	4.0	3-5	4.3	4-5
Cooperative vs. Divisive	4.4	4-5	4.3	4-5

Table 5. Participant ratings of the meetings on a scale of 1 to 5 (1 = very unfavorable; 5 = very favorable).

In terms of the pace of the teams' activities, the Hog Kill team's mean rating was 3.6 (range: 3-5) and the Hog Cut team's mean rating was 3.25 (range: 3-4).

All 12 respondents felt that the information from the workers performing the jobs under study had been sought and adequately represented in the teams' activities. There was similar unanimity among respondents when asked whether they felt that the workers were satisfied with the teams' activities and whether the teams were meeting their goals. Two individuals added remarks that there is still more work to be done. In terms of satisfaction with the plant's ergonomics program, the mean response from both teams was 3.8 (range: 3-5).

When asked about the teams' futures, 75% of the members felt the teams should continue on as they have. Comments associated to this response included:

- "Emphasize strong leadership." (Hog Cut)
- "Maintain strong active leadership." (Hog Kill)
- "Meetings where everyone can attend." (Hog Cut)
- "Meet more often if possible." (Hog Kill)

The other three (25%) recommended that the teams continue on, but change in some ways. Their comments included:

- "More advanced notice for the meetings so we the workers might gather more information to help with problems." (Hog Kill)
- "I feel more emphasis should be put on ergonomic design instead of ergonomic upgrading." (Hog Cut)
- "More workers on the committee." (Hog Cut)

As final comments, the following were noted:

- "I feel this project has improved an already workable ergonomics program and has benefited by our association with the consultant." (Hog Kill)
- "Very good program. This way things do get done even if it takes time." (Hog Kill)
- "I feel especially with the renovation – a committee

will be important in dealing with the new problems related to new equipment and increased line speed. All jobs should eventually be targeted to make them as comfortable as possible." (Hog Kill)

- "Excellent effort by all – persistence of J.W.'s part as team leader was very effective. I enjoyed participating in such a meaningful and positive committee." (Hog Kill)
- "Need to insure follow through on all ergonomic problem areas identified." (Hog Kill)
- "A lot was discussed and things did get done to improve work areas." (Hog Cut)

MEASURES OF BENEFITS

Assessment of the Corporate Ergonomics Program

There are several potential measures of a program's effectiveness. Perhaps the most important criteria are whether the program is achieving or has achieved its defined objectives and whether the management and workers believe that the program is worthwhile. Both the Steering Committee and the Corporate Ergonomics Coordinator consider the ergonomics program favorable for both of these criteria.

Both of the above criteria are fairly subjective and difficult to measure; therefore, additional analyses, based on more objective data, have been done in an attempt to quantitate the effects of the ergonomics program on the corporation. These analyses primarily examine changes in injury and illness statistics and workers' compensation expenses since the program's implementation. The program's effects on quality and productivity are also examined, but only qualitatively. Since the impact of the program represents the holistic result of numerous specific interventions, brief descriptions of several of the corporation ergonomic successes are also presented in this section.

One statistic used to monitor trends is the crude annual incidence rate. This is calculated by dividing the total number of injuries and illnesses recorded on the OSHA 200 log for one year by the average number of workers employed during that year, then multiplying by 100. The result is the number of injuries and illnesses per 100 workers per year. Another commonly used statistic is the lost-time incidence rate. This rate is calculated in a manner similar to the crude incidence rate, except that only the number of lost-time injuries are included in the numerator. The result is the number of lost-time injuries per 100 workers per year. Another potential measure of a program's effectiveness is the percentage of recordable conditions that were "ergonomics-related" (e.g., strains, sprains, or repeated motions or exertions). If a program were effective in preventing musculoskeletal disorders, one would predict a decrease in this percentage post-implementation.

From a business perspective, many companies are interested in determining how an ergonomics program might affect workers' compensation costs. Annual workers' compensation costs can be compared either in actual dollars or in constant dollars (adjusted for inflation). Another analysis, related to this same data, examines the annual corporate workers' compensation expenses per employee (per capita workers' compensation costs). This may be useful since the number of workers employed by the company could change over the years. These comparisons are addressed in this study.

It is of interest to examine the effects of ergonomics on quality and productivity. In the meat industry, quality can be measured several ways. One is yield – the amount of meat obtained per hog part. Another measure is related to the appearance of the finished product, such as excessive fat, scoring, or sloppy packaging. Productivity is measured by pounds of meat processed per hour. Line speed is a significant factor in determining a plant's productivity.

