THE ERGONOMIC PROCESS
A CASE STUDY IN A NORTHERN ALBERTA LUMBER MILL

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Dedicated to the employees of the Northern Alberta Lumber Mill who participated in the Case Study.

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ABSTRACT

Key Words: *ergonomic process, ergonomic process components, ergonomic program components, consultant's role and ergonomic program model.*

The objectives of the paper were to explore the components of the ergonomic process and the role of the consultant in the development, implementation and operation of the process. The project was divided into two parts. Part one involved the formulation of the ergonomics process model. Part two examined the model within a case study format.

In part one, a literature review was completed along with key informant interviews to determine the components that should be included in an ergonomics process. The following components were identified: management commitment, employee participation, document the ergonomics program, regular program review and evaluation and the ergonomics program. Elements of the ergonomics program included: documenting the need for ergonomics, audit and identification of problem jobs, priorization of jobs, indepth analysis, hazard abatement, training and education and medical management. The following program was formulated for the case study from the aforementioned elements: obtain management commitment, document the need for ergonomics, ergonomics audit, prioritize jobs, in-depth analysis of a work station, generate solutions, implement and monitor mitigative measures.

The purposes of the case study were to: (1) examine the introduction and development of parts of the ergonomics process in a medium-sized company; (2) develop a hypothesis for future testing of an ergonomic process model. The case study was developed in a Northern Alberta lumbermill and divided into four phases. Phase one - secure management commitment, phase two - document the need for ergonomics and prioritize jobs, phase three - in-depth analysis/generate solutions/implement plan and phase four - review of the process with the ergonomics team.

It was evident from the limited literature available that further investigation is required into the ergonomics process components. The case study allowed for a preliminary exploration of the process components (developed from the literature and interviews). The case study validated both the literature and key informant interview responses as to what is important in an ergonomics process. Ideally, to validate the model several comparisons over a longer period of time should be completed, since this study was limited to one case study in one company.

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1.0 CHAPTER 1 - ERGONOMIC PROGRAMS

1.1 Introduction:

In a work environment, the ideal relationship between operators and their work reduces the probability of occupational injuries and illnesses, creates a productive environment and utilizes human resources to their highest potential, while providing the possibility for personal fulfillment for the individual (NRC, 1989). Over the past decade, company injury, accident and Workers' Compensation claims indicate that this relationship between the operator and their work may be changing.

Of all injuries, cumulative trauma disorders and other musculoskeletal injuries/disorders are of growing concern. In the United States between 1981-89 Occupational Safety and Health Agency's (OSHA) latest figures show that in all work-related injuries, cumulative trauma disorders (CTDs) rose from 18% to 52% of reported occupationally-related injuries (Owen, 1991). In 1987, over a typical eight hour shift, more than 4,000 workers are injured in Canada (Ergosystems, 1991). Of these injuries, more than 60% are related to musculoskeletal overexertion (e.g., back and repetitive strain injuries). Of those which are worker's compensation claims, approximately 33% are for repetitive strain injuries. It is evident that CTDs are not only problematic for industry in the United States, but are also a problem in Canada.

The dramatic increase in the occurrence of CTDs and other work-related disorders may be due to the following:

(1) Changes in production demands (the mismatch between the operator's capabilities and limitations and the job and work station design); and

(2) Increased awareness and reporting. (Joyce Institute, 1991)

The costs of cumulative trauma disorders (CTDs) to the company and the individual are both indirect and direct. The latter cost can range from $6,000 to 60,000 per incident, whereas indirect costs are estimated to be four times the direct costs (Ergosystems, 1991). To address rising costs and Workers Compensation Board (WCB) claims related to musculoskeletal injuries, companies are starting to introduce ergonomics. Ergonomics is one method for improving work conditions so that the relationship between the work environment and the operator is working to benefit the company, employee and society. An ergonomics program is one method of providing a structure for the integration of ergonomics in a company.

1.2 Purpose of the Study

The intent of my Masters Degree Project was to examine present ergonomic programs, evaluate their components, develop a structure for an ergonomic program, and then apply it to a case study. The project was both academic and practical in nature. The development of an ergonomic program model was academic, and its application to the case study was practical. The application of the model allowed the company to had a structure in which to implement ergonomics into their own company.

This chapter provides a broad definition of ergonomics and the systems approach, the cost and benefits of implementing an ergonomics effort, an outline of the different types of ergonomic interventions, and finally, factors initiating a program or effort.

1.3 Ergonomics and the Systems Approach:

1.3.1 Ergonomics:

A working definition of ergonomics is: "The systematic and practical application of knowledge about the psychological, physical and social attributes of human beings in the design and use of all things which affect a person's working conditions: equipment and machinery, the work environment and layout, the job itself, training and the organization of work (NRC, 1989,p.3)". Another definition for work place ergonomics by Holzner et al (1989) is that ergonomics is not just back injuries, lifting, lowering, or carrying, rather it is how the worker relates to the work environment, meaning ergonomics covers the whole job. Ergonomics examines the interaction between the worker and the environment; it strives at fitting jobs to people, not people to jobs.

1.3.2 Systems Approach:

Ergonomics can be explored through the systems approach. The systems approach, is the interaction between the person, process, and the work environment (Kantowitz and Sorkin, 1983). Sensory, mental and physical demands are placed on the operator by the requirements of the system in which the operator is operating and also by the environmental conditions (NRC, 1989). Imposed demands may under utilize or exceed the capabilities and limitations of the individual. The systems approach allows one to evaluate the situation as interactive rather than static. For example, a task may require an operator to lift nine kilogram boxes, in a cold environment in a short period of time. In ideal circumstances the operator may be able to comfortably lift nine kilograms, but with the time restraint and cool temperature he now has to labour intensely to lift each box. The initial requirement is not beyond his capability, but due

to the other issues, such as the environmental conditions and the work pace, the requirements are now beyond his capability, thus, not only placing him at risk of injury, but also risking damage to the box. If the interaction is not considered in an evaluation of the job, the wrong conclusions could be made especially when looking at job design and task requirements.

In order to achieve an ideal relationship between the operator and their work environment the following aspects are important to consider and incorporate when planning an effort to balance the relationship:

- determine the objectives of the system as a whole in terms of productivity, work quality, health and safety;
- determine the functions/demands required to fulfill the system objectives;
- identify conditions under which these functions take place;
- identify the sensory, mental and physical demands of different tasks in relation to the targeted user group;
- evaluate task demands according to the criteria set for individual performance, system performance and health and safety;
- evaluate task demands according to the user group through a balanced planning of these intervention strategies:

    - engineering controls - design products, equipment, tools, furniture, environment, procedures and the organization of work;
    - administrative controls - policies and procedures established for tasks that are in question; and
    - training and education - to bring skill level and knowledge in line with task demands.

(NRC, 1989)

When a systems approach is used to improve the interaction between the operator and the work environment, it is a holistic approach in the analysis and generation of solutions to solve the mismatch between operators and work.

1.4 Benefits of Utilizing Ergonomics

1.4.1 Work place Benefits

An ergonomics effort can benefit a company in a variety of ways: improved health and well-being of the worker through the reduction of job-related injuries and illness, increased operator job satisfaction, improved quality of work and product, and improved productivity (both on an individual basis and collectively as an organization) (Durante, 1989). Eastman Kodak (1983) also believes that ergonomics can reduce the number of problematic work tasks that may make a job difficult to staff and increase the number of jobs that could be staffed by women and older workers. In the Ford process (1987), reduced absenteeism and turnover were also identified as positive outcomes of the ergonomic process. Alexander (1986) broke down the cost savings to production (summarized in table 1) and the accident and medical costs (summarized in table 2).

Table 1 - Summary of ergonomic intervention and potential for improvements

	INTERVENTION	POTENTIAL RESULT
PRODUCTION	• improved work methods	• productivity improves
	• improved equipment accessibility	• reduced time to repair equipment
	• improved inspection	• fewer shipping errors
	• better control	• fewer operational errors

Table 2 - Accident and Medical Costs

Direct Costs	• injury ▸ medical treatment ▸ lost work hours ▸ any make up wages paid to supplement disability income • long term disability paid to a worker no longer able to work • damaged equipment • damaged or lost products
Indirect Costs	• a worker no longer able to work at 100%, not able to keep up with the work place being able to perform the task • down-time resulting from the accident (accident investigation or repair of damaged equipment) • hiring and training replacement workers • review meetings

It is important that a company become aware of the benefits that can be obtained by utilizing ergonomics on a regular basis in all aspects of the company. Most benefits will not be seen immediately, but instead will be realized over the long term through review of safety and production data.

1.4.2 Ergonomics Efforts - (Goodyear Tire and Rubber Company and A.T. Cross)

At the Goodyear Tire and Rubber Company an ergonomics effort was initiated in 1986. The effort consisted of two phases: an initial ergonomics intervention and a pilot program. To evaluate the success of the ergonomics effort, lost time incident rates were examined over a five year period in two plants. The rates reported dealt with actual lost days from work for a work related injury or illness. Rates are presented below in Table 3:

Table 3 - Lost-time Incident Rate Comparison Logan and St. Mary Plants (Year End Statistics - per 100 employees)

PLANT	1984	1985	1986	1987	1988
Logan	4.9	4.4	4.5*	0.8	0.9
St. Mary's	9.7	5.6	8.9	(7.4/08)+	2.6

* initial ergonomics intervention, 10-86
\+ pilot training program - 9-87. YTD 8-878 (7.4)
(Geras, Pepper and Rodgers, 1989)

At Logan the number of lost-time cases dropped from 55 in 1986 to 8 in 1988 (Moretz, 1989). Both plants documented a reduction in lost time incident rates after the intervention and training program (Geras, Pepper and Rodgers, 1989).

Another instance where ergonomic analysis and reduction in ergonomic related risk factors took place is at A.T. Cross, the penmaker. In 1988 an initial analysis identified areas where workers frequently showed up with back strain among operators doing bench work, such as assembling pen cartridges. The company introduced new chairs and work benches so that the operators could sit or stand. The impact of the changes in the first year were dramatic: a 43% reduction in injuries involving lost-time and a 71% drop in total lost days (Fefer, 1992).

These two examples illustrate the effectiveness of an ergonomics effort, but it must be pointed out that there are a number of ways to apply ergonomics: in-plant studies, design of facilities and equipment, product design, and an ergonomics program.

1.5 An Ergonomics Effort

There are a variety of methods used when introducing or utilizing ergonomics. An ergonomics effort can be introduced to a company either as a short term intervention, such as a A.T. Cross in 1988, or as an on-going program as its own entity as in Ford

and General Motors, or as a component of an overall health and safety program. A project intervention is usually reactive in nature responding to a work-related injury or accident or an effort to control an increase in WCB claims or accident rates. Often an ergonomist will be asked to conduct an analysis of an area and provide recommendations for change within the work environment. Project-level ergonomics can provide work station or job specific analysis and recommendations, general ergonomics awareness, and the initiation factor to support the start up of an ergonomics program. A project may encompass an analysis and provision of recommendations, but, due to limited resources and lack of top management commitment, recommendations may not be implemented. Thus, project level ergonomics alone only has a short term impact and is not effective for inclusion of ergonomics in the long term goals and objectives of a company. An ergonomics program may provide the structure necessary to establish inclusion over the long term. Project level ergonomics should be part of an overall ergonomics program. A program establishes the structure, method and resources to:

(1) identify problems or potential problem areas;
(2) analyze problem areas;
(3) implement modifications; and
(4) measure the effectiveness of an ergonomics effort.

(Alexander, 1986)

1.6 What initiates an Ergonomics Effort?

Driving forces to initiate ergonomics in a company may be internal or external in nature. The following are internal events that occur that may allow for an ergonomics effort (project or program) to take place: (1) an incident/accident occurs so it is reactive in nature; or (2) a "champion" of ergonomics believes in the potential benefits of ergonomics and initiates an effort-which can be both reactive and proactive in nature

(Attwood, 1987). Alexander (1986) identified six events that may initiate an internal effort: (1) information regarding a particular topic is covered in a trade magazine or technical journal; (2) a competitor utilizes ergonomics and obtains a marketing advantage; (3) information provided by the trade association sparks the curiosity of upper level management; (4) an accident or injury occurs and the company reacts by engaging in an ergonomics effort; (5) a recent graduate starts to talk about the benefits of employing ergonomics from a production point of view; and (6) colleagues get together to talk about how to better utilize the person in the production process.

External forces also have an impact on the initiation of an ergonomics program. In a survey of corporations, four external forces were identified that push a company to initiate an ergonomics program: legislation, competition, organized labour and outside suppliers (Attwood, 1987).

1.6.1 Legislation

Legislation or pending legislation frequently drives a company to start an effort in ergonomics (Attwood, 1987). In many countries specific legislation pertaining to ergonomics has been initiated and implemented. In the United States, a bill pertaining to video display terminal (VDT) use was instituted in the city and county of San Francisco and in New York State. Both ordinances were struck down in the local courts (Occupational Hazards, 1992). In 1990, the Council of the European Communities issued a directive-89/391/EEC in cooperation with the European parliament stating that "ergonomic aspects are of particular importance for a work station with display screen equipment." The directive then laid out guidelines to be followed. "Employers shall be obliged to perform an analysis of work station in order to evaluate

the safety and health conditions," and "appropriate measures to remedy the risk found." The directive also stated that, "member states shall bring into force the laws, regulations and administrative provisions necessary to comply with the directive by December 31, 1992" (Joyce Institute, 1991). In many countries, legislation has been initiated and has moved companies toward an ergonomics effort or program.

1.6.1.1 VDT Legislation:

In the United States, 38 states have passed legislative bills that would restrict the use of VDT's in offices. In San Francisco a "VDT" ordinance has been passed that stated, "the Board of Supervisors of the City and County of San Francisco find and declares that it shall be the public policy of the city and county of San Francisco to provide public and private sector employees who operate video display terminals within the city and county of San Francisco with a safe and healthy work environment" (excerpt taken from the publication, "The Ergonomic Perspective on The San Francisco VDT Ordinance" Joyce Institute, 1991). The ordinance would have effected approximately 56,000 workers. Compliance requirements were as follows: all employers with fifteen or more employees were to comply to the following schedule.

- "after one year, all newly purchased VDT's, desks and chairs must meet minimum ergonomic requirements specified by the ordinance;
- after three months, employers must spend up to $250 for each existing work station to ensure that it meets the standard;
- After four years, all work stations must comply, regardless of costs;
- within two years, employers must provide fifteen minutes aggregate alternative work breaks every two hours to all workers who perform repetitive keyboard motions for four or more hours a day;
- within six months, employers must begin providing extensive ergonomic training and education, which must be updated annually as well as provided to all new hires."

(Joyce Institute, 1991, p.1)

To date, other states and cities are evaluating and considering similar legislation (Joyce Institute, 1991). In Canada, VDT related bills have been introduced into provincial legislatures, but none are currently active. The very presence of legislative activity can have a direct effect on program development and the establishment of policy before a bill is ever passed (Attwood, 1987).

Another driving force in the United States for the development of ergonomics programs is the regulatory power of the Occupational Safety and Health Agency. In the past few years they have been enforcing and laying fines for infringement on health and safety violations. A maximum penalty for a single violation can be up to $10,000 (Moore, 1990). These fines can also be applied to identified ergonomic hazards.

1.6.1.2 OSHA Proposed Ergonomic Standard

In the United States in 1970, the OSHA Act was instituted and it states that it is the general duty of the employer to provide their employees with a work environment that is absent from recognized serious hazards. This included the presence of ergonomic hazards. In 1989, OSHA introduced preliminary guidelines to provide a framework for their ergonomic programs. OSHA recognizes that the guidelines are a framework for an ergonomics program, and must be altered according to the company's size and function (Joyce Institute, 1991). The goal of the proposed standards in terms of ergonomics is to eliminate or reduce work exposure to ergonomic hazards that lead to cumulative trauma disorders and related injuries and illnesses (OSHA, 1989).

In the United States a number of companies have started to incorporate ergonomics as a single program or as a component of a larger occupational health and safety program.

1.6.1.3 National Research Council (NRC) Role of ergonomics in Provisions of Occupation Health and Safety Legislation

In Canada, none of the provincial Occupational Health and Safety authorities have to date introduced program guidelines. In 1989, a publication sponsored by the National Research Council of Canada investigated the role of ergonomics in implementing occupational health and safety legislation. The study encompassed a number of questions addressing the issue. From the results, information concerning legislation, agencies and programs was obtained.

Even though the term ergonomics is not mentioned in present legislation, all provincial governments have some form of a general act under which a number of varying codes and regulations are proclaimed. It is evident that there was a degree of ergonomic influence in job and work place design criteria in legislation and/or regulatory programs. In terms of enforcement, ergonomics was implied rather than defined in specified orders. For example, the mission statement of Alberta Occupational Health and Safety states that they exist, "To enhance the Health and Safety of Alberta's Workers" (AOHS, 1991). They achieve their mission through activities directed at: (1) increasing the adoption of safe and healthy work practices by employers and workers; (2) achieving a healthy and safe work environment; and (3) increasing public awareness of the importance and benefits of work place health and safety. Nowhere in its broad statement is ergonomics specifically noted but it is implied in both statements one and two. In terms of legislation, both provincially and federally, the NRC reported that there were no plans to change existing ergonomic-related legislation or regulations.

In terms of government agencies, responsible agencies in Canada are associated with labor compensation or health departments. The overall mission of an organization will have an impact on how legislation is directed and the resources that are available

within it for program activities in health and safety generally, and in ergonomics, specifically.

Finally in terms of programs, most agencies do not have a specific program job title or division dedicated to ergonomics. It is important to note that to date both the Alberta Occupational Health and Safety Agency and the Workers' Compensation Board have formulated programs and have designated ergonomists on staff.

The recommendations that came out of the NRC report encouraged provincial Occupational Health and Safety Agencies to: (1) identify policy statements concerning its direction for integrating ergonomics; (2) provide staff, program areas and assign responsibility for the coordination of ergonomic applications within the agency; (3) have each government review its existing legislative program with respect to its potential for using ergonomics to fulfill its occupational health and safety mandate; (4) ensure governments convene a workshop on legislation and ergonomics bringing together various sectors to ergonomics; and (5) review legislative practices in other countries in order to gain insight into alternative models for integrating ergonomics into legislative and enforcement programs (NRC, 1989).

The NRC report provided some direction for Canadian agencies to be able to formulate legislation pertaining to ergonomics. It is evident from the information provided that the United States and Europe have provided legislation, direction and enforcement of ergonomics. In Canada, Occupational Health and Safety agencies have not yet formulated guidelines for program development. Some agencies are now employing staff and developing programs internally, providing specific direction for companies developing and implementing an ergonomics effort.

1.6.2 Competition

Competition is another factor that drives a company to start an ergonomics program. Often a company realizes that the proper application of ergonomics can provide an edge over a competitor that does not apply the discipline of ergonomics (Attwood, 1987). Companies are also starting to see the relationship between injury prevention and improved productivity and quality (Joyce Institute, 1991). For example, Milton Bradley, the games manufacturer, showed a 90 percent jump in quality in the packaging area after ergonomics was applied in the form of engineering controls. In addition, they saw a drop in CTDs of the upper limbs and back at the packing job which accounted for 10 percent of all CTDs.

1.6.3 Organized Labor

Organized labor is another driving force that is becoming more powerful and informed about work issues. In the United States, Moore (1990) states that employees are becoming more aware of work place hazards due to (1) increased media attention on hazards; (2) the recent regulatory attention regarding issues such as communication of hazards and limitation on exposure to toxic chemicals; (3) increased use of criminal laws in cases of work place accidents; and (4) OSHA's penalty policy. Drewczynski (1986) reported that 40% of all ergonomic inquiries received by the Canadian Centre of Occupational Health and Safety were from workers or representative of the employee population. Employee groups are now seeking the inclusion of ergonomics in collective agreements such as at the Ford Motor Company (Ford Process, 1987).

Associations are also getting together and calling for a association standards on reducing work related injuries and illnesses. For example, the National Union of

Journalists put forth a motion calling for a campaign promoting awareness about repetitive strain injuries (RSIs). The group called for the formulation of a code of practice on the avoidance of repetitive strain injuries (RSIs) which should include the following recommendations:

- "reasonable ergonomic equipment and work environment
- frequent breaks, at least every hour from computer terminals
- reduction of social isolation that screen use can involve
- training for keyboard users in the ergonomic principles that reduce the likelihood of contracting RSIs
- work place procedures for the reporting of symptoms of RSIs as soon as they are noticed
- workers who suspect they may be affected to be urged to see their own doctors as well as company doctors
- exercise programs away from the work station
- record-keeping of the incidence of RSIs in the work place
- regular reviews of equipment and work practices".

(Morgan, 1991)

Organized labor is becoming more aware of and demanding safe work environments. Companies are meeting many employee concerns and needs through the introduction of an ergonomics program.

1.6.4 Outside Suppliers

Many products now bear a title or statement indicating that they are ergonomically designed. Many office chairs and other furniture items claim that they are ergonomically designed. Companies may be sparked to investigate the meaning of this statement and may therefore seek to utilize equipment that promotes better user comfort and ease of operation. This may encourage a company to develop set procedures for purchasing or it may encourage engineers to incorporate ergonomic principles into plant or work station design.

1.7 Conclusion:

In a work environment, the ideal relationship between operators and their work reduces the probability of occupational injuries/illness, creates a productive environment, utilizes human resources at their highest potential, while providing personal fulfillment for the individual (NRC, 1989). Over the past decade company injury and/or accidents and Workers' Compensations Claims indicate that this ideal relationship between the operator and their work may be changing. Ergonomics is one method of improving work conditions so that the relationship between the work environment and the operator benefits the company, employee and society. Driving forces to initiate ergonomics into a company may be internal or external in nature. There may be a number of factors that encourage an organization to engage in ergonomics. This may be at a project or program level. Both levels will bring awareness to a company in the short term, but an ergonomics program will provide a structure for inclusion of ergonomics over the long term.

The following chapters are divided into three parts. Part one addresses the methodology, literature review, key informant interviews and the program model that will be used in the case study. Part two includes the case study and part three summarizes the project conclusions.

PART 1

CHAPTER 2 - ERGONOMIC PROGRAM MODEL STUDY DESIGN

2.1 Introduction

To date very little has been published on the development and implementation of an ergonomics program. This paper reviews current literature and reports and interviews with ergonomic consultants and company ergonomists in order to develop a framework for an ergonomics program. The framework, once developed, will be applied to a case study to examine its relevance to a medium-sized company.

2.2 Objectives

1. To interview company ergonomists and external consultants to: (1) identify components and elements that should be included in an ergonomics program; (2) identify the role of a consulting ergonomist in an ergonomics effort and/or program; and (3) identify the role of employee participation in an effort and/or program.
2. To develop a model for an ergonomic program based on the data gathered.

2.3 Research Questions

1. What components are required in an ergonomic program? It will be important to determine which components are necessary and for what reasons they are required. Each component will then be reviewed to determine its content and how it fits into the structure of the ergonomic program.

2. Who needs to be included in the ergonomic program to ensure long term success? It is important to determine which departments should be included and how they can contribute to the program.
3. How is an ergonomic program different when there is not a full-time ergonomist on staff? Many companies are not large enough to hire a full-time ergonomist.
4. What is the role of a consulting ergonomist? A consultant may have to be brought in to provide expertise in ergonomics. How would this consultant facilitate the function of an ergonomic program?

2.4 Study Design

2.4.1 Phase 1 - Formulation of the Ergonomic Program Model

Formulation of the ergonomic program model was based on the information gathered from both reviewing pertinent literature and from interviews conducted with key informants in both academic and industrial settings.

2.4.1.1 Literature review

Literature pertaining to the development and implementation of an ergonomic program was reviewed. This literature available was limited and much of it focused on preexisting published programs. The "Preliminary Guidelines for Ergonomic Programs" (1990) formulated by Occupational Safety and Health Administration in the United States was used as a starting framework to which other available programs and guidelines were compared. The OSHA preliminary ergonomic program guidelines were chosen as a comparative framework since access to the guidelines is nation-wide in the United States and at present no such guidelines exist in Canada.

The literature review was divided into the following sections: (1) factors required for a successful program; (2) program elements identified in existing programs; (3) employee participation; and (4) the role of the consulting ergonomist in the formulation and continuance of an on-site ergonomics program. Chapter 3 summarizes the information obtained in the literature review.

2.4.1.2 Key Informant Interviews

The purpose of conducting key informant interviews was to obtain information regarding: (1) the identification of key elements that should be included in an ergonomics program; (2) the role of the consulting ergonomist; and (3) the role of the employee population in the ergonomics program.

