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Whose turn is it anyway : the impact of job rotation on the reduction of cumulative trauma disorders

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ABSTRACT

WHOSE TURN IS IT ANYWAY: THE IMPACT OF JOB ROTATION ON THE REDUCTION OF CUMULATIVE TRAUMA DISORDERS

by
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In today's fast-paced world, repetitive activity on the job has become very demanding. Many workers are suffering from injuries known as cumulative trauma disorders (CTDs). Job rotation can be an effective and powerful tool when seeking to minimize CTDs by allowing workers to experience different activities, thereby distributing the physical demands on the workers' bodies.

A case study was conducted on a northwestern New York manufacturing facility to identify the presence of excessive work stressors and to formulate potential corrective actions, including an analysis of their current job rotation system. The jobs were evaluated using the Rapid Upper Limb Assessment.

This study provides valuable information on the benefits of an effective job rotation system, and the steps necessary to implement one. For the case study, a reduction of exposure to work stressors of 20.9% for the Overall Risk Index can be accomplished using the new job rotation system methods.

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APPROVAL PAGE

WHOSE TURN IS IT ANYWAY: THE IMPACT OF JOB ROTATION ON THE REDUCTION OF CUMULATIVE TRAUMA DISORDERS

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This thesis is dedicated to my parents, Francesco Sr. and Rosa Maria, and my fiancée Cathy Ann.

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CHAPTER 1

INTRODUCTION

1.1 What Are CTDs

In today's fast-paced world, repetitive activity on the job has become very demanding. Although automation has reduced the amount of "heavy" work, it has introduced new "light" jobs that require highly repetitive motions using smaller muscle groups (Bridger, 1995). High demand from the market requires companies to push large quantities of product out the door. Mass production has become common practice. In turn, workers have to increase their productivity. To do so, workers need to perform high paced physically demanding activities throughout the day. However, little or no consideration was given to how these physically demanding jobs would affect workers. Therefore, many workers are suffering from injuries known as cumulative trauma disorders (CTDs).

CTDs are disorders of the musculoskeletal and nervous systems that occur in either the upper or lower extremities, including the back and shoulders. These disorders can become quite painful and debilitating in severe cases. With CTDs simple everyday tasks, such as pushing a shopping cart, combing hair, writing with a pen, or picking up a baby become difficult and laborious to perform. The inability to perform these activities often leads to frustration and depression and conditions may even worsen due to these negative psychological factors.

The body works as a machine. Just as with all other machines, the body has limitations and capacities. If those limitations are exceeded, the machine will observe damages and eventually break down. Similarly, if the body is overexerted, injuries will occur. Also, machines need proper preventative maintenance to ensure they will run at full capacity. For the body, proper preventative maintenance includes replenishing fluids and vitamins, exercise to strengthen the body, and obtaining sufficient rest and recovery time. With proper maintenance and care, the body has the ability to repair itself and run efficiently.

There are several occupational factors that contribute to the occurrence of CTDs. These factors are known as work stressors. Work stressors include repetition, force, and posture. Repetition refers to how frequently a task or set of motions is performed. Highly repetitive work involves rapid and frequent muscle contractions, which subjects muscles and joints to repeated and changing stress. Without adequate time to recover, this stress can build up and result in damage to these tissues (Mackinnon and Novak, 1997). Force signifies both muscle activity exerted by the body and outside forces acting on the body, such as pinch points and sharp edges. Exerting high muscle forces, or keeping muscles partly contracted for long periods of time, can interfere with circulation and lead to pooling of blood, which leads to muscle fatigue and eventual tissue damage (Mackinnon and Novak, 1997). Outside forces such as vibration, impact shock, and pressure from gripping or leaning against hard edges can damage tendons, nerves, and blood vessels.

Awkward work postures concerns taking the body out of its normal alignment or moving a joint toward the limits of its range of motion. Figure 1 illustrates the upper extremities range of motion, with the anatomical motions at their maximum bounds. Several studies have shown that improper work posture observed for prolonged periods of time has the greatest impact of all other work stressors (Higgs and Mackinnon, 1995; Klein, 1997). When the body's posture is at it's range limits, it causes unusual and uneven stress on the joints and surrounding soft tissues and may overload muscles and tendons (Klein, 1997;

NIOSH, 1992). Awkward work postures are mechanically inefficient, so muscles have to exert more force than when the body or joint is in neutral or normal alignment (NIOSH, 1992).

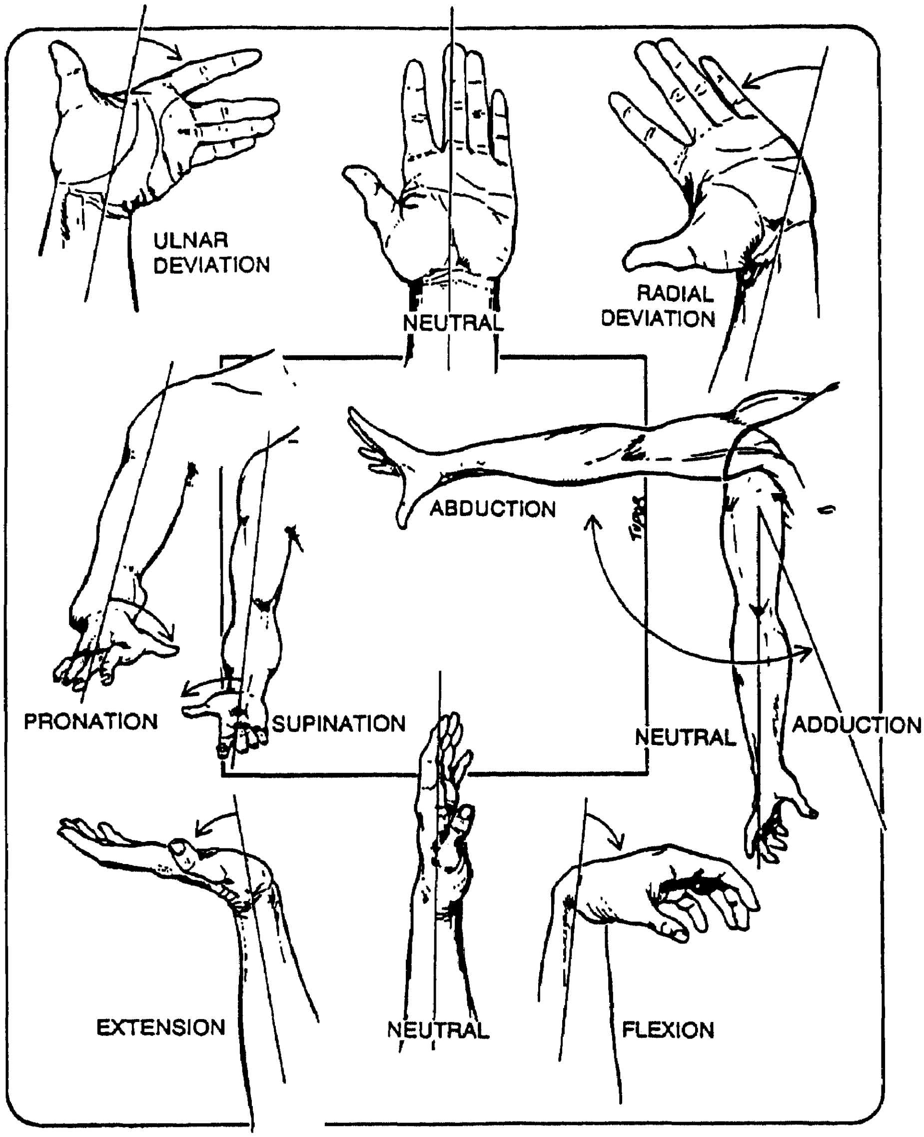


Figure 1. Anatomical Motions of the Upper Extremities (Putz-Anderson, 1988)

When a worker is exposed to undesirable levels of stress from any or a combination of these work stressors, the risk for injuries and illnesses greatly increases and CTDs can occur (Klein, 1997; Mackinnon and Novak, 1997; Silverstein, 1987).

In addition there are other individual risk factors that affect the occurrence of CTDs. A person's diet is directly related to the development of CTDs. Poor dietary habits, such as working long hours without eating properly, can diminish the body's natural ability to repair itself. Obesity can also pose a significant problem to the occurrence of CTDs (Nathan, *et al.*, 1992b). Many obese persons are less active due to their condition, which limits their body's circulatory and digestive systems, thereby increasing their risk of developing CTDs. Also, extra weight puts additional strain on the body and increases the potential for back injuries. Insufficient vitamin levels in the body play a significant role in the development of CTDs. Low levels of Vitamin C reduce the body's ability to build collagen, which is used by the body to continuously build tissue. A deficiency in Vitamin B6 may cause depression, nerve irritation and malfunction of the immune system, which can increase the probability of developing CTDs. Smoking and drinking alcohol reduces the body's ability to carrying oxygen. This inability to carry oxygen causes the person to work harder to perform ordinary body functions, such as breathing, walking, and moving arms and legs. Because a person must work harder to perform these functions, there is a higher risk for injuries. An individual's personal level of fitness contributes greatly to reducing their risk of developing CTDs. Maintaining a fitness program, such as stretching, walking, swimming, proper diet and weight control can greatly reduce CTD occurrence. Carpal tunnel syndrome (due to swelling) and back problems can be complications of pregnancy, but symptoms generally subside at the end of the pregnancy if the individual maintains a good fitness program.