Methods

Injury and Illness Statistics: Complete OSHA 200 log data were only available from 1987 through 1993. In general, data for years prior to 1987 were not available because the corporation retains OSHA logs for only five years (consistent with OSHA record-keeping regulations). As a result, it was not possible to examine the effects of the ergonomics program pre-implementation versus post-implementation for all of the injury and illness statistics. Rather, most of the available data describes the changes from one year post-implementation onward. One exception was that the corporation had maintained data for the lost-time incidence rate since 1984, thinking it could be important for future comparisons. As a result, it was possible to compare pre-implementation data to post-implementation data.

Workers' Compensation Costs: The corporation preferred that its absolute dollar figures for annual workers' compensation costs not be published. Data was available for fiscal years 1987 through 1993 (the corporation's fiscal year ends in October). The costs for 1987 were assigned a value of 100%, and costs for years 1988 through 1993 are expressed as a percentage of 1987. To make the comparison as valid as possible, the 1987 costs were adjusted for inflation. According to the corporation's top insurance executive, the company's average annual rate of inflation for medical services was 12% in this time period (Corporate Insurance Executive, 1993). To determine the per capita workers' compensation costs, the actual dollars were divided by the number of workers for that year. As before, the results are expressed as a percentage of 1987, except these figures were not adjusted for inflation.

Quality, Productivity, and Line Speed: No data were available to assess the effects of the corporation's ergonomics program on quality, productivity, or line speed. However, production workers and engineers were interviewed to determine the impact of the ergonomics program on these three issues.

Results

Injury and Illness Statistics: In Figure 1, the crude incidence rate for 1987 was used as a baseline value. Initially, the crude incidence rate increased during the early post-implementation period, then plateaued at a level approximately 30% higher than baseline. This observation is attributed to the company's efforts to promote early reporting of musculoskeletal symptoms and signs (Corporate Ergonomics Coordinator, 1993). In the most recent two years, the crude incidence rate has decreased and is almost equal to the 1987 level.

Figure 2 illustrates the magnitude of the lost-time incidence rates, expressed as a percentage of the 1984 rate (14.9), for years 1984 through 1993 (year-to-date). There has been a consistent and marked decrease in the lost-time incidence rate since the implementation of the ergonomics program. The lost-time injury rate declined by 50% during the first year of the ergonomics program and has continued to show a downward trend in subsequent years. In 1993, the rate was only 11% of that observed in 1984. This dramatic reduction in the lost-time incidence rate was attributed to ergonomics, safety-related improvements, and other factors such as altered assignments for workers recovering from injuries (Corporate Ergonomics Coordinator, 1993).

The percentage of total recordable disorders that were considered "ergonomics-related" are presented in Figure 3. This percentage decreased 31% from 1987 to 1993. In 1987 and 1988, approximately two-thirds of all recordable conditions were due to "ergonomics-related" injuries. Subsequently, this decreased to approximately 40%. It should be explained, however, that this percentage varies from plant to plant. The plants with the lowest percentages, ranging from 9% to 16%, are highly automated canning plants. The plants with the highest percentages, ranging 50% to 66%, are hand-intensive processing and packaging plants.

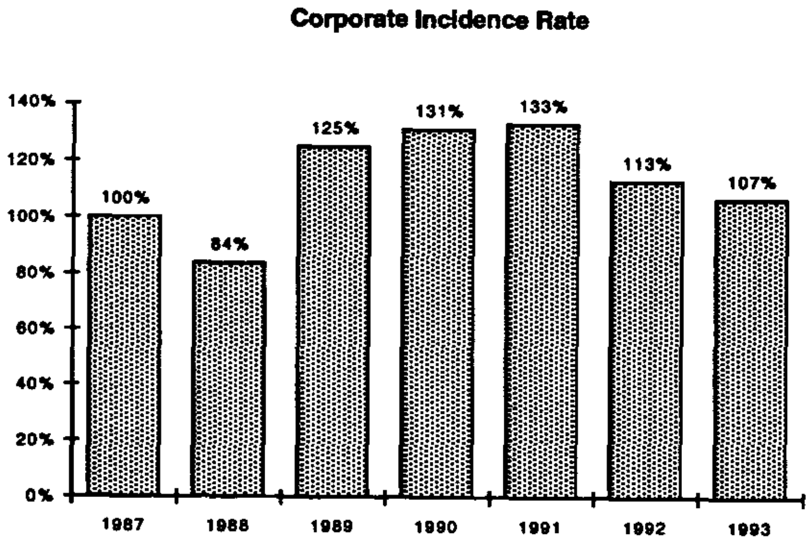

Figure 1. Percentage changes in annual corporate crude incidence rate for the years 1987 through 1993 compared to 1987.