Subjects

The sample size was twenty participants, eight of which were full-time ergonomists on staff within a company and the other twelve were external consulting ergonomists. The sample was drawn from both the directory of the Human Factors Society in the United States and the directory published by the Human Factors Association of Canada. The sampling procedure used was the "systematic sample" (Oyster, Hanten and Llorens, 1987), as all sampled participants were chosen from a set of criteria. The criteria utilized for selection were as follows: (1) all must have been practicing ergonomists-either a company ergonomist or an external consultant; (2) each participant must have expertise in industrial ergonomics; and (3) each participant had to consent to an interview once they had been fully informed of the goals and objectives of the study. Interviews were conducted with those individuals who met the aforementioned criteria, those that agreed to participate were included in the convenience sample.

Design of the Questions for the Interview

The interview questions were based on the same issues investigated in the literature as outlined in Section 2.3 Research Questions. The initial draft was formulated and pretested on 3 academic colleagues. Problem areas were identified and were reworded or omitted as needed.

Method

A letter or phone call was presented to each potential participant to inform them of the goals and objectives of the study. If the participant consented to the interview, a time was arranged for personal interview. Unfortunately, one of the interviews could not be done in person due to geographical limitations. Thus, one of the consulting ergonomists was interviewed over the telephone.

The interview was standardized; designed to collect information from each participant on a set of issues related to ergonomic programming. The standardized format allowed for the identification of issues to be comparable and classifiable (Oyster, Hanten, and Lloren, 1987). The interviews were pre-scheduled, with all the questions predetermined and set out in an established order.

Open-ended questions were used. The questions sought to obtain descriptive responses regarding: (1) components and elements that should be included in an ergonomics program; (2) the role of an external consultant; and (3) the role of employee participation.

All responses were kept confidential and were reported in the study as overall group responses. A copy of the questionnaire is provided below:

Company

Interviewed subject:

Role in the Organization:

1. *What elements do you feel are necessary in a company ergonomics program?*

2. *What makes up each of these elements?*

3. *Who do you feel needs to be involved in the ergonomics program and why?*

4. *How do you measure success of your program or an ergonomics intervention?*

   Do you have a case study to illustrate this point?

5. a. *for internal ergonomists:*
   Is ergonomics its own separate section or does it fall under another department?

   b. *for the external consultant:*
   Under what department should ergonomics be?

6. *In a small-medium sized company (< 300 employees) how would a program have to change if there was not an ergonomist on staff?*

7. *What role would a consulting ergonomist play?*

8. *What is the role of an ergonomics committee and how would it function in an organization?*

Coding Responses

Two methods can be used to code responses, either word or concept coding. Concept coding is the preferred method, since it provides more meaningful information as opposed to word coding (Oyster, Hanten and Llorens, 1987).

In this study, concept and word coding were both utilized. Each concept code and definition is provided in Chapter four - "Key informant interviews" along with the responses. Data was interpreted as overall group responses - percentages for each question are provided.

3.0 CHAPTER 3 - LITERATURE REVIEW

3.1 Introduction:

In 1973, United Auto Workers and General Motors began a cooperative effort to address occupational health and safety records (Mohr and Fielder, 1989). The following are some of the reasons why the effort lacked long term success: (1) minimal involvement by the employees: (2) the ergonomics program was not a part of the business goals set by the company; and (3) labor-management history hindered the process of change (Mohr and Fielder, 1989).

Village (1991) describes a variety of obstacles that interfere with the implementation of ergonomics in the work place: (1) supervisors are concerned about the effects ergonomics will have on the productivity of workers; (2) there is a strain on the economic and personnel resources of the organization; (3) manufacturers are unwilling to customize products for specific user needs; and (4) an organization's resistance to change. Village (1991) goes on to say that in order to have a successful application of ergonomics in a company, both management and the employees must be involved and communication must take place between all levels of personnel within the organization. It is also important that the ergonomics program fit into the organizational structure of the company in order for it to operate efficiently (AMI and Ergotech Inc., 1990). Furthermore, it is important that a company trying to develop an ergonomics program understands all the components of a successful program and is able to obtain support financially and technically to implement an ergonomics effort or program.

In general, very little has been published on ergonomics programs, and no information was located that dealt with the aforementioned issue of developing an

ergonomics program without a full-time ergonomics staff person. The following sections review: (1) what is needed for implementation of a program; (2) program components consistent in the literature across companies; (3) the OSHA preliminary guidelines; (4) participatory ergonomics; and (5) the role of the ergonomics consultant in an ergonomics effort.

3.2 Critical Aspects in Implementing an Ergonomics Program

Alexander and Pulat (1986) identified five aspects that are critical to successfully implement an ergonomics program:

(1) A broad base of support for the program within the company;
(2) an understanding of the users' needs;
(3) organizational members must be aware and interested in industrial ergonomics;
(4) a way of making it work; and
(5) a way of creating a lasting change.

The following sections will investigate each of the aforementioned issues that aid in the implementation of an ergonomics program.

3.2.1 Broad-Based Support

A company's approach to the development and implementation of an ergonomics program will depend on the company's organizational structure, management style and size. A company may chose to develop the base of support for the program through a multilevel committee structure or alternately, require the program to sustain itself (Alexander and Pulat, 1986). For example, at Eastman Kodak and General Motors, each division has its own ergonomics committee that deals with issues that are pertinent to that particular work area (confidential communications with company, 1991). This does not

mean that a company with only one committee does not need a full multi-level base of support. A single committee or champion will have a harder time establishing and maintaining a program, but if members are from a variety of levels it can still achieve success over the long term. The champion and single committee approach is used in small to medium sized companies. A good illustration of this is seen with the formation of most occupational health and safety programs in smaller companies. It is started by a company employee who is interested and/or is requested by management to champion a health and safety program. In many companies, ergonomics will fall under an existing program or evolve in the same manner as an occupational health program.

It is important that the ergonomics program is endorsed by top level management (Taylor, 1990). Overall support will not occur until the program is seen as an activity supporting the company's goals (Alexander and Pulat 1986; Blanche, Tuscany and Tsai, 1989). If management is not sold on the ergonomics program, the chance for long term success and company-wide support at all levels will be difficult to achieve and sustain. Individuals at all levels must visibly see the commitment by management through policies and procedures and the provision of organizational resources to develop and implement an ergonomics effort (AMI and Ergotech, 1990). Individual support will come as individuals have their own experience with the success of the effort (alexander and Pulat, 1986). For the manager, it means improving performance parameters such as safety, quality or productivity. For the engineer, it means helping to solve a design problem (Alexander, 1986 and OSHA, 1990).

To build a multilevel base of support, a two step process can be utilized: (1) users must have a favourable introduction to an ergonomics program or effort and what it can do for them; and (2) users must have a favourable experience when they use

ergonomics initially (Alexander and Pulat, 1986). In order to achieve these two goals it is important that the users' needs are identified and a plan of action is established to address those needs (Alexander and Pulat, 1986). An understanding of the users needs will help focus and develop the awareness for an ergonomics effort in a company. Liker (1987) and Coughenour et al. (1986) stated that training and communication is essential for the success of an ergonomics program. Training, education and communication at all levels should establish commitment. If this is established in the early stages of program development and implementation, the organizational resources and motivating force should be able to be established over the long term (AMI and Ergotech, 1990).

3.2.2 Establishing the Users' Needs

A number of different areas must be represented and targeted in the initial presentation of ergonomics. It is important to determine the users' needs and develop a presentation addressing some of those needs. The following groups need to be considered when developing ergonomics awareness training: operators or first-line supervisors, line supervisors, managers, designers and engineers, and other specialized groups such as medical, safety, industrial hygiene, purchasing and maintenance personnel. There is a basic level of information and awareness that is required by each group. After this basic level is met, the group's needs and requirements for information will differ. This basic information should define the ergonomic program objectives, define musculoskeletal injuries, describe possible contributing factors related to these disorders and then describe what the company can do to improve and maintain safe and healthy working conditions (Alexander and Pulat, 1986).

Operators/First-line Supervisors:

These individuals work on the line every day and are exposed to ergonomic risk factors throughout the work day. Operators and first line supervisors must have a working knowledge of ergonomics so they can recognize ergonomic risk factors that currently exist on the line (Alexander and Pulat, 1986). Training should be related and appropriate to their jobs (AMI and Ergotech, 1990).

Supervisors

The key for supervisor awareness is to be able to recognize ergonomic problems on the line just as the operators and first line supervisor. It is important the awareness is taken a step further to recognize the benefit of allocating resources and to recognize problems in new designs (Alexander, 1986).

Managers

An appeal to the management level should be made based on the long term interests of the whole organization, with specifics that detail problem correction (Alexander, 1986). Alexander (1986) identified two areas for management to be educated about:

(1) ensure the resources are available to investigate and mitigate problems; and

(2) support the resources designated both financially and in terms of manpower within the company to mitigate problems evident in present operations.

AMI and Ergotech (1990) identified that the type of education received must inform management on the need for intervention, reduction and/or elimination of ergonomic risk factors and allocation of resources for implementation of changes in job and work station design.

Designers and Engineers

The designer and engineer need a good understanding of problem identification and problem solution, as these individuals investigate various problems and formulate the appropriate solution to mitigate the problem. Rodgers and Armstrong (1977) stated,

> *"The design manager must conduct a cost effective program under definite schedule constraints. He and his designer, therefore, may tend to resist changes which increase cost or delay schedules with no apparent immediate benefit. Manager and designer resistance... may be reduced by convincing evidence that human factors can be cost effective within normal schedule constraints".*

These individuals have the ability to approach a problem in the pre-design and design phases of a project, thus taking a more proactive approach to ergonomics.

Medical and Safety staff

In Alexander's (1986) listing of user groups to be targeted, safety and health were not mentioned. According to the OSHA preliminary guidelines (1990) this group can document trends within an organization, provide a screening method for early identification of a cumulative trauma disorder and aid in modified and successful return to work. It is important that this group is well informed of ergonomics, ergonomic risk factors and how their role and participation fits within the overall program.

3.2.3 Creating Interest and Awareness

Awareness training is aimed for the application of ergonomics and to provide a means for increasing skills of the users (Liker, 1987). Each presentation will be different in order to meet the user group's needs and identify the user's role within the program. It is important that presentations are made from the top down in order to first secure management commitment before proceeding to the other user groups (Alexander, 1986). Securing a commitment from management, will allow for the expansion of the awareness training and development of broad-based support. Seeking top level commitment first, before presentation, will prevent expectations from being crushed should commitment not be secured before the program is ever started.

3.2.4 Creating a structure

It is important that the program has a structure that will allow for problem identification, problem formulation, information gathering, solution development, and justification of the solution (Alexander, 1986). It is also important that the structure allows for implementation of the solution and follow-up once the solution is in place to determine if it is mitigating the hazard (Ergosystems, 1991).

It is important to realize that the only way that ergonomics will have a lasting impact is if it becomes part of the organizational culture. An ergonomics program must also fit into the organizational structure of the company in order for it to operate efficiently (AMI and ErgoTech, Inc., 1990). Ergonomics must be placed on the same level as production, costs and personnel relations (Taylor, 1990). An ergonomics program provides the company with a structure that can be implemented within the company's business goals over the long term.

3.3. A Framework for an Ergonomics Program

The following section outlines the framework provided by OSHA (1990) titled, "OSHA Preliminary Ergonomic Program Guidelines", the UAW-Ford Process, the UAW-GM Process and the AMI and Ergotech venture. The latter provide guidelines for the meat packing industry. All of these programs and/or guidelines meet the preliminary guidelines provided by the OSHA document. Further, they also venture into more detail regarding the monitoring and feedback of implemented solutions.

A review of all four programs and/or guidelines will establish a structure for the framework of an ergonomics program. The program and/or guidelines will be reviewed to establish the components that should be encompassed in the start up and implementation of a program and the elements that should be included in an ergonomics program. The following sections will examine management commitment, employee involvement, program elements and training, and evaluation as presented in all four programs and/or guidelines.

3.3.1 Management Commitment:

All of the program structures reviewed documented the need for commitment from top level management. Management commitment provides the organizational resources and "motivating forces" required to identify, evaluate and mitigate ergonomic hazards (OSHA, 1990). The OSHA preliminary ergonomic program guidelines (1990) identify five points supporting the need for management commitment. They are as follows: (1) eliminating ergonomic hazards is made a priority of the company; (2) policy places health and safety on the same level as production, viewing the interaction between the production process and the impact it has on the health and safety of the operator

(health and safety becomes a daily activity within production); (3) assignment and communication of responsibility for various aspects of the program; (4) provide adequate authority and resources to all responsible parties, so that assigned responsibilities can be met; and (5) ensure accountability of individuals for carrying out assigned responsibilities. Commitment at all levels will secure ownership by all employees over the long term, as, in order for a program to be successful, it requires the endorsement of top management (Taylor, 1986).

3.3.2 Employee Participation and Involvement

Employee involvement and feedback is important to identify existing and potential ergonomic hazards, and important to develop and implement effective ways to abate such hazards (OSHA, 1990). According to Johnson et al. (1991) employees and/or frontline operators should be involved throughout the program. They should be trained on how to report problems, analyze jobs, support improvements and participate in implementing change. Many solutions will be generated from operators, production people and line operators (Noro, 1991).

Imada (1991) provides three reasons for involving people in the development and implementation of ergonomic technology:

> "1. Ergonomics in and of itself is an intuitive science. In many cases it simply provides names, and labels for ideas, principles or practices that workers are already using. In one sense it legitimizes the ideas and experiences that the workers have accumulated in the process of doing their jobs.

2. Ownership in ideas enhances the likelihood of implementing ergonomics successfully. People are more likely to support projects for which they feel ownership. In the long run, this has implications for a more involved and dedicated work force committed to problem-solving. It is important that the group understands that they can have an impact on the problem-solving of problems and implementation of solutions.

3. End-user participation developing technology creates a flexible problem-solving tool. That is, if people implement technology, they are more likely to modify it in the future as new problems arise." (p.30-1)

In the past, the traditional ergonomic scenario was that of an ergonomic consultant hired to solve a problem. When the problem emerged again or needed to be modified, the solution needed to be re-evaluated and then implemented with the aid of the consultant. In the short term this may be cost effective, but in the long term, it has negative effects for two reasons: (1) problems are solved on a case-by-case agenda rather than by recognition of a general problem allowing for generalization to other situations; and (2) by not involving employees in job or work station modification or evaluation it conveys to the worker that he/she is not capable of solving problems. Participation recognizes the worker as a valuable resource (Imada, 1991).

Lawler et al. (1986) suggested additional reasons why employee participation is essential:

"1. Individuals are becoming more specialized in their work activities, acting more as problem-solvers who make pertinent decisions. At the same time, new technologies allow people to have greater control over their work. This means that 'effective performance' is not always measurable by traditional standards since it is more difficult to measure the quality of a decision than to measure the number of keystrokes.

2. Changes in the work-force are occurring as people are generally better educated, more knowledgeable about workers' rights and hesitant about accepting 'orders' simply because of a persons' position of power.

3. Many people want control over their work." (p.711)

Participative systems seem to foster positive user attitudes when implementing new technology (Lawler, 1986; and Mumford, 1987). To illustrate this point, a comparative study between Japanese auto plants and U.S. auto plants conducted by Liker, Nagamachi and Lifshitz (1989) was examined. In the Japanese plants, 72% of workers participated in workstation or production modification, while, in the U.S. plants only 19% participated.

It is important to highlight that the Japanese auto plants use a quality circle model. The philosophy of quality circles lays in the responsibilities and requirement for direct participation in continual improvements of employees work. Thus, the work culture has been set up to encourage active participation. It was evident from the research that ergonomic technology used in Japanese firms for evaluating jobs was based more on qualitative judgements rather than quantative measures allowing them to be much more self-sufficient as compared to the U.S. firms. The result was a higher number of work station modifications in the Japanese auto plants. This is consistent with the literature that worker participation is an important factor in successfully modifying a work station (Chaney, 1969; Pasmore and Friedlander, 1982; and Pope, 1987).

In another example, participation was strongly associated with unique changes, while the engineering approach (employee population was not involved extensively in the evaluation or solution generating) was associated with generic changes. A wider variety of opinions, ideas and human resources were available in the participatory approach (Corlett et al, 1986). It is important to note that experts do not have the specific knowledge of the line operators. In cases where participation was encouraged, the quality of results, attitudes towards solutions and new work situations were more positive (Eklund et al, 1986).

OSHA (1990) outlines a number of methods that can be utilized to encourage and obtain employee participation:

(1) An employee complaint and suggestion procedure;

(2) A procedure for prompt and accurate reporting of CTDs by employees; and

(3) Ergonomics teams that identify problem areas, analyze jobs and recommend solutions.

(OSHA, 1990)

In all four documents evaluated, ergonomic teams were stressed and outlined in detail. An ergonomics team is considered multidisciplinary. Members from all levels in the organization should be involved in the team - representatives from safety, medical, engineering, operations management, human resources, union representatives and/or production employees, maintenance, purchasing and a person with expertise in ergonomics (AMI and Ergotech Inc., 1989). The functions of the committee or team are to: (1) hold regular meetings; (2) coordinate activities; (3) set priorities for conducting job evaluations and making engineering changes; (4) identify an action item and who's responsible for it; and (5) keep minutes and document activities (AMI and Ergotech, 1986). It is important to note that a very large plant may have a committee already in place that carries out similar work; there may be no need to assemble a new committee (Noro, 1991). It is essential if a committee is developed, that members are adequately trained (their needs are met and they see the benefits of ergonomics), and aware of their role within the group (Blache, Tuscan and Tsai et al, 1989).

Perrow (1983) noted four problems associated with implementing ergonomics: (1) a lack of general ergonomic knowledge; (2) a lack of specific job knowledge; (3) poor interdepartmental communication; and (4) perceived cost/benefits. If the ground work is carried out by the ergonomics consultant or company ergonomist prior to the ergonomics team taking on a full load of ergonomic initiatives, the success of the team will be a lot higher. This is essential in a smaller organization since a group will have limited resources to draw on. It may also be more effective to rotate employee representatives and line operators periodically to enhance learning throughout the operator population. An ergonomic specialist may be required as a technical expert for more complex problems (Imada, 1991). Participation at all levels is essential for successful development, implementation and on-going success of an ergonomics program.

3.3.3 Written Program

According to AMI and Ergotech (1989), it is important that an ergonomics program that outlines program goals and objectives is written up, endorsed and advocated by top level management. Timetables should also be attached to each objective so that they can be regularly monitored and revised as necessary. Employees plant wide should have access to the program goals, and objectives to be met in order to meet those goals (OSHA, 1990). Implementation dates for program elements should also be established so that the program group can monitor the implementation timetable.

3.3.4 Regular Program Review and Evaluation:

According to OSHA (1990), it is important that program goals and objectives are reviewed on a regular basis. Program elements must be reviewed in terms of their

success in meeting its goals and objectives. Evaluation techniques include methods such as: analysis of trend in injury/illness rates; employee surveys; before and after surveys/evaluations of job work site changes; and review of plant evaluations. The results of the review should be shared with all responsible parties and communicated to employees. Revised goals and objectives should be formulated and then communicated to all employees (OSHA, 1990).

3.5 Work Site Analysis

Work site analysis encompasses a number of activities: documentation of a need for ergonomics, an ergonomics audit of the work site, priorization of jobs, and in-depth analysis and evaluation of a particular job or task. Work site analysis is initiated at a macro level examining the entire company via examination of company records and ergonomics of the work environment. The process (work site analysis) filters to a micro level by focusing on the analysis of a high priority job or task. The following sections examine each of the aforementioned elements in detail.

Identifying Priority Jobs and Documenting the need for Ergonomics

There are a number of indicators to show the need for an ergonomics program: injury and illness incidence rates, workers' compensation rates, first aid/medical aid cases, medical insurance claims, absenteeism rates and the amount of overtime worked in a specified work area (La Bar, 1991 and Morgan, 1991). The OSHA preliminary program guidelines focus primarily on evidence of cumulative trauma disorders by examining existing medical, safety, insurance records and the OSHA-200 log (an OSHA record kept by each company to track injury/illness on the work site). AMI and

Ergotech (1989) also suggest companies look at turnover, jobs or tasks operators particularly dislike and task/jobs that are considered entry level due to undesirability or low skill needs. Finally, the UAW-FORD process (1987) examined failure to meet production standards, high rates of accidents and near misses, and production quality as well. As one moves through a review of information from medical records through to production records, the more involved employees and managers must be to establish trends. Once a trend is identified it is important to classify trends or clusters of ergonomic problems relating to a particular department, process unit, production line, job title, operation or work station (OSHA, 1990). Identification of trends is the first step in the process of establishing a need for ergonomic intervention.

Audit and Identification of Problem Jobs and their risk factors

Once the review of statistical and production information is completed, a more detailed analysis of work tasks and positions should be conducted to determine specific ergonomic factors (OSHA, 1990). Analysis should be carried out through the use of a systematic method such as checklists (refer to appendix A-1), direct observation and where feasible, through videotape review. It is important to determine the primary goals prior to the assessment/audit. For example, if the goal of the audit is to identify risk factors associated with the onset of cumulative trauma disorders, the assessment should be sensitive enough to identify the apparent risk factors such as: excessive repetition, prolonged activities, forceful exertions, pinch grips, prolonged static postures of the body, trunk and/or extremities, awkward postures of the upper body, excessive reaching or twisting of the wrist, continued elevation of the wrist, physical contact with the work surface (edges), temperature extremes, types of tools and their characteristics (shape,

weight, and size), work stations that restrict movement, vibration from power tools and improper seating/support (OSHA, 1990).

From the information gathered through analysis of records and the job audit, priorization for further intervention can be established.

Priorization of Jobs

Once the analysis of injury and production data, along with the ergonomics audit is completed, the company can move on to classify or prioritise jobs that require intervention and hazard abatement (Joyce Institute, 1991). There are a number of methods that can be utilized to prioritise jobs. It is important to determine first, if, a risk factor requires ergonomic intervention to mitigate the problem (Alexander, 1986). If the risk factor requires ergonomic intervention, the job can be classified as low, medium or high in terms of the identified hazards:

Low - "Exposed the operator to minimal degree of risk for potentially developing cumulative trauma disorders (CTDs), and is considered to be safe for the majority of the working population. Low risk jobs will have to be monitored and periodic checklists will have to be completed.

Medium - Considered to be safe ("low risk") for some and hazardous to others. Would require adequate administrative controls and close monitoring, and/or some engineering modifications.

High - Considered to be hazardous to the majority of the working population and will most likely contribute to the development of CTDs. Require serious attention to engineering and some administrative controls."

(Joyce Institute, 1991,p.2)

Jobs that are considered at a medium or high risk should be investigated further to identify and quantify risk factors. It is important to note that each task element is given a rating then an overall rating is given to the job (Joyce Institute, 1991). This process is ongoing and should be carried out periodically to update records. The primary level of analysis provides the evaluator with baseline date to check against when another audit is conducted in the future.

In-depth Job Analysis

If a job is classified as medium or high risk to the employees, an in-depth job analysis should be conducted to provide further hazard identification and quantification (Joyce Institute, 1991). There are a number of methods that can be utilized to further explore a problem area through on-site activities such as: task analysis, link analysis, observation, dimensional measurement of the work station, environmental measurements (lighting, noise, temperature, ventilation and humidity), and interviews with employee and supervisors to better understand problem areas associated with the work station (UAW-Ford, 1987 and UAW-GM, 1988).

Hazard Abatement

Once a problem has been identified and evaluated, solutions can be generated. Solutions can be related to engineering controls, administrative controls and training and education. Engineering controls include the design of products, equipment, tools, furniture, environment, procedures and the organizational of work. Administrative controls include policies and procedures established for tasks that are in question. Training and education include bringing skill level and knowledge in line with task

demands. (OSHA, 1990; and NRC, 1989). It is important to evaluate: (1) the cost of implementation (including design and redesign); (2) the time needed to implement change; and (3) ease of use of the change by operators (Alexander, 1986). Once these areas have been evaluated, resources need to be secured and implementation can take place. Baseline measurements can be evaluated again once mitigative action has been installed. It is important that measurements are taken after the mitigative action has taken place to establish if the action has reduced or eliminated the problem area (UAW-Ford, 1987).

Training and Education:

Training and education provides employees with the knowledge to identify potential problems and participate in solving them (Taylor, 1990). Training should include all affected employees, engineers, maintenance personnel, supervisors and managers.

Training modules may vary in length from two hours to one week depending on the goal of the module. A module is usually made up of a number of separate training sessions. Training sessions may range from lectures to actual practice sessions. Practice sessions allow participants to apply ergonomic principles taught in the lecture sessions to actual work place problems. The training and education component of an ergonomics program should be on-going, in order to keep employees in the company knowledgeable in ergonomics. The following is a brief description of different types of training that may be utilized in a program:

1. General training is a good method for introducing ergonomics and ensuring that employees plant-wide have a basic understanding of ergonomic principles and hazards. Employee representatives will change frequently on the ergonomics team. Thus it is important that each employee has a basic understanding of ergonomics.