Previous hand or wrist fractures, rheumatoid arthritis, hypertension, diabetes, thyroid disorders, kidney disorders, and other medical conditions may also affect the incidence of CTDs. It is important that these conditions are evaluated to identify their impact on the occurrence of CTDs. In addition, the use of oral contraceptives, previous gynecological surgery or other disorders may also affect the body's ability to perform, due to swelling and hormonal imbalances. A health care professional should be consulted if any of these conditions are present. Age also affects the ability to perform work. Certain parts of the body begin to deteriorate with age, including cartilage, bone, ligaments, tendons, muscle tissue, etc. Vitamins and exercise will help to reduce the degradation process. However, each person must understand and respect the body's capacities and limitations regardless of their age or physical condition.

Many activities outside of work can affect an individual's development of CTDs. Some of those activities may include: gardening, knitting, golf, tennis, bowling, piano playing, and home computer use. All of the activities require the use of specific muscle and skeletal system groups to perform them. Use of those muscle groups on a regular basis may place an unusual burden on the muscles and skeletal system, thereby placing the body at risk to injury. Individuals should be aware that their participation in activities requiring exerted force, posture, and repetition may increase their risk for developing a CTD at work. By performing those tasks at home in moderation and with frequent and regular breaks, an individual will greatly reduce his or her chance of developing an injury.

1.2 Magnitude of the Problem

CTDs can be found in most industries, although they are more prevalent in the manufacturing industry. CTDs can occur in a variety of occupations, including secretaries, nurses, and construction workers. Statistics show that CTDs have become one of the leading causes of lost-workday injuries and workers' compensation costs.

The Bureau of Labor Statistics (BLS) of the U.S. Department of Labor (DOL) performs an annual survey to identify the magnitude of the cases of reported injuries and illnesses, called the Annual Survey of Occupational Injuries and Illnesses. The BLS surveys about 250,000 private sector companies at random to identify the causes of their injuries and illnesses, then compiles a summary of the causes to identify those factors which contribute to the most injuries and illnesses. The survey collects injury and illness data from the companies' OSHA Form 200 logs. For 1994, the BLS reported that approximately 705,800 cases resulted from overexertion or repetitive motion. That accounted for about 32% of all reported injuries and illnesses for that year. More recent statistics show:

- CTDs accounted for 34% of all lost-workday injuries and illnesses in 1996.
- There were 647,000 lost workday CTDs reported in 1996.
- CTDs account for $1 of every $3 spent for workers' compensation.
- CTDs each year account for more than $15-$20 billion in workers' compensation costs. Total costs add up to as much as $60 billion.
- Carpal tunnel syndrome, one form of CTD, leads on average to more days away from work than any workplace injury. Carpal tunnel syndrome cases involve more than 25 days away from work, compared to 17 for fractures and 20 for amputations.
- Manufacturing and manual handling operations account for about 60% of all lost-workday CTDs, while employing only 28% of the general industry workforce.
- Incidence rates for lost-workday CTDs are as high as 30.4 and 42.4 in certain manufacturing and manual handling operations, respectively.

- While the rest of general industry does not account for as large a percentage of lost-workday CTDs, a high percentage of some of the most severe CTDs (e.g., carpal tunnel syndrome), are in pockets within these industries.

Recent surveys show a decline in the number of reported cases, but the cause is uncertain (NIOSH, 1997b). It may be due to a reluctance to report such injuries because of the potential repercussions. Another reason the number of cases reported has declined may be an increased awareness of the cause of such injuries has led to preventative measures being taken to eliminate CTDs. Despite a reduction in the number of cases, CTDs are still one of the main injuries observed throughout many industries and are causing considerable lost time and production (NIOSH, 1997b).

Although there are many negative statistics that show CTDs are devastating workplaces, many companies need to focus on the one single most important statistic – CTDs are preventable. However, before attempting to correct the problem, industries must first recognize that a problem exists. Often times the attitude of management needs to be changed and they need to be enlightened to the true root cause of their increased injury rates. Only after accepting the challenge of correcting conditions that cause CTDs can the negative statistics be diminished.

1.3 Epidemiological Evidence

There has been much controversy over CTDs. One of the arguments is that CTDs are not primarily caused by work stressors, but instead are only prevalent in those workers who have smaller anthropometric features or are physically weaker (Nathan, *et al.*, 1992a; Nathan, *et al.*, 1992b; Rempel, 1992). For example, many skeptics believe that wrist injuries such as carpal tunnel syndrome can only occur in operators that have small, weak wrists. Others feel that once an injury is observed, inactivity of muscle groups makes the individual more susceptible to subsequent injuries (Fordyce, *et al.*, 1986). To alleviate the injuries, workers are rotated out of those jobs which they experience the injuries, and are sometimes even placed in workstations or tasks that expose the worker to the same ergonomic stressors that caused the injury. Still others feel that the true root cause of CTDs is often psychological and physical intervention methods have little or no effect (Flor and Turk, 1984; Hocking, 1987). In order to have a meaningful impact, many studies suggest a holistic approach to treating CTDs (Burton, 1998; Higgs and Mackinnon, 1995; Osterweis, 1987), where both biomechanical and psychophysical root causes are identified (Keyserling, 2000) and psychological and physical stressors are incorporated.

In response to such skepticism, the National Institute of Occupational Safety and Health (NIOSH) compiled a review of various epidemiological studies in an attempt to show a causal relationship between work stressors and CTDs (NIOSH, 1997b). The compilation includes over 600 studies that were conducted on various industries in the field. All studies that were lab-based, focused on biomechanical aspects, dealt with clinical treatment, or had irrelevant non-epidemiological information were not considered for the compilation. Emphasis was placed on those studies that contained more objective data than those containing strictly subjective data. Focus was also placed on studies that utilized recognized symptoms and medical evaluation methods. After observing all the results from the various studies, they were pooled together to give an ultimate outcome for the causality relationship. The guidelines used to analyze the causality relationship included strength of association, consistency, temporality, exposure-response relationship, and coherence of evidence. The results of the compilation can be seen in the following table:

Table 1. Evidence for Causal Relationship between Physical Work Factors and MSDs (NIOSH, 1997b)

Body part *Risk factor*	**Strong evidence** (+++)	**Evidence** (++)	**Insufficient evidence** (+/0)	**Evidence of no effect** (-)
Neck and Neck/shoulder				
Repetition		✓		
Force		✓		
Posture	✓			
Vibration			✓	
Shoulder				
Posture		✓		
Force			✓	
Repetition		✓		
Vibration			✓	
Elbow				
Repetition			✓	
Force		✓		
Posture			✓	
Combination	✓			
Hand/wrist				
Carpal tunnel syndrome				
Repetition		✓		
Force		✓		
Posture			✓	
Vibration		✓		
Combination	✓			
Tendinitis				
Repetition		✓		
Force		✓		
Posture		✓		
Combination	✓			
Hand-arm vibration syndrome				
Vibration	✓			
Back				
Lifting/forceful movement	✓			
Awkward posture		✓		
Heavy physical work		✓		
Whole body vibration	✓			
Static work posture			✓	

The review shows either strong evidence or evidence exists between the occurrence of a large majority of body part musculoskeletal disorders (MSDs) and work risk factors or stressors. Insufficient evidence results suggest that in some studies there was insufficient numbers, quality, consistency, or statistical power to form an association of a causal relationship. Also, some studies may have shown a relationship, but had to be considered insufficient evidence because of confounding factors that could not be statistically removed. Examples of confounding factors include age (bone deterioration), gender, smoking (decreased oxygen flow through the bloodstream, increased intra-abdominal pressure due to coughing), physical activity, overall strength, and anthropometry. The most significant results of the review are there were no studies that observed evidence of no effect of work factors upon the occurrence of MSDs. In other words, most of the studies reviewed in by NIOSH suggest that evidence exists between work risk factors or stressors and MSDs and no studies suggested the contrary.

1.4 Control Measures

As with all workplace hazards, control measures needed to be used to minimize or eliminate injuries and illnesses. The preferred method to prevent MSDs is through use of engineering controls (NIOSH, 1994). The purpose of engineering controls is to design (or change) physical aspects of the workplace to reduce or eliminate employee exposure to work stressors. They are preferred over other methods because they are relatively permanent and can benefit anyone who is assigned to the job – not just the specific individual who has experienced a CTD. Except for any required maintenance and employee training, engineering controls should become "transparent" (that is, a normal part of doing business).