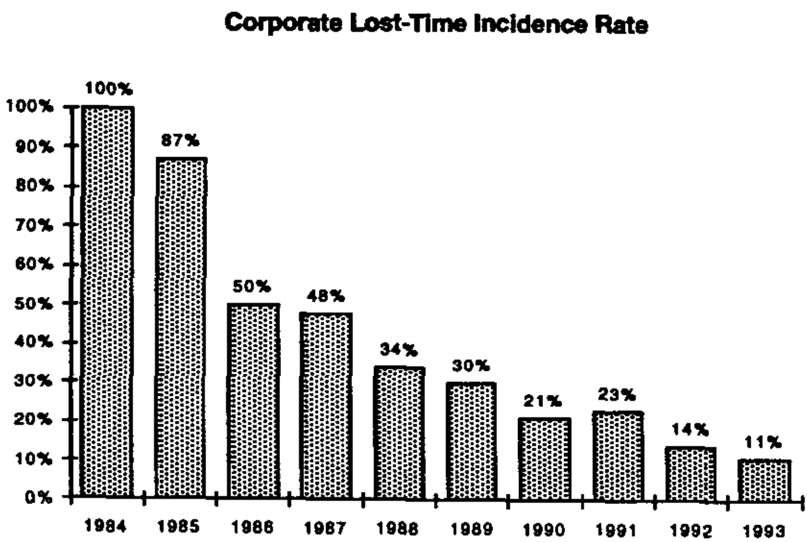

Figure 2. Percentage changes in corporate lost-time incidence rate for years 1984 through 1993 compared to 1984.

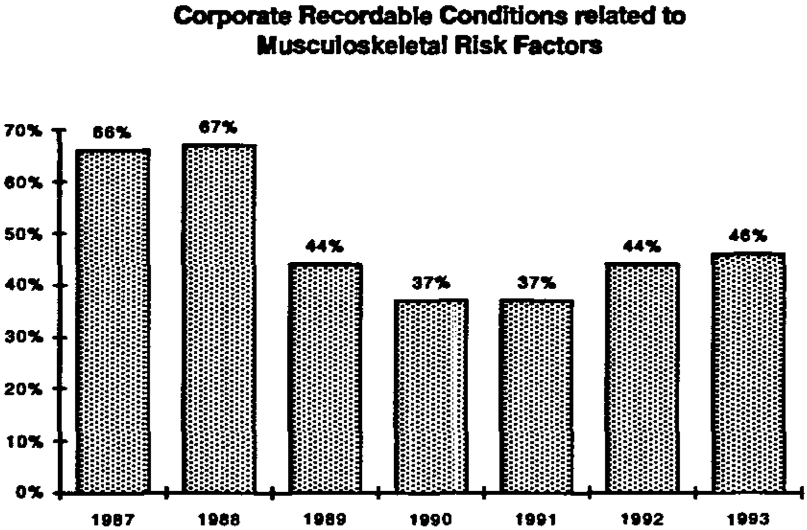

Figure 3. Percentage of total recordable conditions that were musculoskeletal conditions (e.g., strains or sprains) related to musculoskeletal risk factors (e.g., lifting, lowering, or carrying) for the years 1987 through 1993.

Workers' Compensation Costs: Annual workers' compensation costs, expressed as a percentage of 1987 costs, have shown a decrease since 1987 (Figure 4). While the decline has not been particularly steady, there has been an overall decrease in this expense subsequent to implementation of the ergonomics program. The 1993 expenses were 16% of those of 1987 (an 84% decrease). Disregarding inflation, 1993 expenses were 31% of those of 1987 (a 69% decrease). A decrease in workers' compensation expenses had not been observed prior to the start of the company's ergonomics program (Corporate Insurance Executive, 1993).