2. Job-specific training may be chosen so employees can be knowledgeable about specific hazards directly affecting them on the job. This type of training provides the operator with knowledge of ergonomics to better identify problems and participate in the solution generating process.

3. Discipline specific training for supervisors, managers, engineers, maintenance personnel and health and safety staff will vary and thus training should be geared towards their role in the process and as members of an ergonomics team.

(OSHA, 1991)

Training for engineering staff may include more information on human factors principles for design, while supervisors may concentrate more on issues involving human factors and job rotation.

Training and education is an essential component when initiating an ergonomics program. Education is also important for success of a program in the long term, and thus the training and education component should be an ongoing process.

Medical Management:

An effective ergonomics program should have a medical management element that aims to eliminate or reduce the risk of work-related injury/illness through early identification and treatment, and to prevent future problems.

Medical management should target each of the following areas:

- injury and illness record keeping
- early recognition and reporting
- systematic evaluation and referral
- conservative treatment
- conservative return to work
- systematic monitoring
- adequate staffing and facilities (OSHA, 1990)

The following section covers components that should be included in a medical management program.

(1) A program should ensure early identification, evaluation, and treatment of signs and symptoms; to prevent reoccurrence; and to aid in prevention. A health care provider should be part of an ergonomics team.

(2) Training is important for all health care providers with regards to general ergonomics principles and how the health care provider can aid in an ergonomics program. It is important that a health care provider is aware of program goals and objectives and the role they can play in achieving them.

(3) Work place walkthrough - a periodic, systematic walk through allows the health care provider to remain knowledgeable about operations and work practices, and identify light duty jobs. This will aid a more efficient return to work if a physician/health care provider is aware of job demands and the operational structure of the facility. Walkthrough's should be conducted every 3-4 months or when a particular job has changed. It is important to keep records documenting the walk through date, areas visited, risk factors recognized and action initiated to correct identified problems. Follow-up should be documented to ensure corrective action is taken and is effective.

(4) Symptoms Questionnaire - a questionnaire should be designed for three purposes. Firstly, to investigate symptoms of work-related disorders for each area of the plant. Secondly, to determine which jobs exhibit problems and thirdly, to measure progress of the ergonomics intervention. Surveys should be conducted every year to identify changes in prevalence, incidence and location of injuries/accidents within an area.

(5) Health surveillance - an effective health surveillance program should include the following three elements:

a. Baseline health assessment - this establishes a base against which change in health status can be evaluated. All new or transferred workers should receive baseline surveillance

b. Post-conditioning period assessment - conduct a retest concerning aspects of health surveillance that tests those areas that may be at risk of injury due to ergonomics stresses. Tests should be completed after the conditioning period to examine if the employee is experiencing changes in health status.

c. Periodic health surveillance - every 2-3 years a health surveillance should be conducted on all employees who have been involved in positions that expose them to ergonomic stress.

d. Finally, documentation is essential in order to identify trends in a particular work area.

(6) Employee training and education - all employees should be oriented to different types of cumulative trauma disorders (CTDs), methods of prevention, causes, early symptoms and treatment of CTDs.

(7) Encourage early reporting of symptoms - employees should be encouraged to report early signs and symptoms of CTDs to supervisors or occupational health and safety staff. A method of recording episodes and a protocol should be developed to monitor signs and symptoms.

(8) It is essential that records are kept so as to establish any trends that may develop as well as to document the effect of any implementation.

3.3.6 Conclusion

Literature is extensive in the area of project management and analysis of problem areas. The majority of literature on employee participation focuses on examination of quality circles and emerging management principles involving employee participation in the overall operation of the company. Programming is explored in the literature through case studies involving company experiences with the development, implementation and operation of ergonomic programs. From the information obtained in the literature, most ergonomic programs mimic the primarily ergonomic program guidelines provided by OSHA (1990). These guidelines appear to include a strong employee participation component, which is, from the literature, evidently an essential component in the development, implementation and operation of a successful program (in ergonomics or another area such as production).

3.4 Role of the Consultant:

3.4.1 Introduction

Over the past decade there has been a growth in consulting services including services in ergonomics. Gilley and Eggland (1989), state five reasons for promoting growth in the consulting area: (1) technical development; (2) crisis in a department; (3) underdeveloped consulting skills within a company; and (4) discretionary time (limited time and resources within a company). In terms of ergonomics, only in the largest corporations are full-time specialists employed to manage a program (Morgan, 1991).

The reasons for using a consultant may be one of or a combination of the following: (1) the consultant provides objectivity to an issue or departmental matter; (2) a company seeks to overcome organizational resistance to change; (3) analytic skills; (4) specialized knowledge; (5) the company has imposed time restraints; (6) the consultant is to serve as a catalyst on a project; (7) the consultant may provide sensitivity to organizational change; and (8) the consultant may identify political issues in an organization (Gilley and Eggland, 1989). Traditionally an ergonomics consultant has been used as a trouble shooter in a reactive situation to evaluate a specific problem and then provide a specific answer (Eklund et al.,1986; and Haslegrave et al, 1986). In many circumstances the consulting ergonomist has been called in on a project level. A consultant may be called in at either the project or program level depending on the needs of the client.

3.4.2 Aspects that Dictate the Role of the Consultant:

The role of the consultant will depend on the following: (1) the nature of the contract (it will define the duties and activities of the consultant); (2) the client's goals

and objectives; (3) the norms and standards of the client; (4) the personal limitations of the consultant; and (5) whether the consultant is internal or external to the organization (Lippett and Lippett, 1986). Often the role of an internal consultant will be dictated by the organizational structure and culture.

3.4.3 Role of the Consultant

The consultant may have one or many roles. The consultant may be an: advocate, informational specialist, learning provider (trainer or educator), joint problem-solver, alternative identification and linker, fact finder, process counsellor, and/or an objective observer/reflector (Gilley and Eggland, 1989).

An advocate will usually take on a directive approach, provide a proactive means to address the issue and influence the client's decision in the selection of particular goals and values (Gilley and Eggland, 1989). The consultant may work to further validate the decisional process of a client.

An information specialist is, again, directive, as the approach requires some involvement by the client in both the identifying and solving of the problem. The client's primary role in the relationship is to define the problem and explain the situation to the consultant. This is the most traditional consulting role (Gilley and Eggland, 1989).

The role of learning provider (trainer or educator) is to provide training programs and activities that will enhance performance, or introduce and develop organizational change (Gilley and Eggland, 1989). In a situation where the consultant is a joint problem-solver, the client and consultant are both active in the problem-solving process. The consultant becomes a facilitator or collaborator, by providing objectivity to an existing problem(s), while still evaluating alternative solutions to solve a client's

problem(s). The consultant establishes relevant criteria for assessing alternatives, developing a cause-effect relationship for each alternative and establishing an appropriate action plan with the client (the client is proactive in this particular process). The fact finder acts as a researcher throughout the process. The consultant focuses on gathering, analyzing and synthesizing information to provide clients with vital information needed by the client to make a decision. As a process counsellor, the consultant becomes a teacher by instructing a client on how to more effectively and responsively diagnose a problem and come up with a strategy to mitigate the problem (Gilley and Eggland, 1989). Finally, as an objective observer/reflector the consultant acts as a verifier. Often the consultant will ask reflective questions to help a client clarify, modify and alter a given situation (Gilley and Eggland, 1989).

The role of the consultant will be dictated by the needs of the client. The consultant may act in one role throughout the consultation or take on a number of different roles to identify, evaluate and mitigate a problem(s).

There are a number of similarities and differences between an external and internal consultant. The major difference is that the internal consultant is aware of the organizational issues, since the consultant is exposed to the company's system and culture (Gilley and Eggland, 1989). The similarities between an internal and external consultant are: (1) both play multiple roles; (2) both are helpers; and (3) both rely on the organizational members to carry out and implement recommended tasks (Gilley and Eggland, 1989).

The differences between the two types of consultants can greatly impact the decision of whether to utilize an internal or external consultant. The differences are as follows: (1) outside consultants can maintain a broader perspective and have a greater

influence on the organization because they are perceived as experts; (2) the external consultant can reject assignments while the internal consultant must take on assignments as an organizational responsibility; (3) internal consultants can spend more time with members of the organization to identify and establish important linkages in the organization (Gilley and Eggland, 1989). In ergonomics, the internal consultant can readily participate at all levels and provide the driving force within the organization to develop, implement and maintain a project or program. The external consultant is limited by his/her contract and the company's perceived need for their inclusion within the program over the long term.

3.4.4 Hierarchy of Purpose

The role of the consultant will determine the influence that the consultant will have in the organizational change and acceptance of information. Turner (1983) identified a hierarchy according to influence:

1. Providing information to a client.
2. Defining the real issue.
3. Conducting an effective diagnosis of the problem (problem identification, collection of appropriate information and analysis of information).
4. Providing recommendations - providing the client with a consistent, logical action plan to improve an identified problem.
5. Implementing change within the organization.
6. Building consensus and commitment to change throughout various levels in the organization.

7. Facilitate client learning, recognizing employee involvement, develop the client's skills and knowledge needed to identify and mitigate future problems and facilitate learning by allowing the client to participate in the consulting process.
8. Improving organizational effectiveness which implies that management is committed to a process of developing and maintaining important systems, linkages and programs.

3.4.5 Conclusion

As discussed, there are a number of factors that will determine the type of role and how effective the consultant will be within an organization.

In many smaller organizations, because they do not have an ergonomic specialist on staff, the decision to go with an internal or external consultant is not present. They are forced to go with an external consultant. It is important that the aforementioned issues are examined and the roles of the consultant and client within the process are well-defined. It is also important that expectations of both the consultant and the client are defined (i.e. a consulting contract) to enhance an effective and successful consulting experience.

3.5 Conclusion:

The majority of literature supports employee participation and management commitment. Program content is not as well-defined in the research literature. Instead, programming is explored in the literature through case studies involving company experiences in the area of ergonomics. The majority of case studies examine project

level ergonomics, very few examine ergonomic programs. Of those programs examined, most mimic the primarily ergonomic program guidelines provided by OSHA (1990).

The majority of small to medium sized companies do not have a full-time ergonomist on staff. As a result, a large number of companies utilize the services of ergonomic consultants. There are a number of factors that will determine the type of role and how effective the consultant will be within an organization. The role of the consultant in developing, implementing and operating an ergonomics program on-site will evolve throughout the process of the program.

4.0 CHAPTER 4 - KEY INFORMANT INTERVIEW RESULTS

4.1 Introduction

The purpose of conducting key informant interviews with ergonomists was to obtain information regarding: (1) identification of key elements should be included in an ergonomics program; (2) the role of the consulting ergonomist; and (3) the role of the employee population in an ergonomics program.

4.2 Key Informant Interviews:

4.2.1 Subjects

The key informant interviews involved twenty individuals. Table 4 summarizes the breakdown of number of surveyed participants.

Table 4 - Summary of key Informant Interview Participants

	U.S.	Canada	Total
Consultants	5 (35%)	8 (26%)	13
On-site ergonomist	3 (45%)	4 (57%)	7
Total	8 (40%)	12 (60%)	20

4.2.2 Key Informant Responses and Discussion:

The following section reviews the concept codes utilized to classify key informant interview data, summarizes the data and discusses the findings.

4.2.2.1 Questions #1 and #2

What elements do you feel are necessary in a company ergonomics program?

What makes up each of these elements?

Concept Codes

The following concept codes (definitions can be in section 3) were utilized to classify the data obtained in the key informant interviews: management commitment (3.3.1), employee participation and involvement (3.3.2) and regular program/implementation review and evaluation (3.3.4). Section 3.3.5.A defines work site analysis, identifying priority jobs/documenting the need for ergonomics, audit/identification of problem jobs and their risk factors, prioritization of jobs, hazard abatement, training and education and medical management.

Responses and Discussion:

Table 5 summarizes the responses obtained in the key informant interviews. The table includes a summary of the number of informants that reported each concept in their response to questions #1 and #2.

Table 5 - Summary of Key Informant Interviews - Elements of an Ergonomics Program
(informants sample size a=20, consultants b=13, and on-site ergonomists c=7)

	Informants	Consultants	On-site ergonomist
management commitment	20 (100%)	13 (100%)	7 (100%)
training and education	17 (85%)	11 (85%)	6 (86%)
employee participation	20 (100%)	13 (100%)	7 (100%)
document a need	18 (90%)	11 (85%)	7 (100%)
audit	15 (75%)	8 (62%)	7 (100%)
priorization of Jobs	11 (55%)	6 (46%)	5 (71%)
in-depth analysis	19 (95%)	12 (92%)	7 (100%)
hazard abatement	20 (100%)	13 (100%)	7 (100%)
monitoring	18 (90%)	11 (85%)	7 (100%)
medical management	20 (100%)	13 (100%)	7 (100%)

the responses mimicked the elements identified in the preliminary guidelines outlined by OSHA. Management commitment, employee participation and hazard abatement were identified by all respondents as key components of an ergonomics program. All other components except for prioritization of jobs were identified by at least 70% or more of the respondents. Prioritization of jobs was reported by 55% of all reported by 55% of all respondents; 46% of all consultants and 71% of all on-site ergonomists reported it in their responses.

That the responses mimicked the OSHA guidelines may have been due to the fact that most companies in the United States have been exposed to the guidelines. The meat packing industry in the United States has developed industry program guidelines which include the OSHA preliminary guidelines. A number of the consultants and on-site ergonomists interviewed in the U.S., participated in the formulation of the guidelines. This was not known to the researcher prior to the interview. In Canada, the meat packing industry has had access to the OSHA meat packing guidelines. Once again, those interviewed in Canada may have had access to the meat packing guidelines or the OSHA preliminary program guidelines. Finally, the Ford Process document is available through most Occupational Health and Safety offices in Canada. The Ford Process, appears to follow the OSHA preliminary guidelines, and although some terms may be different, the definitions are similar. It appears from the responses, that the elements listed can be considered significant in the development, implementation and operation of an ergonomics program.

4.2.2.2 Question #3

Who do you feel needs to be involved in the ergonomics program and why?

Coding

The following codes were utilized to classify responses: employees, a specialist in ergonomics, management, engineering, company champion of ergonomics, purchasing, maintenance, medical and safety. Table 6 summarizes the breakdown of responses reported by informants.

Responses and Discussion:

Table 6 - Summary of those who should be involved in the ergonomics program (informants sample size a=20, consultants b=13, and on-site ergonomists c=7)

	Informants	Consultants	On-site ergonomists
employees	20 (100%)	13 (100%)	7 (100%)
specialists	12 (60%)	8 (62%)	4 (57%)
managers	20 (100%)	13 (100%)	7 (100%)
engineering	17 (85%)	11 (85%)	6 (86%)
champion	5 (25%)	4 (31%)	1 (14%)
purchasing	15 (75%)	8 (62%)	7 (100%)
maintenance	14 (70%)	9 (70%)	5 (71%)
medical	19 (95%)	12 (92%)	7 (100%)
safety	18 (90%)	11 (85%)	7 (100%)

Respondents considered all of the aforementioned representatives except for a (champion of ergonomics) important in the ergonomics program. Their level of involvement varied with the size and complexity of the organization.

Employee participation was identified by all respondents as essential in the development, implementation and operation of an ergonomics program. Respondents stated that employee participation can take place in the following ways:

(1) Problem identification and understanding of the problem;

(2) design and redesign of the work station/tasks; and

(3) development, implementation and operation of an ergonomics program.

Of course the type and level of involvement would depend on the complexity of the problem.

All respondents identified the need for management participation in the program. Respondents believed the inclusion of management would aid in the prioritization of ergonomic hazards in the work place, place health and safety on the same level as production, understand the impact and interaction production processes have on health and safety, designate financial, technical and human resources, and ensure accountability of participating members.

Engineering involvement was identified by respondents as critical in a ergonomics program. Engineering provides the technical expertise necessary for work place design and re-design of equipment, physical layout and operations.

Twenty-five percent of consultants believed that the efficiency and effectiveness of a program is dictated by the effectiveness of a company champion of ergonomics. The one on-site ergonomist that identified the need for a champion within the company acts within their own organization as a internal consultant due to the size and structure of the company.

Purchasing and maintenance were identified as participants in the program by over seventy percent of the respondents. Participation of purchasing workers allows for direct inclusion of ergonomic principles in the purchase of equipment. This can be accomplished by the use of an ergonomics checklist or direct evaluation of the equipment prior to purchase. Inclusion of maintenance workers allows direct feedback and development of preventive maintenance or housekeeping programs for equipment and implementation of modifications.

Finally, medical and safety personnel were identified by over 90% of participants. Respondents believed that medical and safety workers can identify health and safety trends that may be directly effected by the work environment and/or tasks.

4.2.2.3 Question #4

How do you measure success of your program or a ergonomics intervention?

Coding

The following codes were utilized to classify responses: accident data, preestablished objectives (design or program), review of checklists after an intervention has been installed, photographic documentation of work postures, response of the employees, reports from medical and/or safety, productivity indicators and or absenteeism. Table 7 summarizes the breakdown of responses reported by informants:

Table 7 - **Summary of Monitoring Techniques (informant s sample size a=20, consultants b=13, and on-site ergonomists c=7)**

	Informants	Consultants	On-site ergonomists
accident data	13 (65%)	7 (54%)	6 (86%)
objectives	2 (10%)	2 (15%)	0
checklists	8 (40%)	5 (38%)	3 (43%)
photographs	1 (5%)	1 (8%)	0
employee responses	10 (50%)	4 (31%)	6 (86%)
health reports	10 (50%)	7 (54%)	3 (43%)
productivity	6 (46%)	3 (23%)	3 (43%)
absenteeism	4 (20%)	2 (15%)	2 (29%)

Discussion

Respondents identified a number of methods that could be utilized to measure the effectiveness of an intervention. Accident data, health records and response of employees were identified by respondents as the sources most frequently utilized to determine the effectiveness of an intervention. Accident and health data can be obtained in the form of workers compensation claims, insurance information, industry accident rates and data collection from medical and safety records. Employee responses can be obtained from the comments made to supervisor, managers and health and safety representatives. Standardized interviews can also be conducted to determine the employee's perception of the installation of the mitigative measure on health and safety and performance (productivity).

Respondents identified other sources that can be used as indicator such as company objectives, checklists, photographs, absentee rates, and productivity measures. Objectives can be at a macro and/or micro level. At the macro level the objectives can be those outlined in the company business plan or ergonomics plan. Micro level

objectives may be those specifically established in the targeted goals of a specific implementation of a design and/or re-design of equipment, operations or layout and work practices and/or techniques. A checklist usually summarizes the principles and guidelines of ergonomics. Photographs can be used to examine work postures assumed by operators carrying out tasks at the work station. Productivity can be measured through production data, error rate and overall quality of the product measured output. Finally, absentee rates can be examined. The aforementioned data can be examined for each work area and trends can be established. It appears that some forms of feedback are more widely used in companies, appearing to result from time constraints and the tools accessible on site. Some facilities are hesitant to utilize accident/incident data because they are not sure if a change can be attributed to ergonomic intervention or a process change. Other companies are unable to use this type of data due to inconsistencies identified in the reporting scheme.

4.2.2.4 Question #5

a. for internal ergonomists:

Is ergonomics its own separate section or does it fall under another department?

b. for the external consultant:

Under what department should ergonomics be?

Coding

The following codes were utilized to classify responses: industrial engineering, health, safety and environment, whoever champions the program, ergonomics department, and human resources. Table 8 summarizes the breakdown of responses reported by informants.

Table 8 - Summary-Department ergonomics should fall under (informant s sample size a=20, consultants b=13, and on-site ergonomists c=7)

	Informants	Consultants	On-site ergonomists
industrial engineering	7 (45%)	1 (8%)	6 (86%)
human resources	6 (30%)	3 (23%)	3 (43%)
health, safety and environment	9 (70%)	5 (38%)	4 (57%)
whoever champions the program	2 (10%)	2 (15%)	0
form its own department	2 (10%)	2 (15%)	0

Discussion:

Responses indicated that the focus of the company, structure and size will impact where ergonomics will be placed in the company. Available resources (human and financial) at time of introduction and the department needing ergonomics may be strong predictors to where ergonomics will be placed. Some ergonomists also believed the type of industry would impact where ergonomics would be placed. For example, in a office environment it would be placed under human resources.

All company ergonomists that were surveyed were trained either in the area of kinesiology or industrial engineering. It is the view of the writer that the academic training of the ergonomist greatly impacts the perception of the ergonomist and where ergonomics should fall within a company.

4.2.2.5 Question #6

In a small-medium sized company (< 300 employees) how would a program have to change if there was not a ergonomist on staff?

Responses and Discussion

Respondents believe the complexity and magnitude of ergonomic program development and ergonomic intervention is directly proportional to the size of the company. Most programs and interventions, no matter the size of the company, are reactive in nature. In both a large and medium sized companies the reactive focus can evolve into a proactive focus as efficiency of the program develops.

Responses obtained in the interview did not directly answer the question. It appears by the responses that many participants did not understand the question. This could be due to the wording of the question or the order of the question within the questionnaire.

4.2.2.6 Question #7

What role would a consulting ergonomist play?

Coding

The following concept codes were utilized to classify the responses provided by the informants: support, trainer, in-depth analysts, developer and introducer of an ergonomics program, auditor of an ergonomic program (macro level) and jobs (micro level). The definitions utilized as concept codes are the same reviewed in chapter 3, section 3.4.4.

Responses and Discussion

Table 9 summarizes the responses obtained in the key informant interviews. Consultants and on-site ergonomists responses were examined in relation to the number of reported concepts to those who did not indicate the concept in their response.

Table 9 - Summary of the Roles of a Consulting Ergonomist (informant s sample size a=20, consultants b=13, and on-site ergonomists c=7)

	Informants	Consultants	On-site ergonomists
support	20 (100%)	13 (100%)	7 (100%)
training	12 (60%)	8 (62%)	4 (57%)
audit	5 (25%)	4 (31%)	1 (14%)
in-depth analysis	19 (95%)	12 (92%)	7 (100%)
program development	17 (85%)	12 (92%)	5 (71%)

Review of the responses indicated that the role of the consultant is a supporter, fact finder, program developer and trainer. Supporter is characterized by providing required information, validating an observation or proposed modification and facilitator of the ergonomic process or program. Fact finder identifies problem areas and the complexity of the problem. This information is utilized to understand the complexity of the problem and direct the development of mitigative measures. The consultant is seen as a process counselor to aid development, implementation and operation of an ergonomic program and/or intervention. As a trainer the ergonomist can provide a basic introduction to ergonomics, discipline specific or topic specific training.

Respondents also identified the role of the consultant as an auditor. The five respondents that reported the role of the consultant as an auditor believed the role could be carried out at a macro level or micro level depending on the needs of the company. The macro level approach evaluates the status of goals and objectives in the ergonomic

program or business plan to determine the effectiveness of program components. Audit results can be utilized to determine revisions to existing goals and objectives in the ergonomics or business plan. At a micro level the desired effect of the mitigative measure can be evaluated utilizing a checklist or comparison of the baseline and post-intervention measures.

4.3 Conclusion

The key informant interview results were similar to the literature. The program elements followed the OSHA preliminary guidelines for an ergonomics program. Monitoring was one element that the informants identified as a key element which was not stressed in the OSHA guidelines.

Accident data, health records and response of employees were identified by respondents as the sources most recently utilized to determine the effectiveness of an intervention. Respondents identified other sources not as frequently utilized that can be used as indicators such as company objectives, checklists, photographs, absentee rates, and productivity measures. It appears that some forms of feedback are more widely used by on-site ergonomists in companies, resulting from time constraints and the tools accessible on site.

Informants stressed in the interviews that the development, implementation and operation of a program would depend on the company size and culture. Company size would directly impact the available resources such as manpower and economics and the complexity of projects.

The majority of informants believed that, in a small to medium sized company, ergonomics is introduced to a company in reaction to an event. The event can be internal such as an accident(s) or rising WCB claims; or the event can be external in nature such as meetings introducing ergonomics to the industry in response to an industry wide problem.

The role of the consultant, according to the responses of the informants, will depend on the nature of the contact. The consultant's role may start as a specialist, but change to a trainer as the project or program progresses.

CHAPTER 5 - ERGONOMIC PROGRAM MODEL

5.1 Formulation of the Proposed Ergonomic Program Model:

The responses gathered from the interviews were examined for their similarities and differences in relation to the literature reviewed. Through this comparison, a model was formulated that was utilized in the following case study.

The model did not deviate from the OSHA ergonomic program guidelines other than to expand on the final area of project management - monitoring and modification of mitigative measures. The components are outlined and the implementation model will be graphically represented. Of course, for each company this may change due to their company structure and culture.