In other words, engineering controls should be built into the system and therefore require no intervention to function (NIOSH, 1997a; OSHA, 1999). Proper engineering control measures allow workers to perform their operations with a minimal amount of physical activity required. The following are examples of engineering controls:

- Change product and/or process design to make assembly easier (such as easy-connect electrical terminals, snap-in parts, reduced number of parts and fasteners)
- Modify the assembly process or sequence
- Change workstation layout (such as by using adjustable workbenches, seating, parts bins, etc.) to keep work centered in front of the employee, and within easy reach
- Use adjustable fixtures or positioners to rotate, lift, and tilt work items so employees can work without using awkward reaches or postures
- Set up workstations to allow workers to alternate between motions to minimize the amount of loading on muscle groups.
- Use powered tools or machines to reduce repetitive motions and to apply force, rather than employee muscle power
- Automate or mechanize repetitive, hand-intensive assembly operations
- Change tool designs to allow operators to use minimal forces and maintain neutral postures
- Modifying containers to include handles, slots, or other lifting aides
- Use mechanical assists to lift/lower, push/pull or carry loads, especially if they are heavy or are moved frequently

In some cases, engineering controls are not technically or economically feasible. In these cases, administrative controls can be instituted. While engineering controls target work stressors in the physical work environment, administrative controls are meant to reduce the harmful effects of work stressors on the operators. Administrative controls are management-driven work practices and policies that reduce exposure to work risk factors. This may mean increasing the worker's ability to cope with the stress, reducing the duration of exposure, and/or slowing the onset of fatigue and discomfort (Goldstein, 1995). To be effective, administrative controls require employee awareness of CTD risk factors through appropriate training (NIOSH, 1994). Since administrative controls require worker intervention, management must ensure that the programs and policies are followed in order for the controls to be effective (NIOSH, 1997a; OSHA, 1999). The following are examples of administrative controls:

- Train workers in CTD recognition and procedures to minimize stressors
- Adjust the work pace to one that is perceived as “comfortable”
- Allow more frequent rest and recovery breaks
- Reduce shift length and overtime
- Job rotation

The final method in reducing exposure to workplace hazards is through use of personal protective equipment (PPE). PPE generally provides a physical barrier between the worker and the hazard. Common types of PPE worn to protect against CTDs include back belts, anti-vibration gloves, and wrist splints. The effectiveness of PPE to protect workers against CTDs is questionable. Most times, the PPE only serves as a reminder to the wearer to keep the body in its neutral posture. However, many times the PPE introduces another type of exposure because the user has to overcompensate for the device. For example, if an operator is wearing a wrist splint to avoid bending the wrist, the operator may have to fight against the splint to perform his or her work. In addition splints, back belts, and other such devices cause atrophy of the inactive muscles and make them more susceptible to injury. Several studies have been performed on the effectiveness of PPE to reduce the occurrence of CTDs. The most notable is one performed by Home Depot, a large nationwide retail hardware store, to show the effectiveness of back belts in reducing lower back injuries (Knill, 1997). Although the study claims the back belts reduced injury rates substantially, NIOSH still believes that the effectiveness is questionable. OSHA views use of PPE as a temporary measure only, and other control methods must be instituted immediately to avoid exposure to the work stressors (OSHA, 1999).

CHAPTER 2

JOB ROTATION

2.1 What Is Job Rotation

Job rotation can be an effective and powerful tool when seeking to minimize exposure to work stressors. Although it is an administrative control, if implemented correctly job rotation can help to decrease the occurrence of CTDs. Job rotation involves moving workers from one workstation to another at specified intervals throughout the day. This rotation allows the worker to experience different activities throughout the day, thereby distributing the physical demands on the workers' bodies. It does not eliminate work stressors, but it allows workers to minimize their exposure to the hazards. Though it is not a permanent solution, job rotation may serve as an interim fix until proper engineering controls can be instituted.

2.2 Benefits of Job Rotation

There are many benefits to job rotation. Numerous studies have been conducted to identify the various benefits that a well-designed job rotation system can bring (Hazzard, *et al.*, 1992; Henderson, 1992; Jonsson, 1988; MacLeod and Kennedy, 1993; Triggs and King, 2000). The obvious is the reduction of worker exposure to work stressors that lead to CTDs. By rotating workers from workstation to workstation, the workers change their physical activity and the muscles used to perform the job. Rather than performing repetitive tasks for many hours throughout the day, job rotation allows for a change of body motions. This allows for recovery time for those muscles fatigued during the previous operation. Avoiding potential injuries decreases absenteeism and avoids high turnover rates.

Work rotation is very inexpensive and can be implemented with relative ease. This is ideal since it is considered a temporary fix. However, even after engineering controls are implemented, job rotation can be used continually to ensure workers are not overexposed to work stressors previously undetected. Since the workers are already acclimated to the rotation cycle, there is little need to revamp the process. Although training the workforce to perform operations on multiple workstations requires time and effort, a cross-trained workforce allows the company to move employees between departments as the need arises. Therefore, the cost of training all employees on multiple tasks quickly repays itself.

Another advantage to job rotation are the psychological benefits of workers rotating between jobs. If a worker performs the same operation throughout the day, he or she becomes mentally withdrawn. Mental alertness is diminished due to the monotonous motions. Boredom and inattention result and often times leads to the workers taking unnecessary steps and shortcuts just as a change of pace. These steps and shortcuts are often unsafe and may contribute to the exposure of the work stressors. Job rotation allows the workers to maintain interest and increases motivation to perform the tasks using the recommended procedures. In addition, job rotation also increases innovation by keeping the workers attentive to the tasks. Since the operators are paying more attention to their work, they identify sources for improvement. This increased sense of awareness may also lead to better job satisfaction as the workers feel they have a greater impact on their work environment. Also, workers can help each other to reach solutions not observed before because they were never exposed to the tasks or workstations. This helps to create a well-diversified workforce and creates a positive teamwork atmosphere.

In addition, job rotation helps to reduce mental stress. High levels of stress have an impact on the way the employee "feels". If the employee feels like they are under a great deal of pressure, they become more susceptible to injuries (Montante, 1999). Job rotation allows the individual to rotate between tasks that have high output demands and those that are not as taxing both physically and mentally.

The ultimate advantage of job rotation is simple – increased productivity. It is simple to see that by avoiding injuries such as CTDs can increase the workers' output. But not as obvious is the impact that the psychological benefits have on the production of the employees. As the famous saying says, "A happy worker is a productive worker."

2.3 Challenges of Job Rotation

Although job rotation has many advantages, there are challenges when attempting to implement the system. The focal point of these problems exists in the workplace culture and employee behavior, not in the system. Job rotation cannot be used for all operations. Typically, job rotation is most useful for those jobs and workstations that require short, repetitive tasks. For those operations that require long, multi-sequential steps job rotation may actually cause confusion and slow down production. Therefore, the processes must be reviewed and the need for a job rotation schedule must first be identified. Job rotation should not be viewed as a universal solution, but rather as a solution suitable for certain applications.

As mentioned before, training all workers on all jobs and workstations requires a considerable amount of time. Therefore, training needs to viewed as a long-term investment that will repay in due time. Many times though workers are unwilling to learn new jobs. They are "comfortable where they are" and are unwilling to endure the training process. This attitude is often visible in workers with longer service time. In addition, some workers do not want others to use their equipment and "mess everything up". Certain studies even argue that by rotating employees, knowledge of specialized tasks is diminished and quality and productivity are degraded (Cosgel and Miceli, 1998). Again, training needs to be viewed as a necessary step that needs to be taken at the beginning of the system in order to achieve the desirable results of a properly instituted job rotation program. Focusing on the benefits will often help to change the culture from one of rejection to acceptance and adherence.

Another issue that may arise is that operators performing different operations may be receiving different wages. This is often difficult to adjust and many times leads to grievances by workers. Operators that had less responsibility now have additional tasks to perform. Their idle time is diminished and their physical and mental tasks have increased. Careful consideration needs to be taken to ensure wages match the level of responsibility and workers performing similar tasks have similar wages. One method to address this problem would be to use a seniority system, similar to what unions use. Since the responsibility placed on each employee would be similar (except those workers with supervisory roles), those workers who have more years of experience would have higher wages due to their enhanced knowledge of the operations.

Other challenges may arise if the operations are not analyzed correctly (Moore and Garg, 1994). First, the tasks and workstations must be carefully examined to ensure the appropriate work stressors have been identified. In some cases, workers will develop strategies to avoid obvious hazards, and will therefore inadvertently conceal risk factors

(Lavender, 1990). If misevaluated, the true level of work stressors for the tasks may not be discovered until after an injury has occurred. Analyzing tasks after implementing the rotation system will help to reveal any missed work stressors, as well as identifying areas where engineering controls are needed.

2.4 Ineffective Job Rotation

As mentioned before, the benefits of job rotation can only be experienced if the system is implemented correctly. Inappropriate use of the system can actually lead to higher risks of CTDs (Putz-Anderson, 1988). If jobs or workstations are evaluated incorrectly (misevaluations of work stressors) or the schedule is not planned properly, the operators will be utilizing the same motions and muscle groups to perform various tasks, increasing their exposure to the work stressors. Idle and rest times that were inherent before are now removed because of the rotation schedule. Also, there are some situations where it is difficult to find jobs that do not require the same motions and muscle groups to perform the work. In these instances, it may be best to institute engineering controls first, and then re-attempt to formulate the rotation schedule.