Figure 5 compares the data for years 1987 through 1993 as a percentage of the 1987 expenses per employee. A progressive decline in per capita expenses is noted, with 1993 unadjusted expenses per employee being approximately 73% lower than those in 1987. These savings in workers' compensation costs have a major

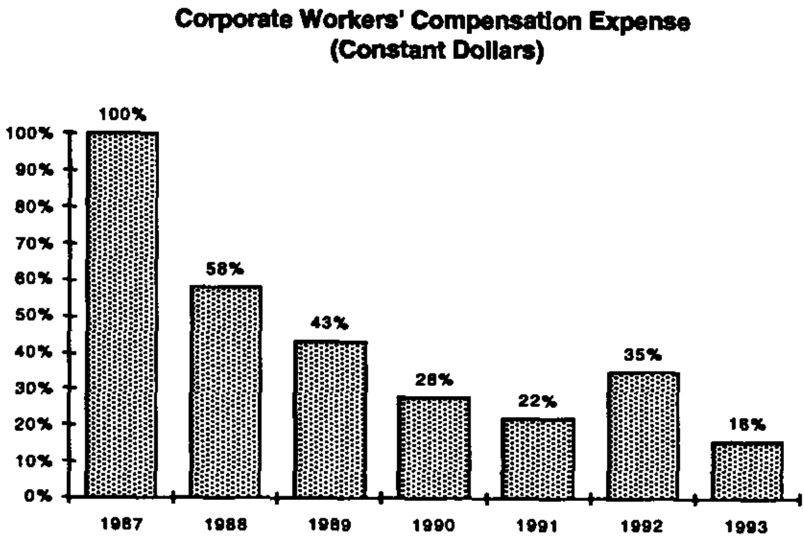

Figure 4. Percentage changes in annual corporate workers' compensation expenses (constant dollars) for years 1987 through 1993 compared to 1987 expenses.

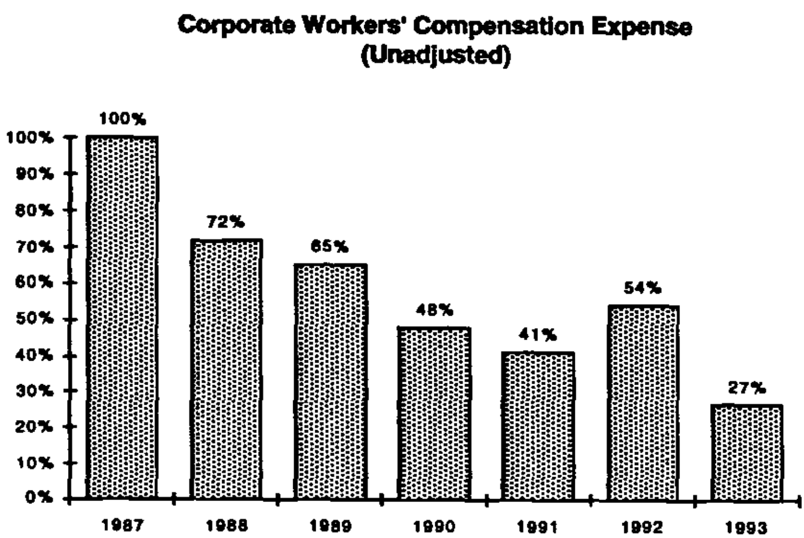

Figure 5. Percentage changes in annual workers' compensation expenses per employee for years 1987 through 1993, compared to unadjusted 1987 figures.

impact on companies' profitability, especially in the meatpacking industry. It is estimated that a $1,000 expense requires the sale of approximately 35,000 pounds of product for the profits from this sale to cover this expense (Corporate Ergonomics Coordinator, 1993).

Quality, Productivity, and Line Speed: Based on the interviews, no ergonomics-related improvement had ever been associated with a sacrifice in quality. Rather, the experience of the workers and management suggested that ergonomic improvements most likely increased quality. The company believes workers who are less fatigued at the end of the day continue to perform better, such as making better cuts, than fatigued or aching workers (Corporate Ergonomics Coordinator, 1993).

In terms of productivity, the corporation believes that workers without fatigue or discomfort maintain steady output throughout the day compared to workers with fatigue or aches (Corporate Ergonomics Coordinator, 1993). Some interventions have led to significant increases in productivity due to automation, better yield, and reduced number of workers. Some interventions have relieved bottlenecks on a line, such as by improved layout or work simplification, and have allowed better line output without adverse effects or impacts on the workers.

Increasing line speed has not been a goal of the company's ergonomics program. Line speed is primarily determined by sales, economies of scale, and availability of raw materials (Corporate Ergonomics Coordinator, 1993). When increases in line speed are scheduled, the company relies on standard industrial engineering methods to manage the effect on existing bottlenecks. After the line speed has been increased for several weeks, the ergonomic effects are re-evaluated via the Safety and Ergonomics Survey. Identified problems are then addressed as discussed previously.