The following components were identified as necessary components of an ergonomics program:

I. Management Commitment

- written policy and program
- regular review and evaluation of the program
- communication at all levels within the organization
- employee participation

II. Training and Education in Ergonomics

- general awareness training
- job-specific training
- discipline specific training

III. Medical Management

- periodic work place walk through
- symptoms survey
- identification of restricted duty jobs
- health surveillance
- employee training and education
- early reporting of symptoms

- appropriate medical care
- accurate record keeping

IV. Ergonomics Process

- document a need for ergonomics
- audit jobs
- prioritize jobs
- in-depth analysis
- generation of solutions
    - engineering controls
    - work practice controls
    - administrative controls
    - personal protective equipment
- implementation of mitigative measures
- monitoring and modification of mitigative measures

The framework utilized for the case study was based on the components and elements outlined in the aforementioned program model. The framework was modified to take into account the company's goals and objectives, structure and culture. The model was applied in the case study as a pilot program in two divisions of the company - sawmill and planer mill.

Training and education, the written program and policy, regular review, and medical management will be discussed and reviewed throughout the pilot program, but will not be formulated or demonstrated in the pilot project. Medical management was not be developed due to project time constraints.

The following process was formulated for the case study from information gathered from the literature review and the key informant interviews (part IV of the framework):

- obtain management commitment;
- document the need for ergonomics
- conduct an ergonomics audit;
- prioritize jobs;

- conduct an in-depth analysis of work station;
- generate solutions;
- implement mitigative measures; and
- monitor.

PART II

CHAPTER 6 - CASE STUDY METHODOLOGY

6.1 Rationale for Conducting the Case Study

To examine the feasibility and effectiveness of the ergonomic program model, it will be examined in a case study format. Case studies are commonly utilized in sociology, marketing, business, clinical psychology, anthropology and medicine (Dodge, 1982). Case study materials are used for a number of purposes, which include: illustration, concept and hypothesis generation, hypothesis testing, prediction and postdiction, methodology development and teaching (Foreman, 1971; and Masoner, 1988). The case study format is set up to provide descriptive and exploratory information regarding a situation (Yin, 1989). A case study examines a complete situation to explore interrelationships among relevant variables. In a situation there is a unit of analysis, this unit could be a person, group, class of persons, an ecological unit or cultural unit (Foreman, 1971).

There are a number of advantages of using a case study: (1) it allows for an empirical description of an actual situation; (2) it studies interrelationships between factors affecting results; and (3) there is a cost trade off with the small sample size. The disadvantages include: (1) limited generalization; (2) statistical reliability is limited; (3) less chance for anonymity for respondents; (4) difficult to limit the massive amounts of information obtained and presentation of material; and (5) limited objectivity (Masoner, 1988; Yin, 1989; and Wardell, 1991).

The purposes of the case study were to: (1) examine the introduction and development of parts of the ergonomics program based on the program model (formulated from the literature review and key informant interviews) into a medium-sized company; and (2) develop an hypothesis for future testing of an ergonomic program model.

6.2 Research Questions:

The case study sought to answer the following research questions:

(1) How were the components and elements of the ergonomics program model developed in the case study?

(2) What was the role of the consultant in the introduction and implementation of the ergonomics program?

(3) What was the potential and perceived role of the ergonomic team (perceived by the ergonomics team) in the implementation and operation of the ergonomics program?

The case study was divided into four phases: (1) securing management commitment; (2) documentation of the need for ergonomics and prioritization of jobs; (3) in-depth analysis/solution generation and implementation or mitigative measures; and (4) review of the process.

6.3 Phase 1 - Secure Management Commitment

The purpose of this phase of the study was to secure management commitment for the project. An initial meeting with interested members of staff from the company was held to obtain the company's position and mandate on occupational health and safety. At this time, the company's organizational structure was reviewed to better understand the company's approach to introducing a new program.

After the initial meeting was held, a general awareness presentation of the goals of the study, what ergonomics is and what it can do for the company was provided. As Smith (et al, 1986) stated, it is very important to select the target audience and then establish the presentation around the needs of the targeted group. Members of the company from the following departments were included in the session: production, management, maintenance, purchasing, employee representatives and occupational health and safety. During this time, a first draft of the on-site work was formulated, as well, the ergonomics team was established.

Once these two meetings were held, a final draft of the proposal for the on-site work was formulated. The following information was outlined in the draft: the goals of the study, a time schedule, the elements of each component of the on-site study, and the technical, financial, and personnel resources required to complete the study. The draft was approved by management, the first section of the study was completed, the next phase of the study was initiated.

6.4 Phase 2 - Documentation for the need for Ergonomics and Prioritization of Jobs

The next phase in the process was to document the need for ergonomics and to prioritize jobs. Sources within the company that were utilized in the process included: review of company health and safety statistics, an audit of identified jobs in the sawmill and planer mill divisions, review of results obtained from the symptoms questionnaires, and informal employee and supervisor feedback while auditing each job. These techniques were cited within the programs identified in the literature review (UAW-Ford, 1987; AMI and Ergotech, 1990; and UAW-GM, 1988).

6.4.1 Review of Company Health and Safety Statistics:

A review of company health and safety data for the past five years was surveyed. Review of the data helped identify the type of injuries that occurred on the job, the perceived cause of the injury, and if injury and/or accident trends existed in a particular job or work station/area.

It was expected that statistics available were primarily associated with acute injuries such as cuts, bruises, and sprains rather than cumulative trauma disorders.

Data Limitations

There were a number of limitations with the data with respect to identifying the type of injury and causal and contributory factors to these injuries. Limitations included consistency of reporting, the focus of the occupational health and safety program (the method of reporting or documenting injuries, such as primarily reporting acute injuries or back injuries associated with lost time or requiring medical attention), the multiple causes of cumulative trauma disorders, difficulties in diagnosis, delays in seeking medical attention and consistency of employee reporting of signs and symptoms.

Types of Injuries

These primary injuries were considered cumulative trauma disorders: tendinitis, epicondylitis, tenosynovitis, DeQuervain's disease, trigger finger, carpal tunnel syndrome, and thoracic outlet syndrome (Putz-Anderson, 1991; and Alberta Occupational Health and Safety, 1991). Back injuries were also included in the survey of company medical records, since many of the job demands predisposed the operator to risk factors that may contribute to the onset of a back injury.

Establishment of Trends

Injury data was reviewed; the following information was documented: injury type, body part, reported causal and contributory factors, type of medical aid required, lost time, modified work duty, job title and location of injury on site. The aforementioned information was not documented in the injury statistics. (Individual records of accident and incident reports were then examined to obtain the required information.

In no way was the data associated with identifying factors of a particular employee. Once all data was reviewed, it was presented in a format that ensured anonymity for all employees by presenting data as a complete group source. All rough data was returned to the occupational health and safety department once the study was completed.

6.4.2 Job Audit:

Seventeen jobs were reviewed in the sawmill and planer mill divisions. The ergonomic team identified jobs they perceived as priority jobs for review. The following criteria were utilized to identify jobs for review: (1) a number of employees were exposed to the work area; (2) the areas were associated with a number of identified risk factors such as: repetition, excessive forces, excessive reaches, non-neutral limb postures, vibration and temperature extremes; and (3) employee feedback identified concerns for their own health and safety while performing particular work tasks. Along with the job audit a preliminary ergonomic awareness session was held and symptom questionnaires were handed out to be completed by employees in both the planer mill and sawmill.

Initial Session

Employees involved with the study were provided a thirty-minute session outlining the definition of ergonomics, the benefits of ergonomics and a review of relevant case studies. Also, during the session the goals and work schedule were reviewed. At the end of this session, a question and answer period was held.

Symptoms Questionnaire

Employees from all three shifts were surveyed with a symptoms questionnaire to identify physical signs and symptoms of pain or discomfort experienced on the job. The questionnaire examined information such as: affected body part, type of pain or discomfort, number of episodes, medical aid required, lost time and possible causal factors that contributed to the onset of pain and/or discomfort (see Appendix B for a copy of the symptoms questionnaire). Demographic information obtained from the questionnaire was restricted to the number of years on the job and the employee's job title.

Questionnaire participation was voluntary. Employees who chose to participate were asked to fill out a consent form, (refer to Appendix B). All responses obtained were in no way associated with one employee. Results were reported as a group and anonymity was ensured for all participating employees.

Audit

Seventeen jobs were surveyed in the lumber mill. The audit included: observation of the work tasks carried out in each work area; physical measurement of the work station; environmental measurements such as lighting and noise; and informal employee interviews. These methods were consistent with the programs reviewed in the literature (UAW-Ford, 1987; and UAW-GM, 1988)

Observation of the work tasks

A work task was carried out to establish the physical and mental demands of the job. The audit documented cycle times of subtasks and tasks. Physical job demands such as repetition, awkward work postures, excessive forces and reaches, extreme temperatures, vibration and periods of prolonged/unsupported postures were identified. Mental demands included information-processing, decision-making, ability to detect errors, and stress related to the high work pace. This helped determine the type and duration of ergonomic risk factors employees are exposed to.

Physical Measurements

Dimensional measurements of the work station were taken using a steel tape measure. Measurements that were taken included: work surface height, measurements to determine reach distances (such as location of tools and controls), measurements to determine movement restrictions, and seating dimensions. Measurements were compared to data obtained from the literature with regards to anthropometric fit (McCormick and Sanders, 1987; and Eastman Kodak, Vol.1, 1983).

Environmental Measurements

General lighting and noise levels were measured. The review was not designed to provide an in-depth analysis of lighting and noise levels, but instead to alert the researcher to inappropriate lighting and noise levels that existed within and around the work station.

Light measurements were taken using a lux meter; the meter was placed at various points on the work surface (approximately five measurements were taken). A composite measurement was documented as well as the range of light measurements.

Noise levels were determined using a noise meter, once again, the meter was placed at various points in the work area. One time measurements were taken as opposed to 8 hr. exposure limits.

Employee Feedback

While carrying out the observation of jobs, employees were asked to comment on the work tasks and work station. Geras, Pepper and Rodgers (1989) believe that problem identification can be aided by interviewing employees working the area. Employees identified problem areas and potential solutions to mitigate these problem areas. Interviews with employees were informal, and feedback was given in group responses.

Report Results Back to the Ergonomics Team

Results from the review of health and safety statistics, the audit, symptoms questionnaire and informal employee interviews were reviewed with the ergonomics team. A set of criteria were preestablished to identify priority work areas or jobs that should be considered for in-depth analysis and mitigative measures to be installed. Both Alexander (1986) and Liker (1987) stated that it is important for the company to have established criteria to prioritize jobs that require ergonomic intervention.

6.5 Phase 3 - Indepth Analysis/Solution Generation/Implementation Plan

This phase encompassed three steps - an in-depth analysis of a high priority job, solution generation and formation of an implementation plan to institute mitigative measures. The success of this phase depended on employee participation both by members of the ergonomics team and the employee population. The employee population in the analyzed work area was interviewed to better understand the problem area as well

as to provide possible solutions to mitigate problem areas (Geras, Pepper and Rodgers, 1989; Joyce Institute, 1991; Alexander, 1986; and Liker, 1987).

6.5.1 In-depth Analysis

The goals of the in-depth analysis were:

(1) To better understand the physical and mental job demands carried out in the surveyed work area.

(2) To provide data to the ergonomics team to develop possible solutions to mitigate problem areas.

The in-depth analysis included the following:

- task analysis
- review of manual material handling
- hand tool analysis
- supervisor interviews (see Appendix A for a copy)
- employee interviews (see Appendix A for a copy)
- data collected in the audit - environmental measurements, and physical work station measurements.

All results were presented to the ergonomics teams to aid generation of possible solutions.

Task Analysis

The task analysis was included in the in-depth review of the tasks carried out at the workstation. Task analysis is utilized to insure that the system is functional and maintainable in a safe and efficient way (McCormick and Sanders, 1987). In this case study, the task analysis helped to identify problem areas in the human-machine interface.

Video-taping was carried out to determine the breakdown of each task and the ergonomic problems related to each task. Video taping took place over a sixty minute

period. The camera was located at the far end of the work area to observe the entire process. All employees operating at the workstation were informed of the video-taping. Those employees who chose to participate were required to sign a consent form, (Refer to Appendix B for a sample consent form). All video-tapes were destroyed at the completion of the project.

Review of Manual Material Handling

Each task was reviewed with regards to its material handling requirements (a checklist was utilized). The manual material handling checklist examined the following areas: weight and force required/handled, size/shape of the object, handle size and shape, frequency/duration/pace of lifting, stability of the load, work place geometry and environmental factors (Herrin, et al, 1974). Where feasible, lifting limits were determined using the NIOSH equation (U.S. department of health and Human Services, 1981).

Hand Tool Analysis

A review of all tools utilized at the workstation was carried out in relation to a hand tool. The checklist evaluated the following areas:

- high contact forces and static loading
- extreme or awkward work postures and joint positions
- repetitive motions with the finger(s)
- requirements for excessive grip strength
- emission of temperature generated by the hand tool
- tool guarding
- weight, size and shape of the tool
  (UAW-Ford, 1987; AMI and Ergotech, 1990; and Eastman Kodak, Vol.1,1983)

This allowed the researcher to identify ergonomic problems related to the hand tool design and use.

Supervisor Interviews

The supervisor for the work area was interviewed to allow the researcher to better understand the tasks carried out at the workstation. The supervisor was asked to sign a consent form in order to participate (Appendix B). The interview was designed to obtain the following information: Supervisor background information, job analysis, task analysis, environmental conditions and reporting of injuries.

Employee Interviews

The fifteen employees who chose to be involved in the study were interviewed. The interview was designed to better understand the tasks carried out at the workstation. Geras, Pepper and Rodgers (1989) stated that to better identify problem areas employee interviews should be carried out. The interview was designed to obtain information on problem areas that the employee believed affected both their health and safety, and production. At this time, the researcher obtained information with regards to possible causes and feasible solutions. Each employee who participated was asked to sign a consent form in order to participate (Appendix B).

6.5.2 Solution Generation

All results from the in-depth analysis were presented to the ergonomics team in a brain storming session. Possible solutions were presented to the ergonomics team to provide the team with a general direction for solution generation. The team was then

asked to expand and further generate solutions to mitigate problem areas. At this point, the consultant/researcher became a facilitator and an informational resource person for the ergonomics team.

6.5.3 Implementation Plan

Each team member was asked to investigate the feasibility of one or two possible solutions. After one month the group reconvened and presented to the team the feasibility of each solution. If the team agreed on the feasibility of a solution, a time schedule was developed, resources identified and a proposal formulated. Possible methods for monitoring were also identified to measure the effectiveness of the mitigative measure. It is important that the institution of a mitigative measure was evaluated for its effectiveness. If it was not effective modifications could be updated (Ergosystems, 1991; UAW-Gm, 1988; UAW-Ford, 1987; and AMI and Ergotech, 1990).

6.6 Phase 4 - Review of the Process with the Ergonomics Team

The final phase of the case study reviewed the ergonomics process with the ergonomics team. A questionnaire was given out to each team member to identify the effectiveness of the pilot program (Appendix A). Medical management, a written policy and program, employee participation, regular program review and evaluation and training and education were discussed further and informational sources and a list of consulting companies were provided to the company if further expansion of the program were to be undertaken.

Design of the Questionnaire for the Interview

The questions were designed to survey the effectiveness of the pilot project. The initial draft was formulated and pretested on academic colleagues. Problem areas were identified and were reworded or omitted as needed. The questionnaire is as follows:

ERGONOMICS PROCESS REVIEW

(1) How do you feel the ergonomics process worked in the pilot project?

(2) Are there any components of the process that you would delete? If yes, which components and why?

(3) Are there any components of the process that you add to the process? If yes, which components and why?

(4) Do you believe the process from the pilot project could be applied company-wide? If yes, why? If no, why?

(5) Do you feel the company can carry on the ergonomics process once the study is over? If yes, why? If no, why?

(6) How did you feel about having the consultant operate as a facilitator in the ergonomic team meetings?

(7) Do you think participation through the entire process by the ergonomics team was effective in understanding the principles of the ergonomics process? If yes, why? If no, why?

(8) Do you like to work using a team approach when investigating and solving ergonomic problems? If yes, why? If no, why?

(9) What type of problems do you think the team could investigate and solve independent of having a full-time ergonomist on-staff?

(10) Do you feel an ergonomics consultant would be required over the long term? If yes, what do you think the role of the consultant would be?

(11) Do you think an ergonomics program can be effective over time?

6.7 Ethical Considerations

6.7.1 Confidentiality and the rights of the Participating Company

All data gathered from companies surveyed in phase one was kept confidential and in no way identified the participating company unless released in writing.

6.7.2 Rights of individual participants in the research

The study was designed to develop a ergonomic program model that can be utilized in an organization < 300 employees. The research was designed and carried out to protect the rights of the workers and other participants.

6.7.3 Health statistics gathered

All health and accident review of data was reviewed by members of the sawmill's occupational health and safety staff. Whenever possible, information gathered by the staff and passed onto the researcher did not include any identification of the individuals. If identifying information was included then the researcher treated the information with the confidentiality assigned to medical records. Any information which included identification was destroyed or returned to the company as soon as the information was extracted. All reports and presentations of the research did not include any identifying information. All information was stored in a secure place. Information obtained from the health data was presented to the researcher in a general form to get a general impression of the health problems associated with the particular site. Since the information was to be presented in a general overview, consent to access individual records was not required.

6.7.4 Supervisor Interviews

The interview included questions pertaining to their job demands and responsibilities. If identifying information regarding a individual worker was used it was kept in the strictest of confidence and not released to anyone outside the research team (the masters degree project student and supervisory committee members).

6.7.5 Employee Interviews

Participation in interviews was voluntary. A sample consent form is located in Appendix B. Individual's responses were kept confidential and anonymous.

6.7.6 Observation

Observation and video-taping at the workstation studied the normal job activity of the employee. Participation did not pose any risk other than that which was normally present in the job. Participation was voluntary and consent was required. A sample consent form is located in Appendix B. Data in the form of individual reports and video-tapes was not released to other employees or the employer. It is difficult to connect a employee with the workstation, since a variety of employees are rotated through the station every two hours.

CHAPTER 7 - CASE STUDY RESULTS

7.1 Background Information

Case Study Project at a Northern Alberta Lumber mill

The health and safety department at the lumber mill was approached in August, 1991, to participate in a case study, examining the development and implementation of an ergonomics program. The project was initiated on site in January of 1992. A meeting which included all levels of management was used as a forum to introduce the pilot project (case study). A brief description of ergonomics was provided in conjunction with the case study plan. With an understanding that commitment was secured for the project, we proceeded to form an ergonomics team.

7.1.1 Management System

The company is presently working within a total quality management system. According to the company, this system totally integrates methods for meeting and exceeding customers' requirements through the continuous improvement of quality. It is a system for achieving increased productivity, consistency, reduction in costs and an expansion of the customer base. The company is working to achieve these goals through company-wide team work. For this reason the appropriate method for implementing an ergonomics program was through an ergonomics team established internally. The team would operate with a number of representatives from all levels within the organization. This allowed for inclusion of ergonomics over the long term, since it was developed and implemented in line with the company's present infrastructure.

7.1.2 Objectives of the company

The 1992 company objectives that identified the need to address the human/machine interface are as follows:

(1) Strive to eliminate work place injuries through training system improvements and behaviour development

- complete the development of safety policies and guidelines
- continue the woodlands contractor safety program development
- begin behavioural safety training

(2) Improve the people systems to attract and keep the best people

- improve training, progression and communication systems.

Both of these objectives address the need for a better match between the worker and the work environment. Some aspects dealt with physical work space design issues and job design, while others dealt with interpersonal skills between members within the organization.

The goals of the ergonomics program were to address issues involving work place and job design. Through the team approach, the ergonomics team derived a better method for individuals from the work environment to relay their concerns to the company.

Introduction of the ergonomics process will aid in achieving the company's goals and objectives previously outlined. The team approach to ergonomics is consistent with the present management culture.

7.2 The Ergonomic Process

7.2.1 Management Commitment

After the ergonomic need has been documented it was important to secure management commitment.

Company

Management commitment was secured at the beginning of the project. A forty minute presentation was provided to members from the company representing the following departments: management, production, engineering, employee representatives, maintenance and purchasing. The presentation included information on the following: a definition of ergonomics, benefits of employing ergonomics, a definition of cumulative trauma disorders and associated ergonomic risk factors, relevant case studies that illustrated the aforementioned topic areas. A description of the project was also provided outlining the goals and objectives of the project. Required company resources were outline. After the session was held, members of staff discussed the relevance of the project to their facilities goals and objectives and how they felt ergonomics could benefit the company. Shortly after the meeting, management commitment to the project was secured and on-site work was scheduled for February of 1992.

7.2.2 Formation of the Ergonomics Team

An ergonomics team should either be developed as its own entity or become a part of an existing team such as occupational health and safety. The team should contain individuals from the following areas: safety, medical, engineering, operations management, human resource management, union representatives and/or production employees, someone with expertise in ergonomics, and other (maintenance, purchasing).

Those involved should represent the various plant functions needed to coordinate and implement changes. Regular meetings should be held - every 2-3 weeks to determine which priorities should be dealt with, and to monitor feedback on implementations, and education on particular topics of interest. Minutes should be taken at all meetings.

The employer should provide a method to encourage employee involvement in both the ergonomics program and in decisions that affect operator health and safety. The following are three suggestions which may prove helpful in this area. First, an employee complaint or suggestion procedure which allows workers to bring their concerns to management and provide feedback without fear of reprisal should be instituted. Next, a procedure which encourages prompt and accurate reporting of potential cumulative trauma by employees so that they can be evaluated and if warranted, treated, is important as well. Finally, safety and health teams or ergonomics teams can receive information on ergonomic problem areas, analyze them and make recommendation for corrective action.

Company

In the lumber mill, members from management, maintenance, purchasing, occupational health and safety, production and employee representatives made up the team. The team was provided general training in ergonomics, but far less than what was required to actively investigate and solve problems existing on the job site. In order for the team to continue functioning over the long term further job-specific and discipline specific training is required.

After the session the team worked with the consultant to formulate the action plan for the pilot program (refer to appendix C for a copy of the action plan).

During the project the ergonomics team was active in all phases of the pilot program. The formation of the team was designed to be active throughout the entire ergonomics project. Their role began with the selection of jobs that were to be included in the ergonomics audit. The ergonomics team was involved further in the following section of the project:

- *the audit*
- *prioritization of jobs*
- *review of the in-depth analysis of the mainline grader*
- *solution generation*
- *formulation of the implementation plan*
- *implementation and monitoring of the plan*

The role of the consultant within the ergonomics team varied throughout the project. The consultant started as a researcher (documenting the need for ergonomics, the audit, and the in-depth analysis of the mainline grader), and then moved into a role as an informational source and facilitator (prioritization of jobs, solution generation and formation of the implementation plan).

The next stage of the process was to introduce the project to the employees across the two shifts.

7.2.3 Document the need for Ergonomics

Before an ergonomics program or intervention can be initiated it is important to document the need for ergonomics. An ergonomist or qualified personnel can help to establish the need for ergonomics. Need can be established by reviewing historical records. Records may include the following sources:

- incidence rates of injuries
- workers' compensation claims
- first aid cases
- medical insurance claims
- absenteeism
- supervisor investigations of incident/accidents
- production quality/error rates for each work area

Once review of historical records is completed, the information should be provided to management in order to secure commitment for an ergonomics project or program. Methods that can further substantiate the need for ergonomics are symptoms questionnaires and an audit of a job to determine if ergonomic risk factors exist.

Company

The lumber mill incident/accident reports were the primary historical record that was available for review. There were a number of problems that made those records less effective in establishing the need for ergonomics. The following section outlines some of the problems.

(1) Incident/accident reports up to 1989 did not identify cumulative injuries, but rather acute trauma injuries such as cuts, bruises, and fractures. For this reason it was difficult to identify cumulative trauma/repetitive strain injuries such as low back injury, or carpal tunnel syndrome.

(2) Trends were difficult to establish, since reporting varied in its completeness.

(3) Job rotation was not consistent. Many times rotation depended on where the production need was in the plant. Therefore, it was difficult to determine whether a particular workstation/job required ergonomic evaluation.

(4) Finally, lost time days were not recorded so it was impossible to establish the cost of an injury either directly or indirectly to the company.

Since 1990, an advanced injury accident program was installed. This new reporting format is more effective in establishing injury trends, since reporting is well established and evaluates the incident/accident and injury from a number of different angles. The one drawback of the program was that the system had not built in a mechanism to record lost time.