2.5 Effects of Shiftwork and Overtime

Shiftwork and overtime can pose additional problems, but if taken into consideration when the job rotation cycle is instituted, the effects can be minimized. Shiftwork involves employees working during specific time blocks or shifts. Shifts are usually eight hours long with an overlap of a half hour to minimize downtime. In some industries, shifts are twelve hours long. Manufacturing facilities typically use three eight-hour shifts, while service industries use twelve-hour shifts. Both types can pose potential hazards that may lead to CTDs. Often times the eight-hour shifts rotate. That is, the workers that are on the day shifts are required to work on the evening or overnight shifts. Night workers are often tired and sleepy because of their work schedule. Being overtired makes it difficult for the operators to concentrate, increasing the probability of errors and accidents. The stresses associated with shiftwork also can aggravate health conditions (Folkard, 1993), such as heart disease or digestive disorders such as upset stomachs, constipation, and stomach ulcers.

Working at night makes it difficult to get enough sleep. Sleep is usually shorter and less refreshing or satisfying (NIOSH, 1997c). The body rhythms, or circadian rhythms, tell the individual to be awake during the day when the individual must sleep. Therefore, day sleep is often short and feels light or unsatisfying (NIOSH, 1997c). Also, brain and body functions slow down during the night and early morning hours, making it difficult for the individual to perform his/her tasks. The combination of these two factors can cause excessive fatigue and sleepiness, making it more difficult to perform well and increasing the risk of accidents (NIOSH, 1997c). Also, night shiftwork can be additionally stressful because of separation from family and friends. These stresses can also be harmful to a person's well being.

Several studies have been conducted to identify the negative effects of shiftwork (Colligan and Tepas, 1986; Rosa, *et al.*, 1989; Taylor, *et al.*, 1997). The results of these studies were shiftwork for night workers and twelve-hour shift workers show a dramatic decrease in performance due to fatigue (Colligan and Tepas, 1986). However the studies also indicated that many employees prefer the twelve-hour shiftwork system because it provides extra days off and allows for more social time (Rosa, *et al.*, 1989). Workers are willing to subject themselves to greater fatigue conditions in order to gain the free time to do other activities outside of work, but the risks associated with higher exposure to work stressors may outweigh the benefits. Much research has been devoted to identifying the optimal work-rest cycle to combat the negative effects of fatigue resulting from shiftwork (Fisher, *et al.*, 1993; Janaro and Bechtold, 1985; Rosa, *et al.*, 1998; Wood, *et al.*, 1997).

Instituting a job rotation schedule may also help to negate the effects of shiftwork by keeping the operators more attentive. If the workers are more cognizant of their tasks, they are less likely to take chances or shortcuts. Also, job rotation can help to alleviate stresses observed for twelve-hour shifts. If work stressors are present in operations, the employees working on the extended twelve-hour shifts are exposed to longer periods of risk factors. This increases the chances for these workers to experience CTDs. By rotating between jobs, the exposures to the work stressors are minimized. In addition, the monotony of working twelve straight hours on one type of task or workstation is broken, and the jobs carry more interest to the workers as mentioned earlier in the psychological benefits.

Overtime carries the same potential hazards as the extended shifts. However, frequently overtime is considered during the operators' shifts and preparation for what tasks the operators will perform must be done instantaneously. In many instances, employees are required to work multiple shifts due to lack of staffing. This disrupts the job rotation scheduling and leads to a very dangerous situation. In addition to potentially performing tasks that expose the workers to work stressors already observed during their normal shift, the operators now experience greater fatigue and are more susceptible to injuries. This leads to shortcuts and risk-taking just to "finish out the shift". If it is anticipated that overtime will be experienced as a part of normal operations, consideration for addition tasks to be performed must be included when formulating the job rotation schedule.

CHAPTER 3

PREPARING A JOB ROTATION SCHEDULE

3.1 Setting Goals

The first step in implementing a job rotation schedule is to quantify the goals that are to be met. The goals for job rotation can be as simple as reducing or eliminating CTDs or achieving any of the benefits of job rotation mentioned before (Section 2.2). It is very important to set these goals and advertise them in a positive manner. This will help to increase worker awareness and assist in changing the culture to accept the rotation schedule. To have the greatest impact, goals should be quantifiable so the workforce can visually see the impact of the job rotation system. For example, setting a goal for the job rotation system to reduce incidence rates or absenteeism/lost-work time is something that can be easily measured and is easily understood by the workforce.

It is important not to set goals too high. It is often useful to set interim goals to ensure the job rotation system is on the right path. Without them, it is difficult to observe any improvements on a short-term basis. Many times this leads to abandonment of the system before the ultimate goals are achieved, and the program is seen as a failure.

3.2 Survey the Existing Conditions/Practices

The next step is to identify the current practices and evaluate their effectiveness. There are several ways to pool the information on current conditions. One method is to create a questionnaire and distribute it to the employees to obtain their subjective feedback on any symptoms they mat be experiencing and to identify high-risk areas (NIOSH, 1997a; Putz-Anderson, 1988). Figure 2 illustrates an example of such a questionnaire.

			No	Yes
(1)	Within the past month, have you had repeated feelings of numbness, tingling, or "pins and needles" sensations in one or both hands?		[ ]	[ ]
(2)	Within the past month, have you had repeated feelings of soreness or pain in either forearm or elbow?		[ ]	[ ]
(3)	Within the past month, have you had repeated feelings of pain discomfort, burning, or tingling in your shoulders?			
		Left	[ ]	[ ]
		Right	[ ]	[ ]
(4)	Have any of the above symptoms (numbness, tingling, soreness, or pain) caused you to be awakened while sleeping?		[ ]	[ ]
(5)	What time does your discomfort regularly occur?			
		Mornings	[ ]	[ ]
		Afternoons	[ ]	[ ]
		Evenings	[ ]	[ ]
		Night	[ ]	[ ]
(6)	Does discomfort in your wrist, arm, or shoulder interfere with your daily activities (eating, writing, sports, etc.)?		[ ]	[ ]
(7)	Have you ever received medical treatment for this pain and/or discomfort?		[ ]	[ ]
(8)	Have you ever received medical help (either company or private doctor) for any of the following:			
		Carpal tunnel syndrome?	[ ]	[ ]
		Ganglionic cysts?	[ ]	[ ]
		Tendinitis?	[ ]	[ ]
(9)	If yes to (8), have you ever had surgery for any of these conditions?		[ ]	[ ]
(10)	Does your present job require arm, hand, or finger actions to be repeated many times each hour and work shift?		[ ]	[ ]

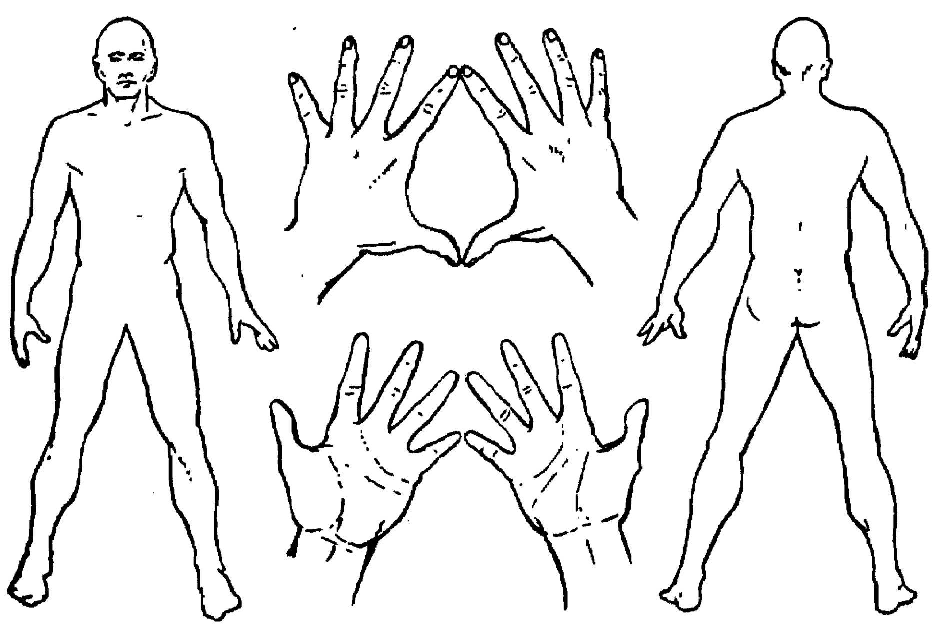


Figure 2. Sample Questionnaire for Surveying Employees (Putz-Anderson, 1988)

Data pertaining to the employees' length of employment, service time at particular tasks or workstations, and perceived stressors and especially important when identifying high risk areas and when comparing the impact of the job rotation system.

Other ways of compiling information includes using past OSHA Form 200 logs to observe any trends (NIOSH, 1997a; Putz-Anderson, 1988). More importantly, the information on the logs can be used to identify high-risk jobs or workstations. Once the job rotation schedule is implemented, future injury cases on the OSHA Form 200 logs can be observed to identify any reduction in the incidences for those areas. Also, a reduction in the number of recordable injuries and illnesses can serve as an excellent goal by identifying the effectiveness of the job rotation system.

3.3 Analysis of Work Stressors

Although surveying the workers will produce valuable qualitative data, to fully analyze the impact of work stressors quantitative data must also be gathered (Moore and Garg, 1994). Qualitative data serves as a good source for employee feedback to the current and subsequent conditions once the job rotation system is instituted. However, formulation of the job rotation schedule requires measurable characteristics about the work stressors. To simply say conditions at a workstation are "good" or "bad" leaves little room for judgment. Without quantifiable data, it is difficult to measure how much physical activity is necessary to perform each operation or how workstations and tasks may increase the workers' exposure to work stressors collectively (Moore and Garg, 1994). When collecting the quantitative data, established measuring tool(s) should be used, such as the NIOSH Lifting Equation or the Rapid Upper Limb Assessment (RULA).