Ergonomic Innovations: Prior to 1982, deboning picnics required over 25 workers using knives to manually dissect out the bone from the picnic. Aside from the inevitable cuts and bruises, this work was associated with a large number of upper extremity disorders. In 1980, the company started a project to examine the possibility of automating this difficult task. A corporate methods and layout engineer worked with a Dutch food equipment manufacturer to adapt their machinery to the corporation's process. The design is based on squeezing the meat from the bone. Four Deboning Machines were introduced at one plant in 1983. The new process involved four machines and five workers (two operators, two meat inspectors, and a trucker). This equipment was subsequently installed in two other plants. The same principle was later adapted to the deboning of hams and these machines were installed in four plants. This change improved the quality of meat and yield increased slightly, but this slight increase, when multiplied by millions of hogs per year, was significant.

The company has also invented several devices, such as automatic hog splitters and hand-held skinners and markers. These inventions have been licensed for manufacturing and sale by national distributors.

Several devices available from national distributors have been modified for unique applications at the company. Examples include the development of new handles for vacuum carrying devices for manipulating heavy boxes, barrels, or bags, and modifications to Whizard knives (new handles).

The company has also developed a variety of innovations for their own use. These include bacon comb lifters; casing and film roll manipulators, bacon comb sharpeners and straighteners, and belly inverters. Projects nearing installation include automated pulling of loins and automatic trimming of bellies.

Assessment of the Plant's Ergonomics Program

Methods

The long-term effectiveness of the plant's ergonomics activities was evaluated according to changes in the plant's injury and illness statistics and the plant's annual workers' compensation costs. The injury and illness data were tabulated from available plant OSHA 200 logs (1988 through 1993). There was no data available to compare pre-implementation statistics with post-implementation statistics. Crude incidence rate, lost-time incidence rate, and percentage of recordable disorders that were "ergonomics-related" were compared as for the corporate data, using 1988 as the baseline year. Severity rate, the number of days lost or restricted per 100 workers per year, was also examined. The workers' compensation cost data were available for the years 1987 through 1993. These were compared in a manner similar to that for the corporate data.

Results

Injury and Illness Statistics: The crude incidence rate increased by approximately 64% between 1988 and 1991 (Figure 6). This pattern is similar to that noted for the corporation, but the magnitude of the increase is somewhat greater. It is suggested that this increase may drop over time, as noted for 1992 and 1993, but not necessarily to the 1988 baseline level. The lost-time incidence rate increased approximately 70% between 1988 and 1992, and a significant decrease was not observed until 1993 (Figure 7).

The plant's experience differs from the corporation's experience for this parameter, where a decrease in the lost-time incidence rate was noted each year post-implementation of the ergonomics program. Further analysis of the plant's data revealed that there was a shift in the percentage of cases with restricted days as opposed to lost days. Restricted days accounted for 26% of the total lost or restricted days in 1988 versus 60% in 1993. This

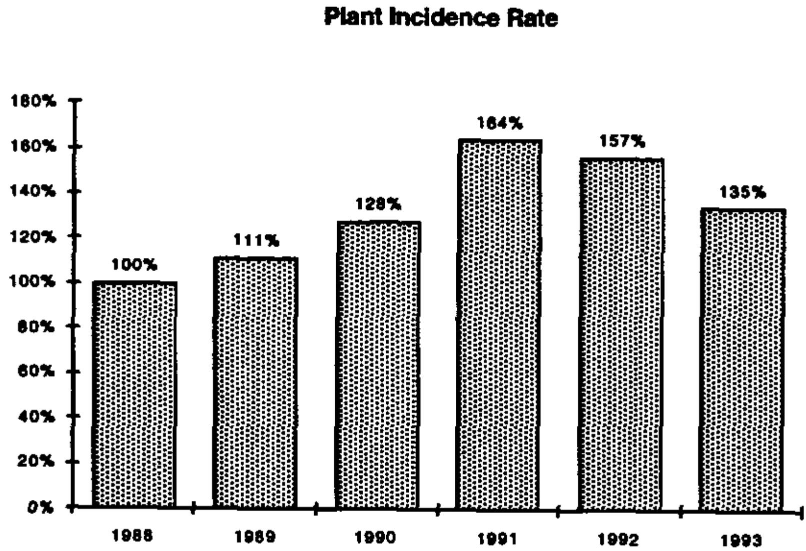

Figure 6. Percentage changes in annual plant crude incidence rate for the years 1988 through 1993 compared to 1988.