It was pointed out to the company that as the ergonomics program develops, the following records may also be beneficial with regards to documenting the need for ergonomics: error rate, down time, and supervisor investigations. Supervisors can remain aware of these sources on a regular basis, thus, alerting the supervisor to a problem area if a difference in the standardized production data is detected, such as increased error rates. Often error rate and down time are associated with a mismatch between the demands of the workstation/job and the operators' capabilities/limitations. For instance, if an operator is not able to keep up with work place/job demands, the risk of error is a lot higher.

Since the data collected from the incident/accident records was insufficient in establishing a need for ergonomics, a symptoms questionnaire was utilized to obtain information that could possibly substantiate a need for ergonomics. The symptoms questionnaire (refer to Appendix B) was handed out to all employees across all three shifts. Participation was voluntary; if the employee decided to participate, he/she was required to fill out a consent form (refer to Appendix B). Of the sixty surveyed, forty-two experienced some form of fatigue or discomfort on-the-job in the past year. Over the past year, 109 lost time days were recorded due to the pain or discomfort. The majority of complaints were associated with the back (25 complaints), foot (9), shoulder (8), and knees (8). The factors associated with the onset of pain included: awkward work

postures, prolonged standing, repetitive motions, excessive forces, poor seating and heavy lifting.

7.2.4 Ergonomics Audit

An ergonomics audit is an observational survey of a variety of work place factors. The audit seeks to identify risk factors that characterize a job, and may affect operator performance and/or well-being.

Audits are usually initiated by an ergonomist or other qualified personnel. An ergonomics audit should be conducted once the need for ergonomics has been documented. The audit may also serve as another mechanism to further substantiate the need for ergonomics. Mir (1982), identified three primary functions of an ergonomics audit:

- identify problems that need to be solved
- help prioritize jobs that require intervention
- provide feedback on effectiveness of an ergonomics effort

In a company, ergonomics targets three functions of a company - input, process and output. An audit generally focuses on the process and outcome measures. Process measures give prescriptive and diagnostic advice of value to the organization. Outcome measures define how effective the company was in ergonomics.

An ergonomics audit is designed to identify a number of work place factors that may affect the performance and/or health of the operator(s). An audit may address the following areas:

- visual aspects
- auditory aspects
- thermal aspects
- instrument/controls/displays
- design of work places
- manual material handling
- energy expenditures
- assembly/repetitive tasks
- inspection tasks (Mir, 1982)

The use of audit information will allow the ergonomics team to prioritize jobs according to need for ergonomic intervention and/or provide a case for further ergonomic investigation of a job.

Company

At the Lumber mill, the audit was utilized as a tool to identify problems that needed to be solved and also helped in the prioritization of jobs (refer to Appendix D for results of the audit). The audit focused primarily on process measures. The audit was conducted over a five day period. Seventeen jobs were reviewed with each review averaging two hours.

Observation was the primary method utilized to audit each job. An audit form was utilized to categorize data. As well, informal operator and supervisor interviews were also used. Seventeen jobs from the sawmill (log preparation and initial breakdown) and the planer mill were reviewed in the audit. The following jobs were part of the audit:

Sawmill (log preparation)	*Sawmill (initial breakdown*	*Planer mill*
cut off saw #3	*optimizer*	*annex*
sort bins	*edger*	*mainline grade*
	schurman	*wrap & strap*
	pocket edger	*studline grade*
	prime sort #1 & #2	
	trim saw #1 & #2	
	stacker	
	sticks 1 & 2	

Once the audit was completed, the consultant presented the results to the ergonomics team for review.

7.2.5 Prioritization of Jobs

Once the ergonomic audit has been completed, it was important to prioritize jobs according to need for intervention. Prioritization can be determined utilizing historical records, ergonomic audit results and input provided by members of the ergonomics team. The team will often identify issues that cannot be established through the audit or historical records. Some of these issues may include: plans regarding re-design, elimination of the task and/or allocated resources to a particular division. These issues may all have a tremendous impact on the implementation/outcome of an intervention.

It is important that all information is presented to the team in a logical form. Each job should be presented to the team in the same format. One member should act as a recorder to keep track of information and issues identified by team members.

Once presentation of information has been completed, the team must establish guidelines with which to prioritize the jobs reviewed. Guidelines will often be determined by the goals and objectives of the ergonomics program. For example, if the goal of the program is to reduce injuries over the next two years through job design and training programs, the team may utilize the injury statistics related to a particular job as

a primary determiner of its priority for ergonomic intervention. This of course can be misleading especially if only acute trauma is detected in the injury statistics. Thus the intervention required may not be ergonomic in nature, but rather an occupational health and safety issue. An ergonomist or qualified person can help the team formulate effective guidelines for prioritization.

Prioritization of jobs should be reviewed every six months to determine if prioritization is affected by issues present in the company culture (e.g., a high priority job has been eliminated). Guidelines should be reviewed yearly, especially if the goals and objectives of the program change.

Company

Once the audit was completed, each of the seventeen jobs was presented to the ergonomics team. The following categories were utilized:

(1) Those that can benefit from a short term ergonomics intervention - high priority.

(2) Those that require long term intervention such as work place redesign.

(3) Those jobs that require intervention, but the intervention is not an ergonomics intervention.

Other issues that also affected prioritization were the number of people exposed to the job area, information obtained from the symptoms questionnaire and company goals and objectives for the future in terms of each area.

From the data collected through the audit, historical records and input from members of the ergonomics team, a number of short term interventions were suggested for each job. The following four jobs were considered high priority for further analysis and intervention:

pocket edger	-	*sawmill*
sticks	-	*sawmill*
wrap & strap	-	*planer mill*
mainline grader	-	*planer mill*

Guidelines for determining priority were established by the consultant and the ergonomics team. They were as follows:

(1) Those jobs placed in job classification number one were considered high priority for ergonomic intervention.

(2) The job was not scheduled for immediate design changes e.g. trim saw #1 and #2, but the company wanted to consider ergonomics in the future.

(3) The job was identified as a high priority for change by employees in the symptoms questionnaire and/or informal interviews during the audit.

All other jobs that were audited were not ranked and in the future will need to be reviewed and ranked according to the guidelines established by the ergonomics team. Prioritization of jobs should be conducted annually in order to review any changes that have occurred since the last review period.

After the review of the pocket edger, sticks, wrap & strap and the mainline grader, the team decided to further analyze the wrap & strap area. The area was chosen for the following reasons:

- *results from the symptoms questionnaire indicated that it was a work area that was of concern to the employees;*
- *a larger number of employees rotate through the positions at wrap & strap;*
- *the following ergonomic risk factors were identified: prolonged standing on hard surfaces, heavy lifting and carrying, awkward work postures are assumed when working, exposure to temperature extremes due to its location near the doors, and repetitive motions.*

The audit was further examined by the consultant after the team meeting - the majority of recommendations provided by the consultant and team were considered costly interventions. The following day the consultant approached the team once again to re-evaluate their decision. The team agreed with the consultant and the mainline grader was then slated for further analysis.

With regards to the mainline grade, it was identified that problem areas could be mitigated with both short term and long term interventions. The job is considered a high profile area in the company. Thus, a successful ergonomics effort in the area could be used by the ergonomics team to further "sell" ergonomics to upper level management for future ergonomic analysis and intervention in the company.

7.2.6 Project Plan for Ergonomic Analysis, Modification and Monitoring

7.2.6.1 Ergonomic Analysis

Once prioritization of jobs has been completed, an in-depth analysis of a high priority job can be undertaken. In-depth analysis may require the services of a ergonomist or an individual trained in a related field. It is important to understand the problem areas that need to be investigated prior to initiating a study. A plan for investigation should be well - established with methods and procedures that will be effective in identifying risk factors.

(1) Risk Factors

Results from the audit, historical records and symptoms questionnaires can be reviewed to identify problem areas and establish risk factors that need to be investigated. It is important that risk factors are analyzed in-depth before solutions are investigated and implemented. For example, if results from the job audit, historical records and the symptoms questionnaire identify that a high number of operators experience signs and symptoms of a cumulative trauma disorder, then a number of factors should be investigated. Typical risk factors that should be analyzed are as follows: excessive repetition/prolonged activities, forceful exertions (usually with the hands), pinch grip, prolonged static postures of the body, trunk and/or its extremities, awkward postures of the upper body, excessive twisting or bending of the wrist, continued elevation of the elbows, continued physical contact with work surfaces, temperature extremes, inappropriate or inadequate hand tools, restrictive workstations, vibration from power tools and improper seating/support.

(2) Investigation

A number of methods can be utilized to investigate risk factors and their effects: observation (video-taping, photographs), checklists, measurement of environmental factors (lighting, noise, thermal aspects), task analysis, job analysis, physical measurement of the workstation (lay out of equipment, work surface height), and employee/supervisor interviews. The services of an ergonomist may be required to set up a plan (methods and procedures) and/or carry out the investigation. Before investigation is initiated, employees should be informed of three things: the investigation plan, when investigators will be in and finally, what is expected of operators.

(3) Baseline Data

It is important to establish baseline data, especially to compare the effects a implemented modification can have on alleviating or reducing risk factors. Techniques that can be used to establish baseline data are as follows:

- supervisor and employee surveys
- review of the injury/illness rates
- re-evaluate the job with the ergonomic

Once the in-depth analysis has been completed, results should be presented to the ergonomics team.

7.2.6.2 Implementation

Information from the in-depth analysis should be presented to the ergonomics team. Team members should brainstorm in small groups (3-5 persons) to establish possible modifications/solutions (UAW-Ford, 1987). It is important that all solutions be recorded and presented back to the entire team for the group to evaluate each solution in terms of feasibility and effectiveness to reduce or alleviate a risk factor(s).

Solutions/modifications may be classified as one of the following interventions: an engineering control, work practice or administrative control.

(1) Engineering solutions are the preferred method of control for ergonomic hazards. The goal of an ergonomics program is to make the job fit the person, not to make the person fit the job. This may be accomplished through re-design of the workstation or introduction of a new tool or machine to reduce high forces or high repetition rates. A workstation should be designed to accommodate the individuals who will actually work at the job. It is not good enough to design for the typical or "average" person. Where possible, workstations should be easily adjustable and designed or selected to fit a specific task.

(2) Job redesign may establish new methods for the reduction of extreme and awkward postures, as well as introduce methods to reduce excessive forces and/or reduce highly repetitive movements. This may be accomplished through new work place procedures (e.g. lifting procedure, designing the job for self-pacing or allowing sufficient rest pauses).

(3) Administrative control focuses on such issues as job rotation and work schedules to alleviate or reduce risk factors.

Once the type of control has been established the team should investigate its feasibility both economically and in the overall schema of company goals. Timetables should then be established to implement modifications.

7.2.6.3 Monitoring

Monitoring is a essential function of a project, as it must be established if the modification reduces or alleviates the risk factor. The modification should be monitored two weeks after its introduction to deal with any problems that the modification may have introduced or even to adjust the modification to improve its effectiveness. For example, when introducing new lighting to improve light levels, the height of the light source may have to be experimented with to determine appropriate light levels. After changes have been made, measurements of effectiveness should be done at six months and again at one year to ensure the measure has mitigated the problem (UAW-Ford, 1987). Measurement methods and procedures should be consistent with methods and procedures utilized to establish the baseline data recorded in the in-depth analysis.

Company - MAINLINE GRADER

The mainline grader was chosen for further analysis by the ergonomics committee based on the following information:

(1) According to the audit, the workstation presented with a lot of ergonomic problems that could be solved in the short term potential for success.

(2) Injury data indicated that over the past five years there have been four cases of carpal tunnel syndrome resulting in lost-time injuries.

(3) Operator performance greatly affects the outcome of the marketable product in terms of its grading.

The in-depth analysis was conducted over a three day period. The analysis included the following:

- *interviews with operators from both the red and blue shifts*
- *supervisor interviews*
- *observation/video-taping of the tasks (blue shift)*
- *work place measurement*

Refer to appendix D for a copy of the raw data, the task analysis and the results of the symptoms questionnaire.

Data was presented to the committee in a three hour working session. The committee was divided up into two groups and presented with the data so as to come up with some recommendations. Once the recommendations were generated, the group assigned each individual with responsibility for a particular recommendation and its feasibility.

One month later the committee re-convened and reviewed feasibility and established time lines for implementation of solutions. All work in the area has been targeted for completion by the end of June 1992.

The next section reviews the in-depth analysis, recommendations and implementation plan.

7.2.6.4 Mainline Grader

ANALYSIS, RECOMMENDATIONS AND IMPLEMENTATION PLAN

A. Work Station Design

The work surface height is not adjustable and thus may be an uncomfortable workstation for those individuals that fall at the extreme ends of the anthropometric spectrum. For the smaller worker, the operator must often work with shoulders elevated. For the taller worker he/she must take on a fairly flexed posture (neck flexion and flexed spine). both scenarios can lead to operator discomfort and even injury (strain/sprains). These postures can all lead to muscle fatigue if they have to be assumed frequently for periods longer than a minute (Grandjean, 1988). The tasks classified at the work station are considered heavy in nature (turning boards would be classified as heavy work due to repetition rate and weight of lumber). Work surface heights for heavy work should fall in the following ranges 85-101 cm males and 78-94 cm females (eastman Kodak, 1983). Height of the work surface at 90 cm is appropriate for most females, but on the lower end for taller males.

Recommendations

i. For the smaller worker a platform could be utilized to lift the operator to a comfortable working height. The platform (non-slip surface) has to be wide enough to allow the operator room to move around and adjust his/her posture. The platform should be easy to move around so that the operator can work in all three operator positions.

ii. Most operator may find it helpful to work with the option to sit/stand. A sit/stand stool may be an option. It is essential that there is adequate forward leg room so that the operator is able to move freely when utilizing a sit/stand stool. The sit/stand stool should be fully adjustable in height and tilt for operator comfort. It is important that the chair or stool is stable, for example five legs is favored over four with a wide base (Eastman Kodak, 1983). It is insufficient to have a chair without a footrest, since the ideal chair height may leave the feet unsupported. When the feet are unsupported pressure is put on the underside of the thighs. Over time this can lead to discomfort.

Conclusions and Implementation Plan:

A platform can be fabricated on-site if facilities are available - size and surface covering should be experimented with, to obtain a comfortable position for the operator (a comfortable working position for an operator usually has the shoulder resting comfortably, with elbows at approximately a 90 degree angle). There is still the factor that the platform could pose a potential hazard, (i.e., an operator could trip and fall).

A sit/stand stool is a solution that can be applied to both the taller and shorter operators, since the adjustability achieved through the stool can accommodate the differences in body type. A sit/stand stool and footrest should be experimented with for approximately 2-3 weeks from suppliers. It may be desirable to evaluate a few stools in this fashion. it is important at that time to obtain operator feedback. This can be achieved through questionnaire or brief interview. When choosing a sit/stand stool for purchase it is important that a number of operators have had the chance to try the stool out and report their feedback to the purchasing group.

The controls at the mainline grader are located behind the operators. Due to the demand on operator #1 to determine correct speeds for incoming lumber, the operator must determine through visual feedback if speeds are correctly set. If speeds are incorrect the operator may have to walk from the table to the control panel up to ten times before the speed is set. If the operator has to leave the table several times the other operators must alter their rhythm from grading every third board to grading every second board. This not only affects rhythm, but it also increases the repetition rate. Increased repetition rate can lead a potential increase in error rate and/or operator discomfort and/or fatigue.

Controls on the panel are not all marked. For the new operator training is more difficult when he/she is not provided with effective visual feedback, such as through a label. The new operator relies on his/her memory, or, in many cases trial and error. The experienced operator depends solely on his/her memory, in terms of control and function.

Recommendations

i. Determine feasible speeds, providing controls that are clearly marked so that operators can set speeds fast and then resume work pace at the table as quick as possible.

ii. Relocate controls closely to operator #1, so that speeds can be easily adjusted.

iii. Re-label all controls so that they are clear and easy to read (black characters on a white background or black on yellow, Eastman Kodak, 1983), ensure all visual feedback is consistent at the workstation and if possible plant-wide. this will aid new trainees and aid an operator when in a stressful situation.

Conclusions and Implementation Plan

Setting incoming lumber speeds and relabelling controls are the most feasible over the long term. Financially they are both low cost solutions. Time will be required by personnel to program speeds, labelling may have to be undertaken by the maintenance department. Both solutions should be effective in reducing down time, error rate, operator frustration and situations that put operators at risk for developing injury or illness.

According to supervisory staff, speeds can be set fairly quickly and put into place in the near future. If possible, operator feedback should be gathered, as well as quality production data gathered to examine the effects before and after the implementation. It is important that data is gathered over a two or three week period in order to get a fair picture of the effects of the modification.

Flooring in the work area becomes quite slippery when an operator has oil on his/her boots. This could put the operator at risk of slipping and falling. Also in many areas there is anti-fatigue matting present and pieces of plywood laying over catwalks. It is important that there is a strong color discrimination between all of them to ensure that operators do not trip and fall.

Recommendations

i. Ensure that house-keeping duties are carried out on a regular basis, to ensure that any materials from work area are removed so that they do not become a safety hazard.

ii. Matting located on top of sheets of plywood in the work area, should be well laid out so that operators are not put at risk of falling. Many workers complain of fatigue they experience when standing on matting for extended periods of time. A combination between the plywood and matting allow the worker to take a break from either surface. Explore other types of anti-fatigue matting that may be more suitable for the area and experiment with thicknesses of medium density fibreboard (M.D.F).

iii. Ensure that operators' footwear is appropriate for the work area. When choosing a work boot the following aspects should be considered - floor surface, standing requirements, nature of the work being carried out, and potential environmental hazards (Eastman Kodak, 1983).

Conclusions and Implementation Plan:

It is important to contact maintenance and set up a system whereby employees can contact maintenance as soon as possible for house-keeping activities. By dealing with the problem soon after it has occurred the company can take a preventive approach in aiding reduction of work place injuries.

Matting and the combination of medium density fibreboard (M.D.F.) should be utilized over a two to three week period. It is important to receive operator feedback, to ensure the matting and M.D.F. are achieving the desired effects.

Set up a footwear program - investigating different types of footwear and their application. Provide operators with guidelines on how to chose footwear, maintenance and detection of breakdown in footwear.

B. Equipment

Grab bars and crayon holders are the most frequently used equipment. Many of the grab bar tips are dull and the tips are not securely attached. The combination of factors may require the operator to use more force and awkward movements than necessary to maintain a grip on the object being grabbed. Force and awkward postures can lead to operator discomfort or even injury if the operator is not prepared for the action. The crayon holder available is awkward in length and diameter. To replace the crayon is a tedious task that requires more time than most operators have to keep up with the work pace. Heavy pressure is required to apply the marking. Graders often break off the end of the crayon, this can frustrate the operator as well as throw his/her rhythm off. Marking requires the operator to take on awkward hand positions which may result in wrist soreness and difficulty in sustaining a grip on a tool (Eastman Kodak, 1983). Tool length should be approximately 13 cm (5 in) a minimum length of 10 cm. Diameter should be no larger than 1.23 in for power grip (recommended for precision operations is 0.3-0.6 in). Over time poor wrist position, repetition rate and force can contribute to the onset of carpal tunnel syndrome.

Recommendations

i. Provide the operator with grab bars that are well maintained.

ii. Reevaluate the use of the crayon holder. Possibly evaluate a larger crayon in terms of diameter so that the holder does not have to be used. Also, evaluate the different hardness of crayons to help reduce the force required to mark and the risk of breakage.

Conclusions and Implementation Plan

Pilot a preventive maintenance program in the mainline grading area. Tips on tools should always be sharp as opposed to dull. Heads of tools should be checked to ensure they are tightly fastened.

In the committee meeting it was evident that a number of different crayon types have been experimented with and the present crayon is most effective for marking. If possible contact the association to identify if there are any other crayon types or methods for marking that may reduce the factors previously identified.

C. Physical Job Demands

Movement is fairly restricted due to the pace of grading (cycle time 2.5-3.5 seconds). Through observation it was noted that workers take on a flexed posture and often work in a twisted position. Space between boards is appropriate when stationary, but due to the speed of the task the spacing may be inappropriate.

Recommendations

i. Slow down work pace or add another grader to the line.

ii. Provide footrest to obtain a better posture when standing, and/or utilize a butt board/stool to provide the operator the option to vary his/her posture over the work period.

Conclusions and Implementation Plan

In the committee meeting it was evident that work pace cannot be slowed down and the cost of an extra grader is also not feasible at this time. In terms of the second solution, a stool has been suggested as a solution for another problem area. Committee members believe that the introduction of a sit/stand stool would provide the operator with a chance to alter his/her posture, as well as to enhance the operator's comfort. It is important that a number of stools and footrests are experimented with before a set is chosen for implementation.

Repetitive motion is the physical demand that is most noticeable in the work area. Operators typically turn the board with their left hand and mark with their right (with a larger board they will use two hands to turn boards). The postures the operators must take on and the forces the operator applies over time, can lead to operator discomfort and may contribute to the occurrence of an overuse injury. It is important that awkward positions are reduced or the exposure is reduced in order to aim at prevention of overuse injuries.

Recommendations

i. Rotate workers between jobs having different force requirements. If rotation between jobs or tasks is not feasible, intersperse the primary task with several lighter tasks that provide a break for the muscles and joints most involved in the task. Ensure rotation every two hours with no more than four hours a day on grading tasks.

ii. Train workers to recognize early signs of repetitive-motion disorders and to report them immediately so they can be reassigned to a less stressful job until the symptoms subside. Early detection of susceptibility can reduce the risk for more severe problems and decrease the time lost from work (Amoroso, Eastman Kodak company, 1978).

iii. Keep the work surface height low enough to permit the operator to work with elbow to the side and wrists near their neutral position.

iv. Keep reaches within 50 cm of the front of the work surface so the elbow is not fully extended when the forces are applied (Armstrong, 1978). Keep motions within 20 to 30 degrees of the wrist neutral point (Tichauer, 1978; Welch, 1972). Avoid operations that require more than 90 degrees of rotation around the wrist (Tichauer, 1978). Avoid gripping requirements in repetitive operations that spread fingers and thumb apart more than 6.25 cm (2.5 in) (Hertzberg, 1955).

v. For continuous, highly repetitive operations, design into the activity a five minute break to perform another activity every 30-45 minutes.

Conclusions and Implementation Plan

The above recommendations can be implemented with minimal cost to the organization. Most issues deal with work schedule and job rotation. It is important that for job rotation to operate correctly, operators are rotated onto jobs that do not encourage the use of the same muscles or joints as the previous.

Early recognition of signs and symptoms of repetitive motion injuries can be taught in the initial safety training through the use of training video. The video session should be followed up with a description of reporting methods if signs and symptoms develop. An individual should be provided with restricted duty until symptoms subside. It is also important that the safety team develops a set procedure for referral and evaluation with a local clinic. At that time it is important to obtain regular feedback on the operator's condition to ensure appropriate precautions are taken to reduce further deterioration.

In terms of work position it may be effective to video tape operators' positions before, and, after modifications have been made in order to evaluate the effectiveness of the modification. Another option would be to train operators about the benefit of correct working postures and how to set up their work environment to reduce the factors that may contribute to repetitive motion disorders. Training can be provided to operators through 2-3 sessions on ergonomics.

The worker continually stands on either anti-fatigue matting or on a wood surface located on top of the catwalks. Operators expressed that many experience fatigue when standing for extended periods of time in one spot, especially on the vibrating surface. The anti-fatigue matting may be inappropriate for the particular work surface area and may have to be re-evaluated.

Recommendations:

i. Investigate the source of the vibration to evaluate the type of vibration operators are exposed to and possible ways to dampen vibration exposure. Possible solutions include:

- mount equipment on springs or compression pads
- maintain equipment properly; balance and replace worn parts

- use materials that generate less vibration
- modify equipment speed, feed, or motion to change the vibration characteristics to a more suitable range.

ii. Re-examine the particular anti-fatigue matting that is presently being utilized and continue to evaluate the combination of anti-fatigue matting and the M.D.F..

Conclusions and Implementation Plan

At the committee meeting the supervisor of maintenance decided to investigate the source of the vibration. Once the source has been determined it would be effective to evaluate the type of vibration the operators are exposed to and the effects of modification on the vibration operators are exposed to. Vibration studies can be costly to carry out, but information gathered in this area may be useful plant wide in terms of solutions.

Anti-fatigue matting should be evaluated in terms of the type and the effectiveness. A number of different types should be investigated, approximately every two weeks to obtain appropriate feedback from operators. Once again, feedback can be accomplished through interview or questionnaires.

Excessive reaches are not evident when operator rhythm has not been disturbed. Excessive reaching becomes a problem if the operator is inexperienced or losses his/her grading rhythm.