3.3.1 The Revised NIOSH Lifting Equation

The Revised NIOSH Lifting Equation is particularly useful when evaluating manual materials handling (Waters, *et al.*, 1993). The Equation uses elements involved in a lifting task to identify the recommended weight limit. The recommended weight limit identifies the level at which actions need to be taken and the maximum permissible limit or the maximum weight that an individual can manage with those elements present without observing a high potential for an injury. The equation is equally applicable to lowering tasks. Factors that affect the recommended weight limit include:

- Horizontal Multiplier – distance from the load to be lifted to the operator.
- Vertical Multiplier – distance from the knuckles of the hands at the start of the lift to the ground/operators' level.
- Distance Multiplier – distance the load is to be lifted.
- Asymmetric Multiplier – the degrees from the midpoint of the hands to the neutral posture (straight ahead) during the lift.
- Frequency Multiplier – number of lifts per minute or lifting duration.
- Coupling Multiplier – ease or difficulty of the load to be grasped by hands.

After calculating these multipliers, the lifting index is derived. The lifting index identifies the cumulative effect that the risk factors have upon the particular lifting task. The main purpose of the lifting equation is to rate several alternative lifting tasks to identify that which presents the least risk. In other words, the lifting index is useful in determining if lifting a load using method "A" is better or worse than using method "B". Although it is a useful tool, the actual lifting index may be slightly altered due to imprecise calculations that result from several assumptions that must be made for the Lifting Equation to be applicable for the task. They include:

- The lift must be only a few steps.
- Both hands are used.
- No obstructions to impede the lift.
- Lift is performed in a standing position with both feet flat on the lifter's level.
- The load is stable, balanced, and can be handled without additional hazards (electrical, temperature, etc.).
- Environmental conditions are favorable (temperature, relative humidity, etc.).

Although it is implied these assumptions are met and will not have any effect on the lift, the reality is that there are usually outside factors that inhibit the lift to some degree. For this reason, the lifting index should only be used to compare alternative lifting methods and not as a finite measuring tool.

3.3.2 RULA

The Rapid Upper Limb Assessment, or RULA, is an excellent tool when evaluating the exposure to work stressors for upper extremities (McAtamney and Corlett, 1993). Based upon the posture of the upper limbs of the body during the motions of the job, the frequency of the motions, and the force exerted, a strain score or risk index is derived. This index can be used in the same manner as the NIOSH Lifting Index to compare tasks to identify high-risk tasks and tasks with similar motions that may have a synergistic effect. As with the lifting index, the risk index should not be used as an exact measurement because outside factors may adjust the true measurements of the elements for the assessment.

The first step in calculating the RULA risk index is to determine the posture scores. The posture scores are calculated by measuring the degrees of motion of the body's limbs from the neutral axis. The extremities are divided into two groups. Group A covers the upper arms, lower arms, bending of the wrists, and rotation or twisting of the wrists, while Group B encompasses the neck, trunk, and legs. Although the legs are lower extremities, they affect the worker's balance and posture and are therefore considered when analyzing the effect on the upper extremities. The further the limbs move from the neutral axis and approach the body's limitations of movement, the greater the risk and postural score.

Next, the frequency score is calculated by identifying the number of repetitions per minute required for the task. In addition, if the task requires a static posture (postures held for greater than one minute), a higher risk score is given. After identifying the frequency score, the force or load score is calculated. The greater the force necessary to perform the task, the higher the score will be.

Finally, once all the scores have been calculated, a grand score is given for the entire job. The grand score is dependent upon all the scoring for the individual elements that contribute to the task. Hence, the grand score identifies the task's risk index. Using this index, the jobs can be compared and grouped. Also, the individual work stressor scores reveal vital information about the task. Reducing the elements that contribute to a higher grand score can help to reduce the risk index of the overall job. In addition, the individual scores will help to identify which particular muscle groups are at a higher risk and may assist in finding the route causes of injury trends. Appendix A contains the process and scoring for RULA.

It should be noted that RULA focuses on the postural work stressors. That is, much of the scoring and ultimate risk index of RULA depends heavily upon the observed postures. Although the force scores allow for a broader range of assessment, RULA scoring for frequency is very constricted (0 or 1). The frequency scores do not completely reflect what the demands of the jobs/tasks are. However, for certain applications, especially those where frequency of jobs/tasks are unavoidable, RULA serves as a valuable tool in assessing the work stressors of the jobs or workstations.

3.3.3 Identify Control Zones

After assessing the tasks and workstations, it is necessary to determine what the control zones are. The control zones are those regions where it is necessary to implement engineering or administrative controls. If the risk indexes are very high, it is necessary to implement engineering controls. Administrative controls may reduce the exposure, but the work stressors may be so significant that an ergonomic injury may still occur. Therefore, the control zones should be carefully planned to ensure the proper measures have been taken.

Often times the focus of the control zones is not to eliminate all of the hazards associated with the task, but rather to reduce the risk index by implementing controls for the work stressors of the task which are at undesirable or unacceptable levels. For example, to reduce the risk associated with a task that requires minimal force and repetition but extreme postural stresses, the controls implemented would reduce the motions necessary and postural requirements of the task, thereby decreasing the overall risk score. Reducing the force or repetitions required would do little or nothing to solve the problem in this case.

3.4 Development of the Job Rotation Schedule

3.4.1 Forming the Rotation Schedule

When formulating the job rotation schedule, several factors should play a role. The basis of the rotation cycle should be the quantitative data gathered through the task and workstation analyses. As mentioned earlier, the subjective data gathered through the employee questionnaires serve as a good starting point, but the risk index should be carefully observed to make certain similar motions and muscle groups are not used consecutively and work stressors are not compounded. Ideally, tasks that have a high risk index should be paired with tasks with very low risk indexes. Tasks that require considerable physical activity should be scheduled before breaks or tasks that have very low risk indexes, such as inspection tasks with minor activities necessary to allow muscles time to recover. The best activities are those that allow the workers to use varying muscle groups, but this is not always feasible. If similar muscles are to be used successively, the tasks should have average to low risk indexes to make certain they do not have a synergistic effect.

The next challenge is determining how many tasks to include in the rotation cycle. There are many studies that address this issue. Some feel it is best to minimize the number of different jobs rotated between so the operators can become specialists or experts at those workstations (MacLeod and Kennedy, 1993) while others feel it would be best to include many jobs in order to diversify the workforce and create a positive teamwork attitude (Volpe, *et al.*, 1996). This issue can be resolved by addressing the decision in the goals for the job rotation system. If the intent is to keep workers focused on only certain jobs, only a few jobs should be included. If the aim of the system is to increase all employees' knowledge of many tasks by cross-training the workforce, several varying tasks should be incorporated. In either situation, the primary focus of the job rotation system should be to reduce the exposure to work stressors, with diversity/specialization of jobs as an additional benefit.

Also, the schedule should allow for mental activity variation. If the worker has many consecutive tasks where the mental demand is high, despite the physical activity being low, the worker may "feel" stressed and overexerted. On the other hand, coupling activities that require only physical activities with little mental activity will lead to tedious rotation cycles that will lead to monotony and boredom. Developing a job rotation schedule that allows the worker to vary between physically demanding and mentally demanding activities will keep the operators alert and interested.

3.4.2 Training

When training employees to use the job rotation schedule, care should be taken not to rush them into the system. Sufficient time is needed for the operators to become familiar with the new tasks involved and to adapt to the new environment of the rotation cycle. The intent of the training period is to teach employees how to eliminate additional stresses by using the job rotation schedule to their advantage. Pressuring employees to adapt too quickly will produce additional anxiety and will often lead to failure of the system.

A critical element of the training regiment should include on-the-job training on approved or accepted techniques and motions to perform the jobs. These procedures should be reviewed and analyzed to ensure workers are using movements that minimize their exposure to work stressors. It may be beneficial for management to review the tasks in advance and formulate written procedures that can be utilized as part of the training process.

3.4.3 Implementation

Implementing the job rotation system can be difficult if not managed properly. It is inevitable that some operators will find the system difficult and will have troubles adapting. Rather than dealing with these instances with negative measures, such as disciplinary actions, employees should feel comfortable to approach management for assistance to acclimate and, if necessary, retraining. Management needs to prepare for reduced productivity for a short period to allow the employees to adapt to the system. It must be understood and accepted that the benefits will come in due time, but the job rotation system needs time to mature to observe the positive returns.

3.4.4 Evaluate Effectiveness

After implementing the system, the job rotation scheduling should be evaluated to ensure the cycles are effective in achieving the desired outcome. The obvious way to do this is to observe any trends in injury/illness rates. Other ways can include employee feedback, reductions in absenteeism, and increases in employee morale. If it is found that the system is not effective, the process should be repeated beginning with setting goals. Questions should be asked, such as "Are our goals too aggressive?" or "Have our goals changed?" Often times benefits of the program are overlooked because they represent only interim goals and not ultimate outcomes. As mentioned in Section 3.1 ("Setting Goals"), it is important to observe short-term benefits to make certain the program is moving in the right direction.