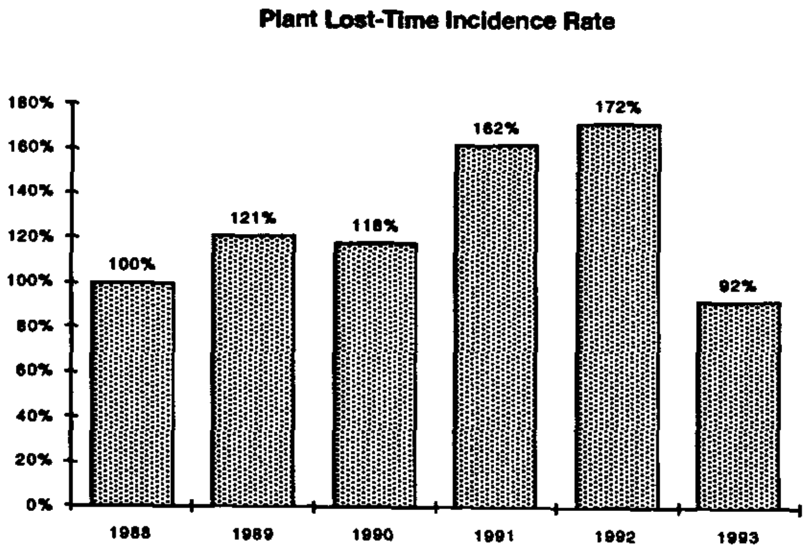

Figure 7. Percentage changes in the plant's lost-time incidence rate for years 1988 through 1993 compared to 1988.

suggests that, in combination with increased early reporting, workers are more readily assigned alternate duty assignments, thus reducing lost days while increasing restricted days.

Figure 8 illustrates the percentage changes in severity rates for years 1988 through 1993, expressed as a percentage of 1988 rates. No consistent pattern is readily evident, but there is some suggestion that the severity rate may have started to progressively decrease in recent years.

The percentage of total recordable conditions that were considered "ergonomics-related" are illustrated in Figure 9. This percentage has been almost constant at 40% during this time period. Unlike the corporate data, there has been no significant decline in this percentage during the observed post-implementation period.

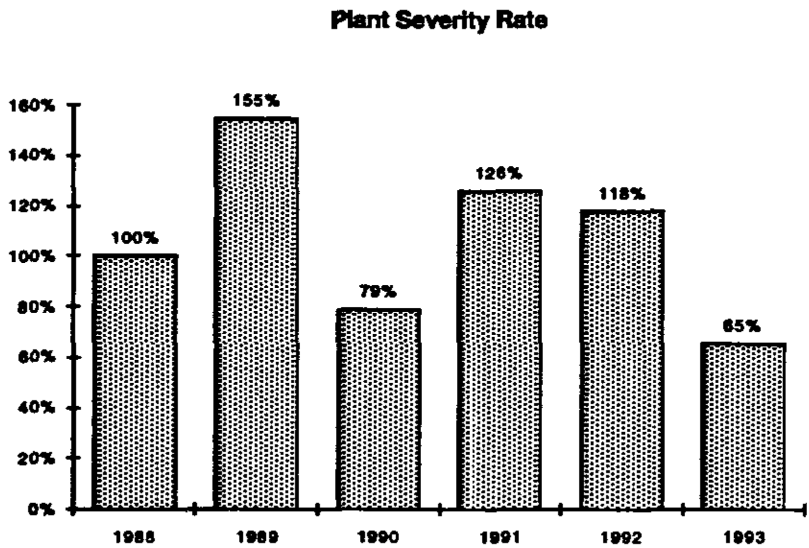

Figure 8. Percentage changes in the plant's severity rate for years 1988 through 1993 compared to 1988.