Recommendations

i. For those operators that are inexperienced, grading time should be limited. A schedule that establishes the amount of time spent grading should be developed so that new operators can develop a grading rhythm.

ii. Whenever possible have no less than three graders working in order to maintain a reasonable work pace. If the operator gets behind in keeping up to the flow, he/she may have to continually reach far to the right when grading.

iii. Provide the operator with appropriate aids to reach skewed boards or boards that are jammed.

Conclusions and Implementation Plan:

At present the workstation allows for an adequate training period to encourage new operators to develop a comfortable rhythm for grading. It is important to be aware that each individual requires a different amount of training time and so it is important to be flexible when training to accommodate those differences.

The number of graders is usually three at any one time. When the lug loader is operating well and speeds are set correctly, the system is effective. When the lug loader has a problem, or speeds are difficult to determine (the operator must leave the table frequently to adjust the controls) operators are often pressed to keep up and then may need to reach excessively to mark boards they may have missed.

D. Fatigue

Operators in the interview stated that over the course of the two hours many experience increased levels of fatigue. Some experience fatigue in their legs due to the standing, while other experience overall body fatigue and a mental fatigue. The overall body and mental fatigue often gets worse when the operator has to work more than two hours straight on the mainline grader and if temperature is above normal and/or two graders have to take on the job normally assigned to three graders. The following environmental factors tend to enhance fatigue: machine pacing, repetition, monotonous tasks, isolation, awkward posture requirements, high heat and humidity, high noise levels, glare and nonadjustable work places. Fatigue can often effect operator performance and put the operator at risk of injury.

Recommendations

i. Increase the intensity of the defect; use color, shape or special marking codes to set it off from the background (Murrell,1965).

ii. When feasible, provide rapid feedback to the operator about performance. If a defect is detected later in the system the operator who missed it should be informed immediately.

iii. Provide redundancy in alarms so that more than one sense is involved.

iv. Where practical, for visual tasks, provide operators with visual aids for comparative judgement.

v. Try to reduce environmental factors that enhance fatigue.

vi. Utilize job rotation to allow time for muscles and joints to rest.

Conclusions and Implementation Plan:

The first two solutions are difficult to implement at the mainline grader. The number of defects that the operator must be aware of varies greatly with the type of board he/she is evaluating. Defects also vary in contrast to the wood, from a burn on the wood to a split in the wood (very difficult to detect).

The final four solutions can be implemented at a fairly low cost. Redundancy alarms or alternative feedback are presently utilized in the area and are effective in alerting the operator. Visual aids such as the grading rules are located at present in the work area behind the operator. To be more effective these rules should be located in front of the operator and large enough so that operators can easily read the guides. Environmental factors such as lighting, noise, temperature and humidity can all be effectively monitored. Recommendations are identified in the next section on environmental factors. Finally, job rotation can be effectively implemented if supervisors have a clear understanding of the physical demands of each job. It is important that operators rotate onto jobs that do not require the same physical demands so as to allow the muscles and joints a chance to recover.

E. Environmental Factors

Temperatures in the summer are high. Due to the nature of the task (heavy work) the temperature causes the operator to tire quickly since the body is not able to cool itself adequately. Another factor that may affect quality is when temperatures are so high operators often have sweat in their eyes. This may result in eye irritation or visual interference with the task (Eastman Kodak, 1983). It is important to reduce high heat and humidity as both enhance fatigue.

Recommendation

i. Ensure that temperature control is appropriate throughout the summer months with good ventilation and dust extraction systems.

Noise levels fall into a range that makes it difficult to communicate with other operators. In many cases operators must rely solely on visual cues in the environment

to provide feedback on operations taking place at the workstation. Rhythm of grading is determined primarily by the number of graders and thus can be easily disturbed if a grader leaves the station to perform another task. The noise level makes it difficult to hear the public announcement (P.A.) system when training. If communication is interfered with, it is difficult to communicate with new employees that are grading at the workstation. Noise also isolates the operator from those around them and isolation can contribute to increased fatigue levels.

Recommendations

i. Short of insulating the room it is very difficult to control the levels of noise that workers are exposed to. Possibly looking at an alternative communication system - the overhead system is large enough and easy to read-feedback is also given through the physical shut-down of the system. Alternative methods may be through the use of a head set, and an improved P.A. system.

ii. Sound proofing of the planer, chipper room and low pressure fan will help reduce noise levels.

Light levels are too low for the inspection area. Contrast ranges from very high to very low (burn on the wood to a crack or split in the wood). When lighting levels are too low, it decreases the operator's ability to adequately view a task. Poor light levels can also enhance the fatigue factor.

Recommendation

i. Look at increasing levels from > 200-500 or > 500-1000 lux to improve the operators' ability to conduct visual inspection tasks. This may be accomplished through better lighting or to lower the lighting closer to the work surface. As well, background colors should be explored to improve overall area lighting. A suggestion the committee came up with was to remove the opaque fibre glass in the top area of the building and to replace the opaque fibre glass in the top area of the building and to replace the opaque with a clear glass. The one caution is to monitor temperature levels over the daytime, they may increase slightly.

Conclusions and Implementation Plans

All three areas should be investigated further. Investigation with the aid of an occupational hygienist would identify present levels and provide guidelines for acceptable temperature, lighting and noise levels for comfortable operation. Information can be obtained from Occupational Health and Safety - Edmonton. Once guidelines have been established modifications can be implemented. Information gathered from this particular workstation can then be applied in other areas of the work site.

At present the planer mill has installed a better P.A. system that to date is more effective than the one previously utilized - surveyed employees expressed that communications are clearer and easier to understand.

E. Visibility of Task Requirements

Visibility of the task is crucial due to the nature of the job which is an inspection task. There are two aspects of the job where visual discrimination is crucial: (1) determine the grade of the lumber and; (2) determine trim length. These two aspects of the job can directly affect the quality of the product as well as the profits of the company. Grading is a stressful job due to the aforementioned reasons and thus it is important that the operator feel comfortable when performing his/her job effectively. It is important that the operator is able to adequately see his/her work. The normal vertical angle of downward rotation of the eyes from the horizontal is 15 degrees. At six meters the operator can detect a 0.15 centimeters in marking when the marking is a black character on a white background on a vertical wall. Most operators when viewing lumber of longer lengths may have difficulty detecting defects in the wood.

Recommendations

i. Provide a clean mirror at the opposite end of the grading table.

ii. Improve lighting in the work area and reduce glare that may interfere with grading.

Conclusions and implementation plan

Many of the defects in the wood are difficult to detect, since there is not a high contrast between the wood surface and the defect. It is important that lighting is adequate, so that the operator can effectively detect a defect. A number of different

solutions will have to be experimented with due to the fact that the defects are difficult to identify and the fact that the operator may have to detect a defect at a distance up to twenty feet. Obtain operator feedback when experimenting with new solutions. To detect information on how it has affected quality, record grade marks and compare the quality before and after modifications have been implemented. It is important that the same operators are reviewed before and after since experience will definitely play a factor in the quality of grading.

F. Lug Loader

The lug loader is a piece of equipment that requires a lot of modification to be effectively used in the grading area. During operator interviews almost every operator stated that they dislike operating the lug loader due to the problems associated with its operation.

The following problems were identified through the interview and observation of the workstation:

- doubles are frequently released when speeds are too high. This forces the operator to lose his/her rhythm and affects the rhythm of both operator #2 and #3.

- controls are located behind the operator. Speeds are not set according to the size of lumber and thus an operator may have to leave the table 50-10 times in order to adjust the speed to the proper level (this will vary with operator experience).

Recommendations

i. Provide two more eyes on the lug loader to ensure that boards are released straight and one at a time.

ii. Develop preset speeds so that operators can set speed once and return to the table without disrupting the flow of production.

Conclusions and Implementation Plan

At present both solutions have been implemented at a fairly low cost. Upon evaluation the preset speeds have been positively accepted by the graders. As of October 1992, the lug loader eyes have not been installed into proper position to be effective and thus will have to be adjusted.

Implementation and Monitoring

As of October 1992, the modifications made to the lug loader have been instituted. Table speeds were determined for all sizes of lumber arriving to the mainline grader. A committee comprised of supervisors, line operators and production spent one afternoon formulating the correct table speeds. The committee then entered the table speeds into the on-line computer and also provided supporting controls to operate the speeds correctly.

The committee decided to evaluate the effectiveness of the implementation by monitoring employee feedback and examining production rates.

The production rates standardized across both shifts, since previous to the period of time production rates varied between the two shifts. Jam - up also reduced and thus the stress placed on operator #1 was reduced. The set table speeds reduced the mental stress associated with trying to determine corresponding table speeds so that production was not decreased or halted due to an improper table setting. Overall the implementation of set table speeds to date has been successful in levelling out production rates, reducing jam - ups, and reducing the stress associated with setting the table speeds to their proper rate.

7.3 Final Session of the Pilot Project

The final session of the pilot project reviewed the need for a written policy and plan, training and education, and medical management. All these components should be developed in order to operate a comprehensive ergonomics program.

7.4. Conclusion

It is important, that each component is included to develop a comprehensive program. The method and development of each component depends on the company's structure and organization.

The ergonomic audit provided the ergonomics team with a general understanding of the audit process. As well, identification of some of the risk factors characterizing each of the seventeen jobs reviewed provided the ergonomics team with a guide for scheduling more in-depth analysis of high priority workstations.

The process utilized to conduct the in-depth job analysis and generation of possible solutions for the mainline grader, can be utilized as a template for other jobs in the future. As well, the process required to implement recommendations for the mainline grader provided the team with a general implementation template for future work place modifications.

In a medium - sized company (< 300 employees) an ergonomics program can be developed from the guidelines provided by OSHA. The role of the consultant is important in the initial development and implementation of the ergonomics program. Initially, if there is no support or direction by a qualified ergonomist, the set-up can be overwhelming and thus the program is not implemented due to its complexity. The consultant should also foster employee participation throughout the entire process; it is essential in order to continue the program once the consultant has left the site. Finally, it is important that the consultant be flexible in their role. For one portion of the project the consultant may have to be a researcher or informational resource and then in other sections of the project he/she may have to operate as a facilitator.

In order for the company to successfully implement an ergonomics program, a variety of training programs should be explored. Training and education will provide members of the company with the general knowledge in ergonomics to develop and participate in an effective ergonomics program. All employees from the ergonomics team expressed a need for further training in order to carry the program on.

Overall the project was successful with the introduction of an ergonomics program through the pilot project. All members of the ergonomics team believed that the pilot project could be applied company-wide. They also expressed that the team approach to problem identification and problem-solving provides for solid mitigation of ergonomic problems. All except one of the seven surveyed believed that a consultant would be required over the long term. They felt the role of the consultant would be as an informational resource or researcher for problem areas that were too complex for the team to investigate and mitigate.

8.0 CHAPTER 8 - CONCLUSIONS

8.1 Literature Review and Key Informant Interviews:

The information gathered from the literature review was compared to the responses obtained from the interviews. The responses gathered from the key informant interviews were examined for their similarities and differences. The responses were then examined in relation to the literature reviewed. Through this comparison, a model was formulated that was utilized in the case study.

The model did not deviate from the OSHA ergonomic program guidelines other than to expand on the final area of project management - monitoring and modification of mitigative measures. The following components were identified as necessary components of an ergonomics program:

i. Management Commitment

- written policy and program
- regular review and evaluation of the program
- communication at all levels within the organization
- employee participation

ii. Training and Education in Ergonomics

- general awareness training
- job-specific training
- discipline specific training

iii. Medical Management

- periodic work place walk through
- symptoms survey
- identification of restricted duty jobs
- health surveillance
- employee training and education

- early reporting of symptoms
- appropriate medical care
- accurate record keeping
- periodic program evaluation

iv. Ergonomics Program

- document a need for ergonomics
- audit jobs
- prioritize jobs
- in-depth analysis
- generation of solutions
    - ▸ engineering controls
    - ▸ work practice controls
    - ▸ administrative controls
    - ▸ personal protective equipment
- implementation of mitigative measures
- monitoring and modification of mitigative measures

8.2 Framework of the Case Study

The framework utilized for the case study was based on the components and elements outlined in the aforementioned program model. The framework was modified so as to be in conjunction with the company's goals and objectives, structure and culture. The model was applied in the case study as a pilot program in two divisions of the company - the sawmill and planer mill.

Training and education, the written program and policy, regular review and medical management were discussed and reviewed in the pilot program, but were not formulated or demonstrated in the pilot project.

The following process was formulated for the case study from information gathered from the literature review and the key informant interviews:

- obtain management commitment;
- document the need for ergonomics
- conduct an ergonomics audit;
- prioritize jobs;
- conduct an in-depth analysis of work station;
- solution generation;
- implementation of mitigative measures; and
- monitoring.

8.3 Review of the Case Study

There are a number of limitations that can plague a case study, such as: (1) limited generalization; (2) limited statistical reliability; (3) decreased chance for anonymity for respondents; (4) difficult to limit the massive amounts of information obtained and presentation of material; and (5) limited objectivity (Masoner, 1988; Yin, 1989; and Wardell class notes EVDS 605, 1991). In this case study, there was a strong commitment to the project, both through management commitment and an active champion within the company to head the project. The company culture permitted the project to be implemented without too many limiting factors. Strong commitment and the company culture allowed for a successful implementation and therefore the program elements were appropriate for this industry and company. This structure was applied to a resource based industry, but the facility that it was applied to was classified as a manufacturing environment. If the company commitment, or champion of the program were absent or the culture was not ready for the implementation of an ergonomics program, the model may not be as effective as illustrated in this case.

The case study took approximately one year to complete from initial contact with the company to the submission of the final report. The researcher was new to the process of implementing a program which impacted the implementation time. Obtaining

management commitment may be time consuming especially if the champion or consultant must "sell" the ergonomics concept. It was apparent from the case study, that securing management commitment was essential to ensure available company resources such as financial, manpower (both aiding the researcher and attending meetings), accessibility to company records and the site and general cooperation from staff at levels. the length of program development and implementation in a company will depend on the company's approach and commitment to ergonomics.

It was evident from the case study that the role of the consultant was important in the initial development and implementation of the pilot project. If a qualified person is not available during the initial set up of a program it can be overwhelming and thus the program may not be implemented due to its complexity.

Employee participation was fostered throughout the project. Employee participation proved to be invaluable in the project at a variety of levels. Successful operation of a program hinges on the participation of the employees. It is important the consultant foster employee participation in order to continue the program once he/she has left the site.

During the case study the consultant operated in a variety of roles. Initially, the consultant was an informational resource and researcher. Later, the role changed to a facilitator and program developer. It was evident from the case study that the consultant must be flexible in their role and be sensitive to when their role must change in the process. It is important that the company's expectations of the consultant should be well-defined before the consultation. Expectations can be outlined in a contract signed by both the company and the consultant.

In the case study participants expressed a need for further training and education in the area of ergonomics. Training and education provides members of the company with general ergonomic knowledge to develop and participate in an effective ergonomics program.

Overall, the project was successful with the introduction of an ergonomics program through the pilot program. All members of the ergonomics team believed that the pilot project could be applied company-wide. They also expressed that the team approach to problem identification and problem-solving provided for solid mitigation of ergonomic problems. All except one of the seven surveyed believed that a consultant would be required over the long term. The six who believed the consultant would be required over the long term felt the role of the consultant would be as an informational resource, and researcher for problem areas that were to complex for the team to investigated and mitigate.

8.4 Future Research

It is evident by the limited literature available that further investigation is required into the components that should be included in an ergonomics program. The case study allowed for preliminary exploration of identified program components (developed from the literature and interviews). The case study validated the literature and interview responses as to what was important in an ergonomics program. Ideally, to validate the model several comparisons over a longer period of time should be completed.

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GLOSSARY OF TERMS

Carpal Tunnel Syndrome (CTS)

- is a compression of the median nerve as it passes through the fibro-osseous carpal tunnel at the wrist. CTS can be caused by any process that narrows the cross-sectional area of the carpal tunnel, swells or applies extrinsic compression on its contents can cause symptoms of CTS. CTS symptoms include hand numbness, pain, weakness, and functional disability. (Burnham, 1993)

Cumulative Trauma Disorders (CTDs)

- "refer to a category of physical signs and symptoms due to chronic musculoskeletal injuries where the antecedents (causes) appear to be related to some aspect of repetitive work (Putz-Anderson, 1988, p.15)."

De Quervain/s disease

- is stenosing tenosynovitis, "a disorder affecting the tendons on the side of the wrist and at the base of the thumb (Putz-Anderson, 1988, p.16)".

Ergonomics

- "the systematic and practical application of knowledge about the psychological, physical, and social attributes of human beings in the design and use of all things which affect a person's working conditions: equipment and machinery, the work environment and lay out, the job itself, training and the organization of work (NRC, 1989, p.3).

Medial Epicondylitis

- "an irritation of the tendon attachments of the finger flexor muscles on the inside of the elbow. Epicondylitis is associated with tasks that require repeated or forceful rotation of the forearm and bending of the wrist at the same time (Putz-Anderson, 1988, p.16)."

Musculoskeletal Injuries

- injuries of muscles, joints, ligaments and the skeletal system.

Tendinitis

- a form of tendon inflammation that occurs when a muscle/tendon unit is repeatedly tensed. With further exertion, some of the fibers that make up the tendon can actually fray or tear apart. The tendon becomes thickened, bumpy and irregular. In tendons without sheaths, such as in the shoulder, the injured area may calcify, Without rest and sufficient time for the tissues to heal , the tendon may be permanently weakened (Putz-Anderson, 1988. p. 16)"

Tenosynovitis

- "is a general term for a repetitive-induced tendon injury involving the synovial sheath. With extreme repetition, the sheath will be stimulated to produce excessive amounts of synovial fluid. The excess fluid accumulates and the sheath becomes swollen and painful. (Putz-Anderson, 1988, p.16)"

Trigger Finger

- "the tendon sheath of a finger is sufficiently swollen so that the tendon becomes locked in the sheath, attempts to move the finger will cause snapping and jerking movements (Putz-Anderson, 1988, p.16)."

APPENDIX A

i. **Supervisor interview protocol**

ii. **Operator interview protocol**

SUPERVISOR INTERVIEW PROTOCOL

1. Work station: _____

Supervisor background information

2. Reference number: _____

3. How long have you been a supervisor: _____

4. Did you work as an operator on the line before you became supervisor: _____

5. What safety training have you received?

6. How many line operators do you supervise?

Job Analysis:

7. Please describe the job of a line operator.

   a. tasks

   b. training and selection criteria

   c. By your experience what are the most common causes of injuries or health problems for line operators?

8. Please describe other job positions which you supervise.

   job:_____

   a. tasks

   b. training and selection criteria

   c. By your experience what are the most common causes of injuries or health problems for line operators?

9. Please describe other job positions which you supervise.

job:_____

a. tasks

b. training and selection criteria

c. By your experience what are the most common causes of injuries or health problems for line operators?

Task Analysis

10. By your experience, what tasks are most likely to cause an injury or health problem?

11. What tasks do your line operators least like to do?

12. What lifting task should not be done by one person?

a. who(what job)

b. what(object lifted)

c. where

d. How often does this occur?

e. How can such a lift be avoided in normal work?

f. What equipment do you use to make lifting easier?

13. Are there other tasks which you consider to be comfortable or dangerous?

If so, describe who what and where.

Environmental Conditions

14. Please indicate which of the following seem to interfere with the operator's ability to carry out the task or comfort when operating at the work station.

lighting_____
noise_____
vibration_____
temperature____

If you have indicated one of the above please answer the following:

a. what task?

b. how does it impact the task?

c. when?

d. how could this environment factor possibly be changed?

Reporting and management of injuries

15. What is the procedure for reporting an injury which requires medical attention?

16. Do you change tasks for a worker when he returns to the job after time off or medical aid?
eg. restricted duty, job modification

17. What would you do with a worker who complains of a health problem which does not seem to require medical attention? (sore back)

a. Is there a procedure for reporting a health complaint?

b. Do you change tasks for a worker who complains of a health problem?

eg. restricted duty, job modification

18. Can you suggest any ways to prevent injuries in the jobs you supervise?

OPERATOR INTERVIEW PROTOCOL

1. Work station:_____

Operator background information

2. Reference number:_____

3. Job:_____

4. How long have you been in this job?_____

5. What job, if any did you have before you took this job_____

6. What safety training have you received?_____

Job Analysis

7. Please describe you job
   list tasks and % of time

Task Analysis

8. By your experience, what tasks are most likely to cause an injury or health problem?

9. What tasks do your line operators least like to do?

10. What lifting task should not be done by one person?

    a. who(what job)

    b. what(object lifted)

    c. where

    d. How often does this occur?

    e. How can such a lift be avoided in normal work?

    f. What equipment do you use to make lifting easier?

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Environmental Conditions

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lighting_____
noise_____
vibration_____
temperature____

If you have indicated one of the above please answer the following:

a. what task?

b. how does it impact the task?

c. when?

d. how could this environment factor possibly be changed?

Reporting and management of injuries

12. What would you do if you were hurt on the job and needed medical attention?

13. What would you do if the injury did not seem to require medical attention?

14. What would you do if you were hurt off the job and the injury made your job more difficult?

15. Do you think that the job can or should be changed for workers with back problems?

16. Can you suggest any ways to prevent injuries in your job?

APPENDIX B

i. **Symptoms Questionnaire**

ii. **Consent form for interview**

iii. **Consent form to be video taped**

iv. **Consent form for observation of the Work Station**

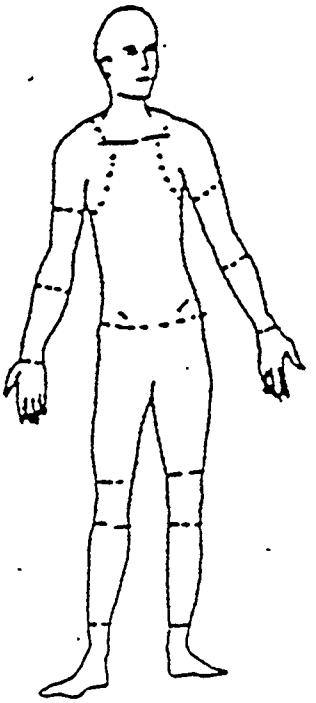
Symptoms Questionnaire

Job title:
Number of years at this job:

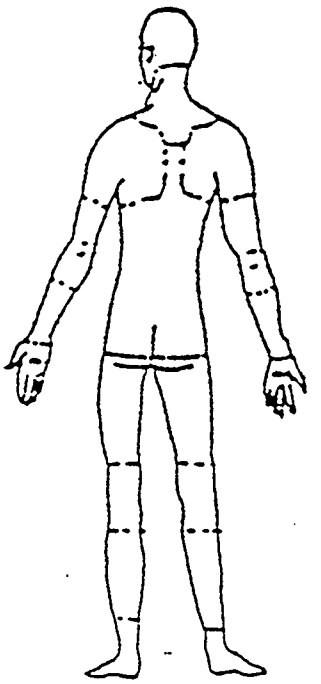
Have you had any pain or discomfort during the last year?

1)Yes_____ No_____ (If no, stop here)

If yes, carefully shade in the area of the drawing which bothers you the most.



Front



Back

Check area: Back_____ Shoulder_____ Elbow_____ Hand/Wrist_____
Fingers_____ Upper Back_____ Low Back_____ Low Leg_____
Ankle/Feet_____

(Complete a separate page for each area that bothers you)

Lumber mill Symptoms Questionnaire

1. Please put a check by the word(s) that best describe your problem

____1)Aching	____5)numbness	____9)Tingling
____2)Burning	____6)Pain	____10)Weakness
____3)Cramping	____7)Swelling	____11)Other
____4) Loss of Color	____8)Stiffness	

2. When did you first notice the problem? _____(month) _____(year).

3. How long does each episode last? (Mark an X along the line)

1 hour 1 day 1 week 1 month 1 year

_____

4. How many separate episodes have you had in the last year?_____

5. What do you think caused the problem?

6. Have you had this problem in the last 7 days? (1) yes_____ (2) No____

7. How would you rate this problem (mark an X on the line)

now

_____

no problem **unbearable**

When it was the worst

_____

no problem **unbearable**

8. Have you had medical treatment for this problem? 1)Yes_____ 2) No_____

8a. If no, why not?

8b. If yes, where did you receive treatment?