CHAPTER 4

CASE STUDY

A case study was conducted to identify the presence of excessive work stressors and to formulate potential corrective actions. The study was performed on an established northwestern New York manufacturing facility. Products manufactured at the facility are medical devices and drug products used by healthcare facilities. The operations are demand driven. That is, although the facility has many lines of products, only some are operating at any given time. Many of the operations at the facility require manipulation of the products and packaging. For purposes of this study, the identity and procedures of the facility and its products shall remain confidential. Wherever possible, names representative of the processes are used to assist in understanding the requirements of the task.

Manual materials handling utilizing the upper extremities is large portion of the jobs performed. Many repetitive motions are required, although the weights of the products are minimal. Forces are generally higher for pinch and hand grips, as the products are generally smaller. Historically the facility has observed high incidence rates of CTDs, which is indicative of the operations performed. Despite their continuing efforts to implement control measures, they continue to observe a high prevalence rate of DeQuervain's Disease and tenosynovitis. DeQuervain's Disease consists of constriction of the tendons on the side of the wrist and at the base of the thumb due to forceful hand twisting or gripping. Tenosynovitis refers to tendon sheath inflammation and swelling due to production of excessive synovial fluid. The tendon's movement is restricted and may lock in severe cases.

In 1998, their OSHA Recordable Illness Rate was 3.11, and the number of lost workdays was 365 – one full year's worth of lost worker production. In 1999, the number of lost workdays decreased to 244, but their illness rate increased to 4.76. A subjective screening for symptoms of CTDs conducted by the facility of employees by department revealed 32 to 100 % of employees for each department have signs or symptoms of CTDs. They have instituted an aggressive medical management plan that includes light duty work and a proactive rehabilitation program in an attempt to address the issue, which would explain the reduction in lost workdays despite the increase in the illness rates. Although the number of cases is still high, they now have a means of reducing the impact of each case towards lost productivity time.

4.1 Demographics

The demographics of the workforce at the facility are skewed. That is, the range of workers at the facility is very narrow from a demographics standpoint. The average worker at the facility is a Caucasian female with an average age of about 40, mostly in the post-menopausal period. These characteristics may cause confounding factors when taking a historical look at facility's incidence rates. It should be observed that these individual factors need to be statistically removed before identifying the true impact of the work stressors to the occurrence of CTDs.

4.2 Current Practices/Conditions

The facility has many controls in place, as they recognize the need to address the work stressors that are causing the high incidence rates of CTDs. They have spent a great deal of time and resources in evaluating tasks and workstations to identify factors that may affect the occurrence of CTDs. They have instituted an ergonomics task force, which uses the gathered information to formulate control measures to eliminate the hazards. The task force involves various fields of management employees, including design and planning personnel, to cover a broader range of resources and perspectives.

The company has implemented many engineering controls in an attempt to eliminate the exposure to the identified work stressors. Engineering controls instituted include modifications to the manufacturing equipment, changes to the packing designs, powered tools and equipment, and automation of certain processes to reduce wok stressors. Although many have been introduced, additional engineering controls will need to be used as the presence of high-risk work stressors are identified through future task/workstation analyses.

Despite the efforts to eliminate all work stressors, risk factors still existed. Therefore, administrative controls were also introduced. Training on the recognition of work stressors and their impact on the occurrence of CTDs helped to increase the awareness level among operators. This heightened awareness of the risk factors allowed management to receive more useful feedback from the employees in identifying the source of the work stressors and the perceived impact on the workers' ability to perform.

Also, no written "approved" methods existed for motions to be used during the operations. Workers are given on-the-job training, but the methods to be used are only transferred by verbal means. To create a more lasting impact, written procedures should accompany the verbal training. If not, very often the operator develops his/her own style for performing the procedures. Sometimes these deviations can lead to undesirable work motions and a higher risk of exposure to work stressors.

Additionally, a job rotation system was instituted. However, the effectiveness of the system is questionable. The primary goal of the system was to increase awareness and interest and to reduce monotonous jobs and to diversify the knowledge of a smaller workforce. They valued having a diversified workforce since the number of product lines operating simultaneously is limited to the demand. Therefore, they value cross-training employees on multiple tasks to reduce turnover rates. However, when formulating the job rotation schedule no consideration was given to the impact of grouping tasks that require use of similar muscle groups.

Furthermore, the jobs being rotated are generally confined to one department or product line. This simplifies the rotation schedule, but is not necessarily effective in reducing worker exposure to CTDs. There are instances where most or all jobs or tasks within a department have similar high-risk exposures to particular work stressors, and rotation between such tasks would have minimal or no effect.

4.3 Methods

4.3.1 Objectives

Since it was recognized that the company has made a positive commitment to instituting control measures, the largest impact would be to evaluate their current control measures to ensure they are operating to the original intent. Namely, there existed a need to evaluate their current job rotation system and make adjustments to any deficiencies in the system. The types of operations performed at the facility are those that would greatly benefit from a well-planned job rotation system, as the majority involve short duration, highly repetitive motions.

Since the tasks involve mainly manipulation of small products and packaging, the focus was on the postures necessary to perform the operations.

The main goal was to formulate a job rotation cycle that would minimize the exposure to similar work stressors and to combine those tasks that would allow the operators to utilize a broader range of motions. By doing so, the primary objective of reducing the occurrence of CTDs could be achieved. Also, the original intentions of the job rotation system (to increase awareness and interest, reduce monotonous jobs, diversify the workforce) were recognized as secondary goals or added benefits of the system and not as the primary goal. Interim goals for the job rotation system included a reduction in the perceived physical and mental demands for tasks, a decrease in worker absenteeism, and a higher level of employee work satisfaction.

4.3.2 Tools and Apparatus

Since the operations involved many repetitive motions, it was decided that the best method to capture the activities observed during the jobs was to use videotaping. Multiple angles were used to ensure fairly accurate observations of the degrees of motion were recorded. Measurements of the workers anthropometric dimensions and the workstations observed were taken to use as markers when analyzing the videotapes. Use of still-motion video and snapshot images using computer-based software were implemented to capture the degrees of motion of the high paced, highly repetitive tasks.

The OSHA Form 200 Logs for the facility for calendar years 1992 to 1999 were gathered to use for analysis and comparison purposes. Additionally, internal statistics were provided by the facility and were reviewed in order to pinpoint the areas of manufacturing that have historically observed the higher incidence rates.

4.3.3 Analysis of Subjects and Tasks

The subjects studied were operators primarily from the day shift (7:00 AM – 3:30 PM). As mentioned earlier, the jobs performed are demand driven. Therefore only certain jobs were being performed (those for product lines that were in production) and observed for this study. In order to analyze the tasks, RULA was used. Appendix B contains the results of the assessments for the tasks reviewed for this study.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 High Risk Tasks

The tasks with the highest degree of exposure to the work stressors seem to be the operations performed on the gauze product lines. Those operations are performed on machine/belt driven lines and consist of relatively small products. Tasks for the gauze product lines include cutting with scissors, manual picking or scooping, and sweeping across the belt or conveyor. Although their overall task scores are comparable to other lines, the greater concern is that the individual scores for Group A/C postures (upper arms, lower arms, and the wrists) are extremely high. The excessive exposures to these postures can directly lead to CTDs. Also, the mental stress is higher for those tasks performed on these lines since they have a machine driven pace. When operators fall behind in their tasks, they often use inappropriate steps or shortcuts to catch up to the pace. Very often it is these deviations from normal work practices that result in injuries.

Table 2 summarizes the results of the RULA review for the 32 tasks observed. The intermediate scores for the individual muscle groups are listed to observe the risk indexes placed upon each of the task elements. Score A represents the calculated postural index for the upper extremities and Score C includes the force and repetition scores, while Score B identifies the postural scores for the neck, back, and legs and Score D includes the force and repetition scores for those body parts. The entire RULA scoring method used can be found in Appendix A.

Table 2. Results of RULA Investigation for Case Study

JOBS / TASKS	SCORE A / C		SCORE B / D		GRAND SCORE / TASK RISK INDEX
Burn Cream Jar Filling	3	5	3	4	5
Burn Cream Rack Filling	3	5	2	3	4
Burn Cream Packing	4	5	3	4	5
Roll Dressing Unpacking	4	5	3	4	5
Roll Dressing Tab Cutting	4	7	2	3	6
Roll Dressing Tab Insertion	2	3	3	4	4
Roll Dressing Packaging	4	5	1	2	4
Gauze Cutting (Long)	2	5	2	3	4
Gauze Scooping (Long)	7	8	3	4	7
Gauze Inspection (Long)	3	4	2	2	3
Gauze Sweeping (Long)	4	5	1	1	4
Gauze Cutting (Short)	2	5	2	3	4
Gauze Picking (Short)	4	7	2	3	6
Gauze Inspection (Short)	3	4	2	2	3
Gauze Sweeping (Short)	6	7	2	3	6
Gauze Pack-Out (Short)	3	4	5	6	6
Incubator Assembly	2	3	3	4	4
Tube Assembly	1	3	1	1	3
Fixture Assembly	2	3	1	1	3
Pediatric Incubator Assembly	3	4	1	1	3
Welding Stylet	2	3	3	3	3
Stylet Insertion	4	5	2	2	4
Autobagger	3	3	1	2	3
Autobagger Labeling And Packing	3	4	4	5	5
Elastic Wrap Rolling	4	5	2	2	4
Elastic Wrap Cutting	4	6	2	2	4
Elastic Wrap Packing	5	6	2	2	4
Burn Pad Belt Feeder	4	5	2	3	4
Burn Pad Belt Operator	3	4	3	4	4
Burn Pad Sewing	4	5	2	2	4
Burn Pad Packing	2	3	3	3	3
Burn Pad Case Packing	3	4	3	3	3

As mentioned earlier, although the analysis identifies those tasks that have high-risk indexes, the numbers may be deceiving. Slight variations in angles and other factors such as using different techniques and styles for performing the tasks may lead to different overall risk indexes. In order to achieve more accurate accounts of the postures, use of goniometers and electromyography to obtain the angles can be used (NIOSH, 1992). However, for purposes of this investigation the estimated angles will suffice.