Workers' Compensation Cost: As shown in Figure 10, there is a clear pattern of decline for annual workers' compensation expenses when compared to adjusted 1987 expenses. The 1993 expenses were 20% of those in 1987 (an 80% decrease). In terms of actual dollars (unadjusted for inflation), the 1993 expenses were 39% of1987 expenses (a 61%

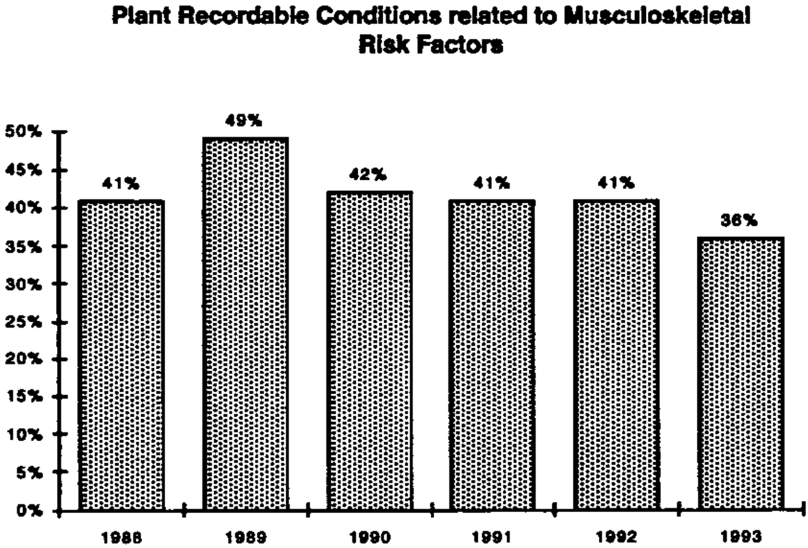

Figure 9. Percentage of total recordable conditions at the plant that were musculoskeletal conditions (e.g. strains or sprains) related to musculoskeletal risk factors (e.g. lifting, lowering, or carrying) for the years 1988 through 1993.

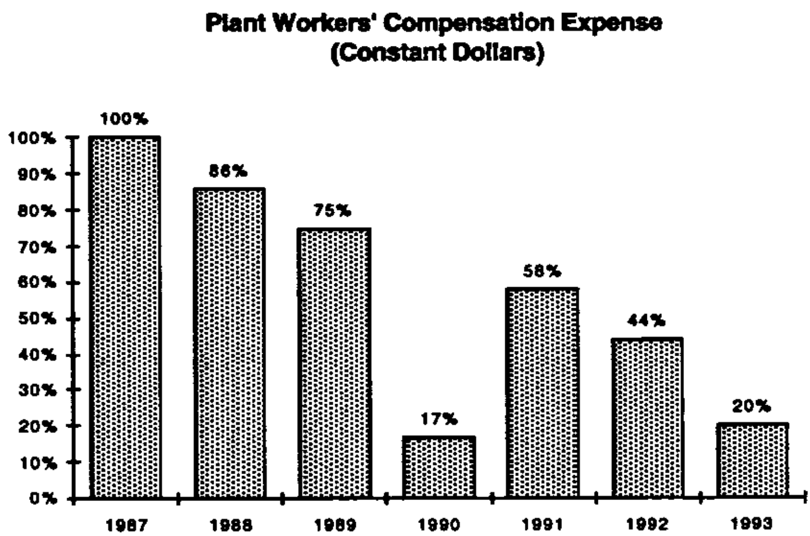

Figure 10. Percentage changes in annual plant workers' compensation expenses (constant dollars) for years 1987 through 1993 compared to 1987 expenses.

decrease). The plant did not experience the same pattern of decrease as the corporation. The corporation noted an almost exponential decrease with greater reductions in the earlier years (1988 to 1990). The plant, however, noted a more linear decrease over time.

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this case study was to demonstrate and evaluate the effectiveness of the participatory approach to solving ergonomics problems, especially problems related to the upper extremity, in the red meatpacking industry. The information in this report is primarily descriptive. Since the methodology was not experimental, e.g., there were no control or comparison groups, it was not possible to draw definitive conclusions regarding factors that caused or contributed to the observations.

The corporation involved in this project had clear and explicit documentation of management commitment for a participatory ergonomics program. This commitment was also evident through the methods chosen to implement the program and communicate its results. Employee involvement was incorporated at the time of the program's inception in 1986. As a result, the study plant also relied on participatory ergonomics methodology.

One aspect of the project was to describe the long-term effects of implementing a participatory ergonomics program in a large corporation and one of its plants. This analysis examined injury and illness statistics plus workers' compensation costs. Unfortunately, it was not possible to compare several years of pre-implementation data (pre-1986) to post-implementation data except for one measure, the lost-time incidence rate. As a result, most of the observed changes reflect the corporation's or plant's experience in the years just after implementation of the program.