1. Company Medical_____ Times in past year _____
2. Personal doctor_____ Times in past year _____
3. Other_____ Times in past year _____

8c. If yes, did treatment help? 1)yes_____ 2) no_____

9. How much time have you lost in the last year because of this problem?
_____days

10. How many days in the last year were you on restricted or light duty because of this problem? _____days

11. Please comment on what you think would improve your symptoms.

Lumber mill Symptoms Questionnaire

1. Please put a check by the word(s) that best describe your problem

____1)Aching	____5)numbness	____9)Tingling
____2)Burning	____6)Pain	____10)Weakness
____3)Cramping	____7)Swelling	____11)Other
____4) Loss of Color	____8)Stiffness	

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3. How long does each episode last? (Mark an X along the line)

1 hour 1 day 1 week 1 month 1 year

_____

4. How many separate episodes have you had in the last year?_____

5. What do you think caused the problem?

6. Have you had this problem in the last 7 days? (1) yes_____ (2) No____

7. How would you rate this problem (mark an X on the line)

now

_____

no problem **unbearable**

When it was the worst

_____

no problem **unbearable**

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3. Other_____ Times in past year _____

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9. How much time have you lost in the last year because of this problem?
_____days

10. How many days in the last year were you on restricted or light duty because of this problem? _____days

11. Please comment on what you think would improve your symptoms.

Ergonomic Program Development

University of Calgary - Faculty of Environmental Design

I am conducting an analysis ergonomic programs. As part of the study, I would like to interview ergonomists involved with ergonomic program development and ergonomists who participate in ergonomic programs. During the interview I take notes on data pertinent to the study. After review of all pertinent literature and review of information gathered during interviews a ergonomic program model will be developed. This model will then be applied to a case study - a Northern Alberta sawmill. If you are willing to participate, please read and sign the consent form below.

Consent for Interview

I voluntarily agree to participate in the interview to obtain information on ergonomic programs. I understand that:

- the sole purpose of the interview is to obtain information on ergonomic programs ergonomics;
- all of the information collected will be available only to responsible professionals who will use it for ergonomics, health and safety purposes;
- no information will be released or printed that would disclose my personal identity without my written permission;
- I need not answer every question or give information that I do not wish to;
- I am free to withdraw from the study at any time;
- there is no physical or psychological risk stemming from my participation in this study;
- a decision by an individual not to participate in the study will not be communicated to other employees or the employer.

_____ _____

Signature Date

Sawmill Ergonomic Study

University of Calgary - Faculty of Environmental Design

We are conducting a ergonomic analysis of the designated site to determine health and safety of the employees operating in the designated area. As part of the study, we would like to observe the tasks which are part of your job. We would like your permission to accompany you on part of your normal work day. During this time we will take notes, photographs, video-tape records of activities of interest. We will also ask questions to understand the purpose and nature of the work. All of this data will be used only by the researcher from the University of Calgary-Faculty of Environmental Design for the purpose of this study. If you are willing to participate, please read and sign the consent form below.

Consent for Observation of Workstation

I voluntarily agree to participate in the study on ergonomics of designated work area and tasks involved in the job, by allowing the researcher to observe my normal work activities. I understand that:

- the sole purpose of the observation is to study the ergonomics of the designated site with the aim of improving the health and safety of this work;
- all of the information collected will be available only to responsible professionals who will use it for ergonomics, health and safety purposes, information will not be released to fellow employees or the employer;
- no information will be released or printed that would disclose my personal identity without my permission;
- I need not answer every question or give information that I do not wish to;
- I am free to withdraw from the study at any time;
- there is no physical or psychological risk stemming from my participation in this study;
- a decision by an individual not to participate in the study will not be communicated to other employees or the employer.

_____ _____

Signature Date

Sawmill Ergonomic Study

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We are conducting a ergonomic analysis of the designated site to determine health and safety of the employees operating in the designated area. As part of the study, we would like to observe the tasks which are part of your job. We would like your permission to accompany you on part of your normal work day. During this time we will take notes, photographs, video-tape records of activities of interest. We will also ask questions to understand the purpose and nature of the work. All of this data will be used only by the researcher from the University of Calgary-Faculty of Environmental Design for the purpose of this study. If you are willing to participate, please read and sign the consent form below.

Consent to be Video-taped

I voluntarily agree to participate in the study on ergonomics of designated work area and tasks involved in the job, by allowing the researcher to video-tape my normal work activities. I understand that:

- the sole purpose of the video-taping is to study the ergonomics of the designated site with the aim of improving the health and safety of this work;
- all of the information collected will be available only to responsible professionals who will use it for ergonomics, health and safety purposes, information will not be released to fellow employees or the employer;
- no information will be released or printed that would disclose my personal identity without my permission;
- I need not answer every question or give information that I do not wish to;
- I am free to withdraw from the study at any time;
- there is no physical or psychological risk stemming from my participation in this study;
- video-tapes will be stored in a safety deposit box till the end of the study (June '92) at that time all tapes will be destroyed (erased);
- a decision by an individual not to participate in the study will not be communicated to other employees or the employer.

_____ _____

Signature Date

APPENDIX C

i. **Audit Checklist**

ii. **Summary of the Work Schedule**

iii. **Audit Results**

SUMMARY OF WORK SCHEDULE

Briefing	(summary of the events that will take place with regards to the project over the next two weeks)
time required	20-25 minutes
materials required	small meeting room, slide projector and screen
Audit	(walk through - gathering information on all jobs in the lumber mill)
time required	5-6 working days
materials required	video camera, video tapes (3), access to general health records
In-depth Job Analysis	in-depth review of a job-including task analysis, supervisor interviews, employee interviews and measurement of general environmental factors in the work areas
time required	3 working days
materials required	small room for interviewing, video camera, 2 video tapes, 2 rolls of slide film
Brainstorming Session	presentation of the job analysis; with the ergonomics committee, a brainstorming session will be designed to come up with solutions and implementation strategies
time required	2-3 hours
materials required	presentation room, television, video tape machine, black board or flip chart and plenty of markers
Final Presentation	two weeks after the project, a final presentation and report will be provided
time required	1 hour
materials required	presentation room, slide projector and screen

JOB TITLE_____
JOB LOCATION_____
CYCLE TIME_____
DATE_____
SHIFT_____
BREAK SCHEDULE_____
INJURY STATISTICS_____
ABSENTEEISM_____

AUDIT CHECKLIST:

1. Does the working space allow for a full range of work movements?

2. Are mechanical aids and equipment provided/accessible where feasible?

3. Is the work surface height proper and adjustable?

4. Can the work surface be tilted or angled?

5. Do workers stand on hard surfaces? no___ yes___

6. Does the workstation encourage excessive reaches? no___ yes___

7. Review of workers' posture at the workstation:

Hand		**task**	**cause**
Repetitive hand motions	L	low____	
		medium_____	
		high_____	
	R	low____	
		medium_____	
		high_____	
Exertion with hand	L	low____	
		medium_____	
		high_____	
	R	low____	
		medium_____	
		high_____	
Bent wrist	L	flexion____	
		extension_____	
		ulnar_____	
		radial____	
	R	flexion____	
		extension_____	
		ulnar_____	
		radial____	
Pressure on palm	L	light_____	
		medium_____	
		high_____	

			task	cause
	R	light_____		
		medium_____		
		high_____		
Vibrating tools	L	low____		
		medium_____		
		high_____		
	R	low____		
		medium_____		
		high_____		
static load-grip	L	low____		
		occasional___		
		constant____		
	R	low____		
		occasional___		
		constant____		
Arm/Shoulder				
Repetitive arm motions	L	low____		
		medium_____		
		high_____		
	R	low____		
		medium_____		
		high_____		
Forceful arm motions	L	light____		
		medium_____		
		heavy____		
	R	light____		
		medium_____		
		heavy____		
elbow away from body	L	neutral_____		
		Medium_____		
		heavy_____		
	R	neutral_____		
		Medium_____		
		heavy_____		
Forearm	L	pronation___		
		supination___		
	R	pronation___		
		supination___		
shoulder	L	flexion____		
		extension___		
		hor. abduct.___		
		hor. adduct___		
		adduction___		
		abduction___		

			task	cause
	R	flexion____		
		extension___		
		hor. abduct.___		
		hor. adduct___		
		adduction___		
		abduction___		
Static load-arm	L	low____		
		occasional___		
		constant___		
	R	low____		
		occasional___		
		constant___		

Back/Neck

Repetitive motions	low____		
	medium_____		
	high____		
loads or forces on back	light___		
	medium_____		
	heavy___		
Awkward Back Posture:			
bending over	neutral___		
	medium_____		
	severe___		
twisting	neutral___		
	medium_____		
	severe___		
bent neck	neutral___		
	medium_____		
	severe___		
heavy lifting	low___		
	occasional____		
	constant____		
repetitive lifting	low___		
	occasional____		
	constant____		
prolonged standing	low___		
	occasional____		
	constant____		
prolonged sitting	low___		
	occasional____		
	constant____		

8. Do the employees have the option to vary their posture?

9. Are the employees hands or arms subjected to pressure from sharp edges on work surfaces?

10. Is an armrest provided where needed?

11. Is a footrest provided where needed?

12. Is the floor surface irregular, slippery or sloping?

13. Are cushioned floor mats provided for workers who are required to stand for long periods?

14. Where chairs or stools are provided are they easily adjustable and suited to the task?

15. Is the workplace temperature too hot or too cold?

16. Are all task requirements visible from comfortable positions?

17. Is there a preventive maintenance program for mechanical aids, tools and other equipment?

18. Are all task requirements visible from comfortable positions?

19. Is there a preventive maintenance program for mechanical aids, tools and other equipment?

20. Are workers exposed to vibration?
    type?
    source?

21. Workers exposed to excessive noise levels?
    noise level_____ dBA

22. Is lighting appropriate for the task being carried out?
    lighting level_____lux

23. Is personal protective equipment used?
    type?
    purpose of equipment?

    how does it impact the task (manipulation)/

General Comments:

AUDIT RESULTS

The following audit was conducted over four days. The audit examined information gathered from a walk through of the plant, injury statistics (1985-91) and a symptoms questionnaire administered to employees from all three shifts in the sawmill and planer mill.

Injury statistics gathered on site previous to 1989 did not include effective reporting of cumulative trauma injuries (injuries that tend to occur over a long period of time) - the number of injuries reported in the paper represent "acute" trauma, injuries which occur immediately such as fractures, sprains, bruises, cuts and contusions. Another factor that effects reporting is that an operator rotates on a unfixed schedule, so it is difficult to directly associate an injury with a particular workstation, particularly in the case of overuse injuries. For this reason, injury statistics are reported, but do not contribute significantly to the audit.

The following section examines problems that were identified through the audit followed by some recommendations. Note that before implementing solutions it is important to follow-up the audit of each job with a more in-depth analysis in order to better understand the complexity of workplace factors that effect comfort levels, efficiency, quality and contribute to injury/illness.

2.1 Cut off saw (C.O.S.) #3

1. Console

Due to the fixed height of the console, the operator's movement of both the upper and lower extremities is restricted. The console is also to short for the taller workers and thus the taller worker must sit twisted if he/she is unable to comfortably fit his/her legs under the console. Due to the size of the console the operator is unable to view his/her work comfortably, operators often must stand up and lean over the console to better view their work (refer to appendix b, figure 1 for graphic representation). This promotes a lot of static bending at the hips that can promote muscle fatigue over time and thus possible injury.

Recommendation:

i. Re-design the console to allow the operator full range of movement. The design could be in the form of a captains chair with a split console. Operators expressed that a split console would aid them and improve comfort at the workstation. A split console would also allow comfortable viewing of the work area.

Labels on controls are faded and in some cases too small to read, this requires the operator to memorize the functions of each control. This can be difficult when training new operators or hazardous in an emergency situation..

The **button lights** on the console that indicate stop are inconsistent, some are red and others are green. To many users the color green indicates go, while the color red indicates stop. It is important that the color indicating stop is consistent if it is to be an effective form of visual feedback.

Results from the **symptoms questionnaire** indicate that some operators find the placement of frequently utilized controls uncomfortable to operate.

Recommendations:

i. Short-term: re-label all controls so that they are clear and easy to read (black characters on a white background or black on yellow, Eastman Kodak, 1983), ensure all visual feedback is consistent at the workstation and if possible plant-wide. This will aid new trainees and aid an operator's when in a stressful situation.

ii. Long-term: re-evaluate the functions required by the operator and apply both operating and human factors requirements to the re-design of the console panel.

2. Chair

The chair utilized in the work area is not adjustable and provides no form of back support. Tasks require operators to sit for extended periods of time - up to 2 hours without a stretch break. The chair does not encourage proper posture and comfort with regards to the demands of the task and workplace.

Recommendations:

i. Provide the operators with a fully adjustable chair with lumbar support (refer to appendix b for a brief description on guidelines for choosing a chair). The adjustability should accommodate various body types (size and weight) of operators and allow for more comfortable operation. It is important that if adjustable chairs are introduced employees are taught how to use them correctly.

ii. Chose a chair that is design for the workplace and tasks that are to be performed.

iii. Allow operators over the two hour period time to get up and walk around

3. Matting

Matting has been provided underneath the chair and console. The problem is that the chair base is wide, solid metal and the operator tends to stand on the base rather than the mat, which defeats the purpose of the matting.

Recommendations:

i. It is important that the matting is accessible and the base of the chair not interfere.

ii. Relocate matting or provide another chair with a smaller base.

4. Visual Scanning

Visual scanning is difficult due to the number of obstructions in the view of the operator such as: the console, cage and the catwalk located to the right of the operator. This restricts the operator from fully viewing the entire operation. A number of decisions regarding trim and size are made at this station and due to visual obstructions the operator does not always receive adequate visual feedback on decisions that have been made. This factor can negatively affect the quality of the task being carried out at the workstation.

Recommendations:

i. Re-locate existing cage and/or catwalk.

ii. Utilization of a split console would alleviate the present viewing restriction imposed by the size and shape of the existing console.

5. Environmental Factors

Environmental factors such as temperature control and lighting are continual problems. The lighting in the booth provides a contrast between the console room and the operations being viewed outside of the console room, but the lighting is insufficient to carry out tasks that involve reading or inspection.

Recommendations:

i. Work area should be provided with a task light for reading located next to the operator.

ii. Due to poor lighting it is essential that controls are clearly marked.

Temperature within the booth varies greatly due to the exposure of the booth to the outside elements. When the temperature varies from a comfortable operating temperature the operator will fatigue a lot faster and comfort level will be affected. If temperatures affect the comfort level of the operator it may reduce productivity (Eastman Kodak, 1983).

Recommendation:

i. Re-evaluate the temperature control systems and possibly provide a better floor heater and fan. Eastman Kodak (1983) recommends temperatures of 19 to 26 celius as the outer limits for temperature regulation in areas where sedentary or light work is performed.

2.2 Sort bins

1. Console

Button layout does not correspond to the facility layout, which makes it difficult to operate the console efficiently for new operators or in an emergency situation. Labels on controls are faded and in some cases too small to read, this requires the operator to depend on memorizing functions that are controlled by each button. The button lights on console that indicate stop are not consistent, some are red and others are green. To many user the color green indicates go, while the color red indicates stop.

The console height is inappropriate due to the viewing demands of the operator (shack frame impairs the operator's view if he/she wants to sit comfortably at the console). Instead the operator is required to sit a lot higher and continually takes on a bent posture to operate the controls.

Recommendations:

i. Short-term: re-label all controls so that they are clear and easy to read.

ii. Long-term: re-evaluate the functions required by the operator and apply both operating and human factors requirements to the re-design of the console panel. Possibly utilize a split console to improve comfort and efficiency.

2. Chair

The operator spends the majority of his/her day seated, the chair has limited adjustability, no back support and no footrest. In this area the footrest is essential due to the awkward posture the operator must assume in order to view the entire work environment, in most cases the operator is so high up off the floor that his/her legs tend to tangle. It is preferred that when seated, feet are flat on the floor or support on an adjustable footrest.

Recommendations:

i. Provide a fully adjustable chair with adequate back support (refer to appendix b).

ii. Ensure operators are trained how to use the adjustability of the chair properly.

3. Physical demands

Physical demands will depend on how many cross-ups occur over the shifts. If a cross-up occurs the operator must jump into the bin, push and pull logs (8'-20' in length, varying widths), and may have to lift weights between 50-300 lbs. depending on the size of the log. Other physical demands include balancing on uneven surfaces, crawling, stooping and extreme work postures. This all occurs in a short period of time usually after a long period of sitting (30 min. - 1 hr.), in this situation a worker risks injuring his/her back, because he/she has not adequately stretched or warmed-up prior to the physical exertion. It must also be noted that due to the size, shape and texture of the wood the logs are often beyond safe lifting limits for one person.

Recommendations:

i. Provide the work area with a winch.
ii. Ensure all operators have been instructed on proper body mechanics i.e. lifting.
iii. If two or more operators are working together to free a cross-up, it is important that communication is adequate and individuals have been taught correct lifting procedures when assisting another individual during a lift.

4. Environmental factors

Noise levels exceed 85 dBA and operators wear personal protective hearing equipment. Due to the equipment and noise levels communication among employees is difficult and in some case impossible. This can be unsafe when operators are together in operating bins trying to alleviate a cross-up. In this situation operators must solely rely on gestures which can be misinterpreted.

Recommendation:

i. Investigate alternative communication devices.

5. Shack

Due to its location it is difficult to view all operations, requiring operators to constantly sit twisted. Bin #2 is impossible to view and thus cross-ups are difficult to prevent. Often a cross-up is not detected until a number of logs are involved in the cross-up. Due to layout of equipment and the frame of the shack, operators must sit fairly high to view over the frame. As well, operators must operate the controls in a bent over/twisted position due to the fixed height of the console. This operating position is uncomfortable and may lead to fatigue in back muscles.

Recommendations

i. Provide a mirror to improve viewing of operations located behind the operator.
ii. Install a camera to view bin #2 to help prevent cross-ups.
iii. Reevaluate kicker system, operators believe that logs are not kicked off belt evenly.
iv. Re-evaluate the location of the location of shack to place it in a more strategic position to view all operations.
v. Investigate task functions and re-design layout of console, cameras and chair to allow for more effective and comfortable operation.

6. Small ramp on cat walk

The slope and metal surface when oily can be a hazard, especially if the operator is in a hurry he/she may slip.

Recommendation:

i. Ensure housekeeping is informed when the surface of the ramp is oily to ensure clean-up.

ii. Provide a removable ramp that can be easily attached to step when required by maintenance.

2.3 Pocket Edger

1. Physical demands

The operator is required to stand in one position for up two hours at a time, which can be uncomfortable and lead to overall fatigue. Anti-fatigue matting is in area, but only covers a small portion of the operating area.

Recommendation:

i. Ensure that anti-fatigue matting is placed throughout operating area.

Due to volume of incoming lumber the operator is required to carry out repetitive pulling and pushing of boards from the storage table to pocket edger. In the symptoms questionnaire operators indicated that the repetitive nature of the job was physically demanding on their shoulders and back, leading to fatigue and discomfort.

Recommendation:

i. Examine job rotation schedules to ensure that the operator is rotated onto a station that does not require the same types of movement to perform the task, so to allow the body a chance to recover from the physical demands placed on it at the workstation.

Finally, due to height of the pocket edger worker must continually lean over work surface, encouraging poor work posture. This particular posture is stressful on the back and may lead quickly to fatigue in back muscles, which may affect operator comfort and productivity.

Recommendations:

i. Currently the pocket edger height is 80 cm. Ideal operating work surface height for heavy work is 85-101cm for males and 78-94 for female. Re-evaluate area and determine an optimal work surface height. If possible provide adjustability of work surface height. This will encourage proper work postures.

ii. To allow the operator to vary his/her posture an adjustable butt board and/or footrest should be provided at the workstation (refer to appendix b for general information regarding footrests and butt boards).

2. Layout of workstation

Due to present layout, the operator's movement is often restricted by the location of the storage table and the large amount of lumber that piles up on the table if the system has been down for a period of time. It is important that a workstation allows for full range of movement.

The present location of the camera requires the operator to frequently twist to view the camera, which can be uncomfortable.

Recommendations:

i. Re-locate the camera to avoid excessive and repetitive twisting.

ii. Review lumber production and provide a more even pace for incoming lumber to prevent excess build up on the storage table.

2.4 a Prime Sort #1

1. Physical job demands

In the symptoms survey, prime sort #1 and #2 were considered to be the most physically demanding workstations and the area with the highest risk of injury to occur in initial breakdown.

Operators are required to complete a variety of tasks: ensure flow of unscrambler, prevent and remove cross-ups, visually scan lumber (39-55 boards a minute) and direct lumber to either the optimizer or chipper. The aforementioned tasks involve pushing/pulling heavy slabs of wood (8-10 boards varying in weight from 30-100 /lbs.), lifting same amount, jumping in and out of bins, balancing on uneven surfaces, excessive reaching, and standing while operating foot pedals.

One of the most stressful tasks on the shoulders and back is discarding slabs from the table to the chipper located directly behind the operator. The operator is pulling and lifting at the same time pieces of lumber and discarding lumber at a rapid pace so to keep up the production. If the operator is not well conditioned or is fatigued he/she can be at risk of shoulder injuries or low back injury.

The physical demands placed on the operator can often set up a situation that encourages back injury or some other type of cumulative trauma/overuse injuries.

Recommendations:

i. In the short term, it is essential that people are rotated regularly into less physically demanding workstations.

ii. For trainees or individuals returning to work after an extended holiday or illness/injury should be limited to no more than 15 minutes with ample periods of time for recovery with lighter work (Eastman Kodak, 1983).

iii. Long term - further investigation should be carried out to institute engineering controls to reduce the physical demands placed on the operator.

Operators' expressed during the walk through that they find they are standing on their heels to operate the foot pedals for almost the entire two hours. Through the symptoms questionnaire it was noted that this task this leads to a lot of discomfort and fatigue in the operators's legs especially the calves.

Recommendation:

i. Place the foot pedal on the grading while the operator is standing on the anti-fatigue matting - to prevent operator from standing on his/her heels constantly.

2. Stress - physically and mentally

Throughout the observation it was noted that the operator must deal with a lot of decision - making when a cross-ups and/or delay occurs. An operator must shut down the line, fix the problem in a hurry and then make up for the lost production time. If delays occur frequently over the two hours quality and efficiency may be sacrificed as the worker's frustration level increases along with his/her fatigue levels.

Recommendation:

i. Provide engineering controls to prevent the high number of cross-ups.

3. Workstation layout

Due to layout cross-ups are difficult to detect until they have impacted the flow of the unscrambler. This can lead to a lot of down time and pressure on the operator to fix the situation quickly so as not to disrupt production for an extended period of time.

The layout of the unscrambler, landing table and chipper, restricts movement and encourages excessive amounts of bending and twisting of the back - these factors combined with high repetition rates and high weights handled can lead to fatigue and/or injury of the back and/or shoulders.

Recommendations:

i. In the short term, ensure the work area is maintained and free of excess clutter, remove equipment that does not aid the operator in performing his/her job.

ii. In the long term, ensure operator input and human factors when re-designing the workspace.

4. Environmental factors

Light levels are below recommended values for operation. When lighting levels are not adequate, comfort of the operator can be affected thus impacting overtime quality and efficiency of operations.

Recommendation:

i. Conduct a light study to determine area light levels and obtain information on modifications and lighting systems that can be installed to obtain recommended light levels. For the tasks carried out at prime sort, light levels may need to be in the range of >200-500 Lux.

Noise levels exceed 85 dBA and thus hearing protection is utilized by all operators. Due to hearing protection and high noise levels communication among operators is difficult.

Recommendation:

ii. Investigate an alternative communication system to allow for better communication between operators.

2.4b Prime Sort #2

Although problems identified in Prime sort #1 are relevant to prime sort#2, the following problem areas are unique to prime sort #2.

1. Chipper

The location of the chipper in regard to the operator encourages extreme twisting and bending of the back to extract the slabs from the table and throw it into the chipper. These movements combined with the heavy weights and varying repetition rate (depends on how many slabs are let through from prime sort#1) encourage poor body mechanics and can lead to low back injury.

The chipper in this area does not have rollers to aid the entry of a slab into the chipper as does the chipper in prime sort #1. The resistance caused by the wood rubbing against the metal requires the operator to use more force to get the slab into the chipper.

Recommendations:

i. In the short term, add a roller to the mouth of the chipper.

ii. Long term layout of the station in regards to the tasks required of the operator need to be investigated and incorporated in re-design of the area.

2.5 Trim Saws #1 and #2

1. Physical demands

Physical demands of the workstation include pulling boards to proper length for trim(22-34 per minute), turning boards (1-10) and removing doubles from lugs (doubles often occur when a smaller board is flowed by a thicker board and the thinner board flips on top of the thicker one). There are a lot of tasks to be completed in a short period of time.

These tasks involve pulling, turning boards and lifting - the majority of tasks are done with the left hand unless one is turning larger dimensioned boards. An operator spends the majority of his/her time twisted to the left watching incoming boards. Due to the high repetition rates, weights handled and poor body mechanics, workers may be prone to fatigue and overuse injuries of the shoulders, elbows, wrist and back.