5.2 Effectiveness of Current Job Rotation Schedule

Since the job rotation system the company is currently using is restricted to each department, the effectiveness is limited. Although the secondary benefits, such as increased awareness and decreased boredom, are achieved the main goal of reducing employee exposure to work stressors and resulting CTDs cannot be fully realized without the ability to rotate between departments. For example, the gauze lines offer little variation from the types of physical activity required. Hence, the rotation cycle has limited impact. In addition, the sequence of the tasks performed during a work shift also needs improvement. Currently, there is no consideration for their impact upon one another, so there is a possibility that operators may be required to perform tasks that have similar motions consecutively. This does not allow the body sufficient recovery time, and can lead to an injury even if the rest of the shift does not require those motions to be used again. Table 3 illustrates a sample job rotation schedule that is currently implemented.

It can be seen from the table that several of the high-risk tasks for Group C body parts/extremities are coupled. Furthermore, the averages of the Risk Indexes for each category are considerably high: 5.35 for Group C, 3.59 for Group D, and 5.06 for the Overall Risk Index. This type of grouping may cause excessive fatigue in those particular extremities, and can lead to CTDs.

Table 3. Sample Job Rotation Schedule Currently Implemented

JOBS / TASKS	SCORE C	SCORE D	OVERALL RISK INDEX
Gauze Cutting (Long)	5	3	4
Gauze Scooping (Long)	8	4	7
Gauze Inspection (Long)	4	2	3
Gauze Pack-Out (Short)	4	6	6
Gauze Cutting (Long)	5	3	4
Gauze Scooping (Long)	8	4	7
Break			
Gauze Sweeping (Long)	5	1	4
Gauze Pack-Out (Short)	4	6	6
Gauze Cutting (Long)	5	3	4
Gauze Scooping (Long)	8	4	7
Gauze Inspection (Long)	4	2	3
Lunch			
Gauze Pack-Out (Short)	4	6	6
Gauze Cutting (Long)	5	3	4
Gauze Scooping (Long)	8	4	7
Break			
Gauze Sweeping (Long)	5	1	4
Gauze Pack-Out (Short)	4	6	6
Gauze Cutting (Long)	5	3	4

The recordable cases observed on the OSHA Form 200 Logs reinforces the analysis of the exposure levels to the upper extremity work stressors. The logs identify a high prevalence of CTDs in the arms and wrists. Exposure to the severe postural motions coupled with the repetitive nature of the tasks can easily result in CTDs. Additionally, exposure to high forces from cutting and similar tasks compounds the risk. Although the incidence rates have dropped dramatically over recent years, the effectiveness of the company's administrative controls, specifically the job rotation system, is debatable. More than likely, the reduction is resultant of their continuing effort to implement engineering controls and their aggressive medical intervention system to limit the severity of CTD cases.

5.3 Inter-Departmental Job Rotation

The greatest change to the existing job rotation system necessary to increase its efficiency is identifying the risk factors associated with each task and coupling those with differing physical requirements. To accomplish this, inter-departmental job rotation must be used. It is not always feasible to identify jobs with varying physical demands within a single department. Therefore, the job rotation system must encompass a larger range of tasks in order to ensure the physical requirements of the workday are diversified and exposure to work stressors of particular muscle groups are avoided. Training becomes an issue once again, as operators must now be knowledgeable of almost all jobs within the facility. Since a diversified knowledge of many jobs was one of the intents of the job rotation system, this does not seem to pose a major problem. However, training should be conducted carefully to ensure workers understand how to fully perform the operations using appropriate techniques.

5.4 New Job Rotation Matrix

Using the knowledge obtained through RULA for the tasks, a job rotation matrix can be formed. The matrix would identify those tasks to be performed by operators during their work shift, just as the rotation scheduling was prepared previously. The difference is that the new system has the ability to identify the work stressors and minimize their effect by reducing the exposure duration for the workday. Table 4 illustrates a sample of the "risk zones" for RULA scores. To minimize the exposure to the work stressors, no two tasks with moderate risk indexes or individual element scores should be performed in succession. Additionally, any high-risk tasks should be combined with a low risk task or a break. Also, the overall average of each elemental score should not exceed a specified control level that is designated as high risk. In addition, the risk index should adhere to the same guidelines as specified for the task elements. The duration of each job in the rotation cycle has to be specified prior to formulating the matrix. Table 5 represents an improved job rotation schedule for an operator using the guidelines listed above.

Table 4. Example of Designated Risk Zones for Job Rotation System

Element Group / Risk Index	PERCEIVED RISK		
	Low Risk	**Moderate Risk:** Cannot be consecutive	**High Risk:** Must combine with Low Risk or before break
Group C	1-5	6-7	8+
Group D	1-3	4-6	7+
Overall Risk Index	1-4	5-6	7

Table 5. Sample of New Job Rotation Matrix for 8-Hour Work Shift

JOBS / TASKS	SCORE C	SCORE D	OVERALL RISK INDEX
Gauze Picking (Short)	7	3	6
Gauze Inspection (Short)	4	2	3
Gauze Cutting (Short)	5	3	4
Gauze Pack-Out (Short)	4	6	6
Break			
Gauze Picking (Short)	7	3	6
Gauze Inspection (Short)	4	2	3
Gauze Cutting (Short)	5	3	4
Gauze Pack-Out (Short)	4	6	6
Lunch			
Incubator Assembly	3	4	4
Tube Assembly	3	1	3
Fixture Assembly	3	1	3
Pediatric Incubator Assembly	4	1	3
Break			
Incubator Assembly	3	4	4
Tube Assembly	3	1	3
Fixture Assembly	3	1	3
Pediatric Incubator Assembly	4	1	3

The averages of the Risk Indexes for each category for this example matrix are 4.13 for Group C, 2.63 for Group D, and 4.00 for the Overall Risk Index. When compared to the sample of the current job rotation system identified in Table 3, there is a reduction of exposure for Group C of 1.22 (22.8%), 0.96 (26.7%) for Group D, and 1.06 (20.9%) for the Overall Risk Index.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Implement Controls

It can be seen from the results that the frequency of most of the jobs are high. Of the 32 observed tasks, 87.5% of the Group A extremities and 56.25% of the Group B body parts experienced static posture (held longer than 1 minute) or highly repetitive posture (repeated more than 4 times/minute). Unfortunately, this is an element of the operations that little can be done to correct. The nature of the industry is production of mass quantities of smaller products. Therefore frequency is considered a work stressor that can never be completely eliminated. In order to minimize the occurrence of CTDs it is necessary to minimize the exposure to the other work stressors to offset the effects of the high frequency stressor.

Fortunately, the products are so small the forces necessary to manipulate the products are usually very low to minimal. However, there are several jobs that require use of scissors to cut, requiring considerable hand and finger forces. In addition, there are several operations that require the workers to assemble cases and other packing materials, which also require a fair amount of force to be used. The greatest impact to address the force factor would be to implement use of ergonomic scissors and to provide fixtures or "box makers" to assist in producing the packing materials. These engineering controls should provide sufficient aide in reducing the workers' exposure to the force stressors.

The greatest hazard exists in the workers' exposure to the awkward work postures. Engineering controls would serve the best solution, but they are not always feasible. Rearranging workstations and other similar control measures require substantial workstation design changes. Although they can be instituted as long-term solutions, they will require considerable time and effort to institute. In the interim, administrative controls are needed to reduce exposure. Improvements to the current job rotation system could provide those solutions.

6.2 Challenges to the New Job Rotation Matrix

There are several challenges that may be encountered when implementing the Job Rotation Matrix. There are operators who have existing medical conditions that may hinder their ability to adhere to the rotation schedule. To resolve that issue, medical screening should be performed to understand the operators' limitations and capacities. Then adjusting the designated risk zones should accommodate for the limitations the employee must observe.

Another problem arises when considering formulating a job rotation schedule for all employees. That is, all employees have to have job rotation schedules that will adhere to the guidelines set forth for the job rotation system. This can become quite complicated and time consuming. Supervisors may find it difficult to identify enough jobs to rotate between before having "left-over" jobs. Combining these jobs may work against the aim of the job rotation system. To rectify this problem, it may be necessary to devise an automated program that has the ability to formulate the job rotation schedules dependant upon factors entered as guidelines. The advantage of such a program is that updates to the guidelines for changes in the risk assessments or perceived risk zones could be easily integrated with minimal time and effort. Although expensive and time consuming at first, a well designed, automated job rotation system would pay for itself very quickly and benefits could be observed for many years.