At the corporate level, the following observations were noted during the years following implementation of such a program:

- A significant increase in the crude incidence rate (at least for several years);
- A marked decrease in the lost-time incidence rate;
- A significant reduction in the percentage of recordable disorders that were "ergonomics-related";
- A marked reduction in total and per capita annual workers' compensation costs;
- No adverse effect, and probably a favorable effect, on quality; and
- No adverse effect on productivity and, in general, a means to accommodate required increases in productivity.

In contrast, the plant observed the following:

- A significant increase in the crude incidence rate;
- An increase in the lost-time incidence rate, but a shift from lost days to restricted days;
- No significant change in the severity rate;
- No change in the percentage of recordables that were "ergonomics-related"; and
- An almost linear decrease in annual workers' compensation costs.

Reasons for these observed differences between the corporation and plant could not be determined in this project, but the unique hazards associated with red meat slaughtering work may be one contributing factor.

The second part of this project involved working with ergonomics teams from two departments in the plant. Overall, this component of the project demonstrated that the use of participatory ergonomics teams that rely on structured problem-solving methods are able to work effectively to address musculoskeletal hazards, especially related to the upper extremities, in the meatpacking industry. Both teams had representatives from production workers, supervision, and management. The teams' targeted jobs were some of the most difficult jobs in the plant in terms of number, severity, or cost of injuries and turnover. Subjective assessment of the teams' dynamics by the investigators revealed little need to work on team building or decision-making skills. There were, however, some differences in style between the team leaders. The Kill team leader was more personable, more accommodating to the team, and appeared to be more interested in the program and the problem-solving process than the Cut team leader. To the investigators, this difference contributed to better communication, participation, and enthusiasm among the Kill team than the Cut team. However, both teams were considered productive.

While the problem-solving process used by the teams was prescribed by the investigators, it was observed that the team members seemed to rely primarily on subjective feedback from workers performing the targeted jobs and their own subjective assessments of the jobs. Quantitative ergonomics data and methods were rarely used. It appeared that, for these jobs, the presence of a hazard was undisputed. The injury and illness data plus the worker feedback data were used to identify the body parts most adversely affected by these jobs. Videotapes and the worker feedback data were used to identify task elements that were believed related to the affected body parts. Solutions were then directed at altering these task elements. In general, both teams followed the sequence of steps recommended by the investigators. There were a few circumstances, however, when solutions were recommended prior to completion of data collection and analysis. Given the limited duration of the project, few of the developed solutions were implemented. None of the interventions were evaluated for effectiveness.

The exhibits are presented as documentation of examples of each teams' work. They are summaries that allow others to quickly examine the scope and methods of the team's data collection, data analysis, problem assessment, proposed solutions, and final recommendations. This type of summary can be used as an attachment for an appropriations request or as a reference when subsequent changes in process or productivity warrant re-evaluation of the job. While not necessarily demonstrated in these six case studies, the investigators noted that it is desirable for the committee to have members that are "hands-on" technicians or engineers that are good at design or layout and can assist in making prototypes and setting up simulations.

REFERENCES

Corporate Ergonomics Coordinator (1993). Personal communication with the Corporate Ergonomics Coordinator, Case Study #2 Corporation.

Corporate Insurance Executive (1993). Personal communication with the Corporate Insurance Executive, Case Study #2 Corporation.

Deming, WE (1986). *Out of the Crisis*. Cambridge, MA: Massachusetts Institute of Technology, Center for Advanced Engineering Study.

Local Secretary-Treasurer, UFCW, (1993). Personal communication with the Secretary-Treasurer of the Case Study #2 Plant Local United Food and Commercial Workers International Union.

Moore, JS and Garg,A (in press). "The Strain Index: A method to analyze jobs for risk of upper extremity disorders." AIHA Journal.

Scholtes, PR (1988). *The Team Handbook*. Madison, WI: Joiner Associates Inc.

Swezey, RW and Salas, E (eds.) (1992). *Teams: Their Training and Performance*. Norwood, NJ, Ablex Publishing Company.

Walton, M (1986). *The Deming Management Method*. New York, NY: Perigee Books.

CASE STUDY #3

Based on the Final Report of:

A Cooperative Agreement* with
Department of Mechanical and Industrial Engineering
Marquette University
Milwaukee, Wisconsin

Richard W. Schoenmarklin, Ph.D.
Principal Investigator
John F. Monroe
Graduate Research Assistant

*U60/CCU508726-0101