Recommendations:

i. Immediate changes - encourage a rotation every 30 min. -1 hr. between trim saw operator #1 and #2 to alternate working on right and left sides of the body, this alleviate, continual operation on one side.

ii. After two hours at trim saws ensure rotation onto a job that is less physically demanding.

The operator is required to stand (on hard concrete surface) for the full two hours, which can lead to a lot of discomfort in his/her legs, feet and low back.

Recommendations:

i. To allow for a change in posture provide operators with an adjustable footrest and/ or butt board.

ii. Ensure anti-fatigue matting is placed in the work area, it is important that operators be taught how to use matting effectively.

General Long Term Recommendation:

i. It was stated in a committee meeting that operators will not be required to work in the area when trim saws are re-designed, but it is still important to consider the human factor when designing consoles, control rooms and access to equipment for maintenance purposes.

2. Saw dust

Saw dust is a problem common throughout the entire plant. The saw dust presently in the air is also uncomfortable and can be a health hazards overtime (respiratory problems).

At this particular workstation saw dust often interferes with the operator's ability to properly scan lumber. This is due to saw dust being blown towards the operator from the trim saw. This factor is uncomfortable, can impair vision momentarily and/or lead to an eye injury.

Recommendations:

i. Re-direct the fan away from the operator. For those operators unable to tolerate dust particles, provide a small face mask to help filter sawdust particles.

ii. Long term investigate sawdust particle levels in the plant (an occupational hygienist can provide further information) and the effectiveness of present extrapolation systems.

3. Workstation

Because the walkway is located directly below a overhead frame, an operator can easily hit his/her head if he/she forgets the bar is overhead.

Due to the layout of the workstation the operator is confined to a small area to perform such heavy tasks as removing and relocating doubles to an open lugs. When cutting longer trim, boards often fall out of the trim box and can be a potential safety hazard.

Recommendations:

i. Move walkway a couple of meters over from the frame or paint the frame a brighter color to alert the operator visually of its presence overhead.

ii. The trim box could possibly be extended a couple of feet to ensure all trim ends up in the box.

4. Environmental factors

Light levels are below recommended values for operation. Light levels should range .200-500 Lux for operator comfort and aid the operator to efficiently view tasks.

Recommendation:

i. Conduct a light study to determine area light levels and obtain information on modifications and lighting systems that can be installed to obtain recommended light levels.

Noise levels exceed 85 dBA and thus hearing protection is utilized by all operators. Due to hearing protection and high noise levels communication among operators is difficult.

Recommendation:

i. Investigate an alternative communication systems.

2.6 Stud Sort:

1. Physical job demands

Stud sort is a physically demanding job. The workstation is characterized by the following tasks: visually scanning incoming studs (97 -117 studs per minute), turning the wane (24-60 studs per minute) and discarding incomplete studs (15 - 35 per minute). The job is highly repetitive and requires a lot of forearm (supination to pronation) and wrist (ulnar deviation and extension) movement to turn and discard boards. The repetitive movement can lead to fatigue in the muscles and also contribute to the onset of a cumulative trauma disorder.

The full two hours on stud sort requires the operator to stand. The work pace encourages the operator to stand in a fixed position, this can lead to discomfort in the operator legs and back.

Finally, the operator is twisted to the right for the majority of the task to view incoming studs due to the accessibility from only one side. This position can lead to a lot of discomfort in the back and neck.

Recommendations:

i. Rotate operator positions every 15-20 minutes to allow the front operator time to recover, since it appears that the front operator works at a faster pace then the back operator.

ii. Encourage workstation rotation every two hours. It is important that the operator moves on to a workstation that requires different movements and will allow previously worked muscle groups to recover.

iii. Ensure that all new workers or returning employees condition themselves no more than 15 minutes (Eastman Kodak, 1983) on stud sort then rotate to a less physically demanding workstation.

iv. To allow operators to vary their posture provide an adjustable footrest or butt board. It will depend on the operator's preference, since the table may be a bit high for shorter women or men and the butt board may lower the operator too much causing the operator to work with their shoulders elevated.

v. Ensure proper anti-fatigue matting is present throughout the workstation area.

2. Environmental Factors

Light levels are below recommended values, levels will also vary when the door behind operators is open. The incoming light may also impose a glare factor off the work surface which could hinder the operator's ability to visually check the studs.

Recommendation:

i. Conduct a light study to determine area light levels and obtain information on modifications and lighting systems that can be installed to obtain recommended light levels.

Noise levels exceed 85 dBA and thus hearing protection is utilized by all operators. Due to hearing protection and high noise levels communication among operators is difficult.

Recommendation:
i. Investigate an alternative communication systems.

2.7 Schurman

1. Workstation

The layout of the workstation is the major problem at the schurman. Canters come into the workstation on the right side of the operator. Operators must sit twisted the entire two hours in order to direct canters to there proper destination. When interviewed operator's expressed that the constantly twisting is uncomfortable and in some cases leads to pain in the lower back. Limited leg room also contributes to the extreme degree of twisting.

The operator must excessively reach forward to grab and flip canters to their proper edge. Reaching is always to the right of the operator. Again one side of the body is carrying out all the heavy work and thus muscles will fatigue quicker than if the operator was able to distribute the workload between both sides of the body.

It is difficult for the operator to view the far mirror, due to the cage surrounding the workstation, the distance of the mirror from the operator and the cracked glass/plastic.

Recommendations:
i. Provide the operator with a chance to get up from the workstation every 15-20 minutes to stretch and walk around, this may help reduce fatigue and discomfort in low back muscles.
ii. Utilize job rotation, rotate onto jobs that are do not mimic the physical demands of the schurman, so to allow those muscles that have been overworked time to recover..
iii. Repair front glass of the cage to improve visibility.
iv. Ensure housekeeping keeps mirror clean.
v. Instead of utilizing a mirror another option would be to have a camera located inside the cage.

2. Chair

The operator spends the majority of his/her day seated, the chair has limited adjustability, no back support and no footrest. In this area the footrest is essential due to the awkward posture the operator must assume in order to view the entire work environment, in most cases the operator is so high up off the floor that his/her legs tend to dangle. It is preferred that when seated, feet are flat on the floor or have support on an adjustable footrest.

Recommendations:

i. Provide a fully adjustable chair with adequate back support (refer to appendix b).
ii. Ensure operators are trained how to use the adjustability of the chair properly.

3. Environmental factors

Noise levels exceed 85 dBA and operators wear personal protective hearing equipment. Due to the equipment and noise levels communication among employees is difficult and in some cases impossible.

Recommendation:

i. Investigate alternative communication devices.

Light levels allow for good contrast between the console room and the operator field outside of the cage. Lighting is inappropriate for tasks that require reading or inspection.

Recommendation:

i. Provide a small task light in near console to allow for tasks requiring reading or inspection.

2.8 #1 Edger

1. Physical demands:

The majority of the job is light operations, but sometimes doubles will come in off the unscrambler and require the operator to take on awkward postures,while applying heavy forces. When doubles come into the area, the operator will have to stab one of the slabs, hold the slab while the other slab travels to the edger. The operation of holding back the slab takes a lot of upper body strength and also requires the operator to be twisted and flexed at the waist. This is often done when the operator has been in a static position (sitting) for 30-40 minutes. The physical demands and the fact the operator is not warmed up to carry out the task can put the operator at risk of shoulder or back injury.

Recommendations:

i. Ensure all tools are maintained so that operators do not need to apply extra force to stab or keep a hold on the wood.
ii. Through engineering controls try to prevent doubles from coming off the unscrambler.

2. Console and chair:

The split console allows the operator to view his work clearly and comfortably. The console for many operators is too short and often the operator sits asymmetrically (all controls frequently utilized are on the right side, the left shoulder is often elevated, while the right is depressed in order to operate controls). Over time this position can lead to a lot of discomfort in both the shoulders and the back. Because to most operations are completed on the right side of the console the armrest is worn and the operator is resting his/her elbow on the metal surface, once again over time this can lead to a lot of discomfort.

The chair utilized in the work area is not adjustable and provides no form of back support. Tasks require operators to sit for extended periods of time - up to 2 hours without a stretch break. The chair does not encourage proper posture and comfort with regards to the demands of the task and workplace.

Recommendations:

i. Provide operator with new padding for the armrest, the operators can experiment with different thicknesses in order to find a comfortable operating position. The padding may help the operator to sit more symmetrically, but ensure that the wrist is still within 10 degrees from neutral when operating controls (refer to appendix b figure 3 for a diagram of the different wrist positions).
ii. Provide a fully adjustable chair, so operators can adjust the chair to a comfortable height when operating the console buttons.
iii. Long term design the console and chair to be fully adjustable to allow for the variability in operator sizes.
iv. Provide the operators with a fully adjustable chair with lumbar support (refer to appendix b for a brief description on guidelines for choosing a chair). The adjustability should accommodate various body types (size and weight) of operators and allow for more comfortable operation. It is important that if adjustable chairs are introduced employees are taught how to use them correctly.
v. Chose a chair that is design for the workplace and tasks that are to be performed.
vi. Allow operators over the two hour period time to get up and walk around.

2.9 R/L Stacker

Injury statistics: 9 injuries over a 6 year period

1. Console

The operator work the entire two hours in a twisted position. The location of the console panel forces the operator to work twisted in order to view the incoming load. This position can be uncomfortable and stressful on the spine over time.

The height of the console is too low for most operators. Operators must take on extreme flexion and ulnar deviation of the wrist in order to operate controls. Gloves get in the way of operating controls. The gloves are bulky and the controls are located close to each other. This factor makes it difficult to operate controls with ease and comfort. In some cases the operator may activate another control by accident, when wearing thes gloves.

Recommendations:

i. Relocate the console to a position that allows the operator to view the tasks comfortably and safely while still operating the console.

ii. Long term further investigation is required to determine proper console height, spacing of controls (to allow for safe and comfortable operation when using gloves), and general control layout.

Due to the highly repetitive nature control operations, the wrists positions the operator must assume, and the forces required to hold onto the control, the operator overtime could be at risk of developing carpal tunnel syndrome.

Recommendation:

i. Utilize job rotation to allow the operator to work on tasks that do not require the same wrist actions and forces, possibly rotate every 20-30 minutes with sticks. The jobs are close in proximity and this would also allow the sticks operator relief from a very physically demanding job.

2. Work Posture

Operators are required to stand in one position for the full two hours due to the nature of the tasks performed. Matting is present and sufficient for the area. Standing over an extended period of time can lead to discomfort and fatigue in the feet, legs and low back. It is important that operators have the chance to vary their posture.

Recommendations:

i. Investigate the effectiveness of using a footrest and/or butt board. Both will allow the operator to vary his/her posture.

2.9 Sticks

1. Physical Demands:

The tasks required at this workstation are very physically demanding. The work pace is high and the workstation confined. All these factors contribute to a workstation where operators can be at a high risk of back injury and other related overuse injuries.

The operator is constantly twisting and bending at the waist when extracting the sticks from the bin and placing sticks into the magazine. The twisting and bending at the waist is uncomfortable and could put the operator at risk of back injury.

Excessive reaching also characterizes the job. Often the operator is reaching above shoulder level when extracting sticks and is always above shoulder level when inserting sticks into the magazines. Once again, excessive reaching is stressful on the back and over time can lead to discomfort and contribute to injury of the lower back.

NOISH lifting limits are also exceeded in this area. Limits where assessed for both extremes 58 cm off the ground and 157.5 cm, and the weight of 4-6 stick (4-6 lbs.) was utilized in the formula. Most operators grab 4-6 stick each time when reloading a magazine. In both cases the maximum permissible limit and action limits were exceeded (refer to appendix b, figure 4 for equation and limit values). This would indicate that the operator is at risk of back injury.

Recommendations:

i. Ensure that sticks levels in the bin are between knee and shoulder height. An optimal height is between waist and shoulder level. This can be accomplished either through smaller bins or mechanical lift in the bin that always ensure the level is at the appropriate height (determines height due to the weight in the bin). This will avoid excessive reaching and bending and reduce some of the twisting.

ii. Ensure job rotation onto a task that will allow the operator time to recover, this may be a good job to rotate with the R/L stacker. Rotation should take place every 20-30 minutes.

iii. Long term: an automatic sticks machine may alleviate a lot of the repetitive nature of the task.

2. Flooring

The grating in the area is a problem for two reasons: it is difficult to walk and stand on the grating for extended periods of time and when sticks break, small pieces can get lodged into the grating and operators can trip.

Recommendation:

i. Provide anti-fatigue matting throughout the area, this will allow for better operator comfort and help reduce the chances of broken pieces getting caught in the grating.

3. Magazines

Magazines are difficult to fill, the mouth to the magazine is narrow and requires accuracy when inserting sticks. If the operator is in a hurry or is watching the levels of the other magazine anticipating the next move, it can be frustrating if sticks do not go in easily.

The only indicator of the sticks level is the visual cue that the level is lowering. This is very difficult to observe due to the number of magazines and often levels fall to low level , once levels are too low the sticks are difficult to insert.

Recommendations:

i. Widen flanges on the magazines to aid the operator when inserting sticks, also continue flanges to the bottom of each magazine.

ii. Provide an indicator light on top of each magazine that indicates that levels are low. this will allow the operator time to fill magazine before the levels are too low or run out.

2.10 Optimizer

1. Physical job demands

All operation are performed in standing, approximately two hours. Due to the layout of the workspace, the worker is restricted to a fixed posture, which overtime can be uncomfortable.

recommendations:

i. Provide an adjustable foot rest in work area. Due to the restricted leg room in front of the operator, a foot rest may force the operator to stand to far back from the work area.
II. Provide a butt board which would allow for a change of posture from standing to partial sitting while still maintaining good posture.

Excessive reaching also characterizes the task. When removing debris, operators must lift the debris over a guard (metal) and dispose of it into a bin located on the left side of the operator. The difficulty with this is that the guard is present for protection of the operator, but the debris can be very heavy and range in length from 2' to 10'. Debris of awkward size forces the operator to take on uncomfortable and stressful postures, it can also put the operator at risk of low back injury, due to weight of the object.

recommendations:

i. Long term - investigate the possible engineering controls to eliminate debris from the unscrambler before it reaches the optimizer.

2. Controls

The majority of the controls are located behind the operator. Some controls are frequently utilized and require the operator to stand twist in order to still view operations.

recommendations:

i. Locate those controls that are most frequently used near the operator to prevent the excessive twisting required to operate the controls at present.

3. Vibration

The operator is exposed to a lot of whole-body vibration due to the surrounding equipment. Over the two hours operators often find the vibration uncomfortable. The acceleration and frequency work together to determine the level of discomfort, duration of the exposure will determine the acceptability of the vibration in the work area (Eastman Kodak, 1983).

recommendations:

i. Provide spongy rubber or vinyl floor mat for standing operations (Eastman Kodak, 1983).
i. Investigate the vibration operators may be exposed to in the work area - levels and sources.

1.1.11 Stud-line grader

1. Physical job demands

Incoming stud must be scanned, trim determined and grade determined and marked. Studs must be flipped and marked at a high repetition rate (approximately 24 boards per minute). The action of turning requires a lot of force and awkward wrist motions. Overtime the forces and motions can put the operator at risk of developing cumulative trauma injuries such as carpal tunnel or tendonitis.

recommendations:

i. Ensure that operators rotate every 30-45 minutes onto a task that allows the operator time to recover. If this is impossible, ensure that graders grade no more than 4 hours per day. Provide at least a full two hours between each two hour period on the stud-line grader.

2. Workspace layout

Leg room is restricted due to the panel located directly in front of the operator when seated at the workstation. Operators often sit twisted in order to sit close enough to perform their job effectively.

recommendations:

i. If possible remove the front panel table to allow for more leg room, it is important if panel is removed that operator is still protected from the moving parts located under the work table.

3. Chair

The chair utilized in the work area is not adjustable and provides no form of back support. Tasks require operators to sit for extended periods of time - up to 2 hours without a stretch break. The chair does not encourage proper posture and comfort with regards to the demands of the task and workplace.

recommendations:

i. Provide the operators with a fully adjustable chair with lumber support (refer to appendix A for a brief description on guidelines for choosing a chair). The adjustability should accommodate various body types (size and weight) of operators and allow for more comfortable operation. It is important that if adjustable chairs are introduced employees are taught how to use them correctly.
ii. Chose a chair that is design for the workplace and tasks that are to be performed.
iii. Allow operators over the two hour period time to get up and walk around

4. Posture

Sitting for extended periods of time can be stressful on the spine and lead to discomfort overtime. It is important that operators are able to vary their posture by either taking a break from sitting (walk around) or alternate between sitting and standing.

recommendations:

i. Provide a 3-5 minute break every 30-45 minutes to allow the operator to get up and walk around, this will provide the operator a chance to vary his/her posture.

ii. Investigate the possibility of utilizing a sit/stand stool to the operator the choice to vary his/her posture whenever her/she chooses, instead of depending on a regularly scheduled break.

1.1.12 Annex

1. Mental and physical demands of the job

The annex operator is required to monitor a number of work areas. Due to the location of the controls the operator is unable to view all areas effectively (such as the bypass feed and continuous flow). This forces the operator to continually twist and visually scan the work area to monitor production. Some operators also reported that in order to monitor all areas they depend on the sound produced by each machine and monitor any deviation of that sound (to rely on sound may be misleading, since operators utilize hearing protection). For a new operator this type of feedback can be misleading and result in a poor decision that can effect both the annex and the mainline grader. A poor decision could lead to down time for both the annex and mainline grader, stress on the operator, and frustration on the part of other operators that are affected by his/her decision.

recommendations:

i. Provide the operator with monitors to view operations located behind the workstation. Monitors should be located in front of the operator when comfortably operating controls.

When a problem occurs a number of production areas are effected and the operator is required to alleviate the problem as quick as possible to resume production. New operators find the work area mentally stressful. Supervisors stated that in order to effectively run the annex operators must be trained and experienced, since incoming lumber speeds can greatly effect the smooth operation of the mainline grader. Some operators reported that in order to monitor all areas they depend on the sounds produced.

recommendations:

i. Ensure that the operator is immediately informed of a problem in the work environment such as a display on the control panel or a warning light placed in view of the operator.

ii. Look at developing set speeds for all tables to prevent the vast amount of decision-making required for smooth operation of all work areas, this will also help with training and help to alleviate the trail and error utilized when first learning how to operate work area speeds effectively.

2. Work Posture

All operation are performed in standing, approximately two hours. Due to the layout of the workspace, the worker is restricted to a fixed posture, which overtime can be uncomfortable.

recommendations:

i. Provide an adjustable foot rest in work area. This will allow the operator to vary his/her posture and maintain the natural curves of the back.
ii. Provide a butt board which would allow for a change of posture from standing to partial sitting while still maintaining proper posture.

3. Environmental factors

Light levels are below recommended values for operation. When lighting levels are not adequate comfort of the operator can be affected thus impacting overtime quality and efficiency of operations.

recommendation:

i. Conduct a light study to determine area light levels and obtain information on modifications and lighting systems that can be installed to obtain recommended light levels. For the tasks carried out at the annex light levels may need to be in the range of >200-500 Lux.

Noise levels exceed 85 dBA and thus hearing protection is utilized by all operators. Due to hearing protection and high noise levels communication among operators is difficult.

recommendation:

i. Investigate an alternative communication system to allow for better communication between operators.

1.1.14 Wrap and Strap

1. Physical job demands

The job demands at the wrap and strap are physically demanding. The following tasks are physically demanding on the operator: pulling wrap from the roll, cutting the wrap, and loading and unloading rolls from the other head frame.

Operator #1 is required to stand for the entire two hours. This can be lead to discomfort and fatigue overtime due to the operators inability to change his/her posture frequently. Operator #1 also is required to stock loads if they are not complete, this task requires lifting of lumber that is heavy (10-80 lbs.) and awkward size - very difficult to utilize proper body mechanics. Many times the operator has been stationary for an extended period of time, then is required to carry out the aforementioned task without warming up or stretching before lifting. These factor can put the operator at risk of low back injury.

recommendation:

i. Provide operator with anti-fatigue matting and adjustable footrest.
ii. Evaluate the effectiveness of utilizing a sit/stand stool.
iii. If possible situate lumber is such a way that the operator is pushing lumber onto the load (have the lumber situated on a platform at equal height to the load). It is important that the operator is pushing lumber at waist level not overhead which is stressful on the low back and shoulders.

Operator #2 and #3

When pulling and cutting wrap from the roll the operator is required to work above shoulder level for approximately 3-5 minutes. The operator pulls wrap with a great deal of force in a downward motion. Once the load is covered with wrap the operator must reach over head and cut the wrap free from the load, this task again requires a lot of force to cut the wrap. Over the two hour period the operator may find the pulling both stressful and fatiguing on the back and shoulders. The motion and forces utilized could put the operator at risk for injury.

recommendations:

i. When possible staple the front end of the load first and then move the load forward so that is does the work of pulling and the operator works only as a guide for the wrap. This will decrease both the awkward pulling action and forces required to pull the load significantly.
ii. Investigate the potential for automating the process.
iii. Ensure tools utilized such as knives are always sharp and in good working order, a dull knife can require a lot more force when cutting than a sharp knife. Provide a couple of sharp knives in the area so that the operator can easy change his/her knife when the blade is dull.

Unloading and loading rolls is physically demanding and requires a lot of force, pushing/ pulling motions and awkward postures to carry out the task. Rolls are awkward to handle due to there shape and weight. Due to the demands of the task the operator can be at great risk of low back injury.

recommendations:

i. Provide the area with a winch to aid effective movement of rolls safely.

Finally, operators are required to walk and stand on concrete. Overtime operators may experience fatigue or discomfort in knees, ankles and low back. In the symptoms questionnaire this aspect was frequently cited by operators.

recommendations:

i. Provide anti-fatigue matting in areas that are frequently utilized.
ii. Ensure operators have proper fitting boots and insoles that that provide cushioning to decrease the force experience with heel strike against the concrete. Try on boots with insole to determine proper fit.

2. Work area layout

Due to the physical layout of the work area (frames and equipment) it is difficult for the operator to view processes taking place in the work area. This is both dangerous and can effect quality. Dangerous due to the fact an operator may be hurt or behind in production, but the operator is unable to detect this visually to aid the situation. In terms of quality, the operator is unable to comfortably visually check the result of his/her last action, and may for this reason problem.

Finally, the presence of the frame and equipment restrict movement of the operator around the load and work area, this can lead to awkward work positions and effect overall quality of wrapping.
recommendations:

i. Remove equipment that is presently not utilized in the work area, this would improve visibility and allow for freer movement in the area.
ii. Provide a system for the operator to communicate to other operators ie a head set or hand set .
iii. Provide monitor for the operator in position # 1, so he/she can monitor production in the back area of the wrap and strap.
iv. Long term re-design work area.

3. Working Posture

Due to the size of the load and where staples must be placed the operator is required to do a lot of twisting and bending. Many operators work at a fast pace and thus are unable to utilize proper body mechanics when carrying out the task. The weight of the stapler is minimal, but the postures are awkward and can overtime lead to discomfort and possible sprain or strain of the low back. Another factor, is that operators tend to work and twist to one side, which again can lead to discomfort and fatigue. This factor again does not promote proper body mechanics.

recommendations:

i. Review work procedures and investigate a better method for stapling that incorporates proper body mechanics.
ii. Regularly, rotate operators during two hours from position one through to position three. Rotation should cut down on fatigue and discomfort that may develop when operators in the same position for extended periods of time.
iii. Ensure rotation every two hours onto a job that allows the operator time to recover from physical demands placed on the body at wrap and strap.

4. Hazardous work tasks

Loading and unloading rolls is a dangerous task to both the operator engaged in the task and the operators that may be in the work area. When loading rolls the gap between the brackets and the frame is large enough that rolls could slip through and fall to the level below. It is important that the system for loading rolls is reevaluate and the gap between the bracket and frame is reduced in order to alleviate the risk of an incident taking place.

recommendations:

i. Continue the bracket to the edge of the frame so that the rolls never losses contact with some form of support.
ii. Utilize a winch throughout the entire process to ensure that the roll is support throughout the transport and insertion into the support frame.

5. Environmental factors

Light levels are below recommended values for operation. When lighting levels are not adequate comfort of the operator can be affected thus impacting overtime quality and efficiency of operations.

recommendation:

i. Conduct a light study to determine area light levels and obtain information on modifications and lighting systems that can be installed to obtain recommended light levels. For the tasks carried out at the wrap and strap light levels may need to be in the range of >100-200 Lux.

Noise levels exceed 85 dBA and thus hearing protection is utilized by all operators. Due to hearing protection and high noise levels communication among operators is difficult.

recommendation:

i. Investigate an alternative communication system to allow for better communication between operators.

1.1.14 Mainline grader

The mainline grader was chosen for in-depth analysis. The in-depth analysis will review recommendations and implementation plans.