APPENDIX A

RULA SCORING PROCEDURES

The following Steps and Tables describe the RULA (McAtamney and Corlett, 1993) method for determining the Risk Indexes for tasks/jobs with emphasis on the postural stresses. Please note that extension anatomical motions are represented with a negative sign and flexion anatomical motions are represented with a positive sign (no sign).

Step 1 – Determine the Postural scores for Group A extremities:

Body Part/Extremity	Body/Anatomical Motion or Posture	Score
Upper Arms:	*-20(extension) – 20 °*	1
	-20 °+(extension) *OR* *20 – 45 °*	2
	45 – 90 °	3
	90 °+	4
	Shoulder Raised	Add 1
	Upper Arm Abducted	Add 1
	Leaning or supporting weight of arm	Subtract 1
Lower Arms:	*60 – 100 °*	1
	0 – 60 ° *OR* *100 °+*	2
	Working across midline of body or out to side	Add 1
Wrist:	*0 °*	1
	-15(extension) – 15 °	2
	15 °+(extension or flexion)	3
	Bent away from midline	Add 1
Wrist Twist:	*Mainly in mid-range of twist*	1
	At or near end of twisting range	2

Step 2 – Determine the Postural scores for Group B extremities/body sections:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10°*	1
	10 – 20°	2
	20°+	3
	In Extension	4
	Twisting or rotation	Add 1
	Side-bending	Add 1
Trunk:	*0°*	1
	0 – 20°	2
	20 – 60°	3
	60°+	4
	Twisting or rotation at the waist	Add 1
	Side-bending	Add 1
Legs:	*Trunk well supported while seated* *OR* *Legs and feet well supported and in an evenly balanced posture*	1
	Not well supported	2

Step 3 – Determine the Frequency scores for Groups A and B:

Frequency of Motions	Score
Moderate posture, not static, not highly repetitive	0
Static posture, held longer than 1 minute OR Highly repetitive posture repeated more than 4 times/minute	1

Step 4 – Determine the Force scores for Groups A and B:

Forces Required/Load	Score
No resistance OR Less than 2 kg intermittent force or load	0
2-10 kg intermittent force or load	1
2-10 kg static load OR 2-10 kg repeated force or load	2
$\geq$ 10 kg static load OR $\geq$ 10 kg repeated force or load	3
Shock or forces with a rapid buildup	4

Step 5 – Using the Posture scores from Group A, determine Posture Index A:

		WRIST POSTURE SCORE							
		1		2		3		4	
		WRIST TWIST		WRIST TWIST		WRIST TWIST		WRIST TWIST	
UPPER ARM	LOWER ARM	1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Step 6 – Using the Posture scores from Group B, determine Posture Index B:

	TRUNK POSTURE SCORE											
	1		2		3		4		5		6	
	LEGS		LEGS		LEGS		LEGS		LEGS		LEGS	
NECK	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	8
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 7 – Add the Frequency and Force scores for Group A to Posture Index A to determine the Index Score C.

Step 8 – Add the Frequency and Force scores for Group B to Posture Index B to determine the Index Score D:

Step 9 – Determine the Overall Grand Score/Task Risk Index:

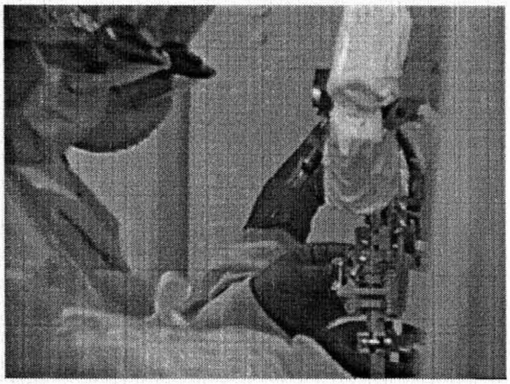
		INDEX SCORE D						
		1	2	3	4	5	6	7+
INDEX SCORE C	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8	5	5	6	7	7	7	7

APPENDIX B

CASE STUDY EXPERIMENTAL RULA DATA

The following pages contain data that was collected for the case study. The data represents the assessment of the tasks performed during the observation period. Although not all product lines were running, the observed jobs represent what the normal daily activities would be. Since it is demand driven, not all lines would run at once on any given day. The task names identified at the top of each page (over the pictures) are ambiguous names that were assigned based upon the type of product being manufactured and the activities performed. The names represent neither the specific brands manufactured nor the manufacturing facility. Pictures are included to aid in visualization of the jobs/tasks performed. The data was gathered and calculated using the RULA procedures described in Appendix A.

BURN CREAM JAR FILLING



Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100 °*	1
	Working out to side	-
Wrist:	*-15 – 15 °*	2
	Bent away from midline	+1
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	1	1	5

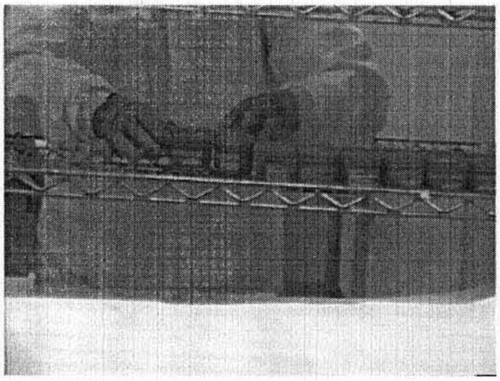
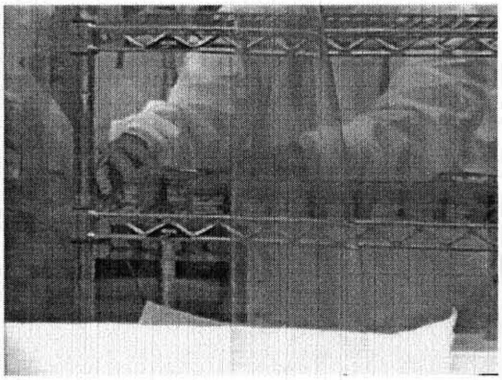
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*20 °+*	3
	Twisting	-
	Side-bending	-
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	1	0	4

GRAND SCORE / TASK RISK INDEX = 5

BURN CREAM RACK FILLING

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*0 – 60 °*	2
	Working out to side	-
Wrist:	*-15 – 15 °*	2
	Bent away from midline	+1
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	1	1	5

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20 °*	2
	Twisting	-
	Side-bending	-
Trunk:	*0 – 20 °*	2
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	1	0	3

GRAND SCORE / TASK RISK INDEX = 4

BURN CREAM PACKING

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100 °*	1
	Working out to side	+1
Wrist:	*-15 – 15 °*	2
	Bent away from midline	+1
Wrist Twist:	*At or near end of twisting range*	2

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	1	0	5

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*20 °+*	3
	Twisting	-
	Side-bending	-
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	1	0	4

GRAND SCORE / TASK RISK INDEX = 5

ROLL DRESSING UNPACKING

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*45 – 90°*	3
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working across midline of body	+1
Wrist:	*-15 – 15°*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	1	0	5

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10°*	1
	Twisting	-
	Side-bending	-
Trunk:	*20 – 60°*	3
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	1	0	4

GRAND SCORE / TASK RISK INDEX = 5

ROLL DRESSING TAB CUTTING


Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*45 – 90°*	3
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working out to side	-
Wrist:	*15°+*	3
	Bent away from midline	-
Wrist Twist:	*At or near end of twisting range*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	1	2	7

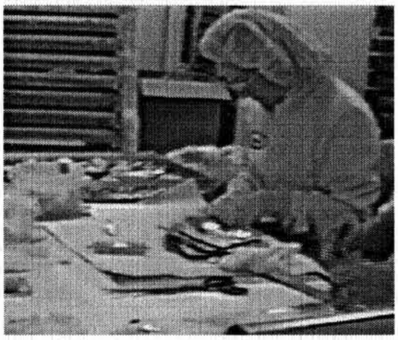
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20°*	2
	Twisting	-
	Side-bending	-
Trunk:	*0 – 20°*	2
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	1	0	3

GRAND SCORE / TASK RISK INDEX = 6

ROLL DRESSING TAB INSERTION

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*-20 – 20°*	1
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working out to side	-
Wrist:	*0°*	1
	Bent away from midline	+1
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
2	1	0	3

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*20°+*	3
	Twisting	-
	Side-bending	-
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	1	0	4

GRAND SCORE / TASK RISK INDEX = 4

ROLL DRESSING PACKAGING

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*45 – 90 °*	3
	Shoulder Raised	-
	Abducted	+1
	Leaning or supporting weight of arm	-
Lower Arms:	*100 °+*	2
	Working across midline of body	+1
Wrist:	*-15 – 15 °*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	1	0	5

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10 °*	1
	Twisting	-
	Side-bending	-
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
1	1	0	2

GRAND SCORE / TASK RISK INDEX = 4

GAUZE CUTTING (LONG)

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100 °*	1
	Working out to side	-
Wrist:	*0 °*	1
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
2	1	2	5

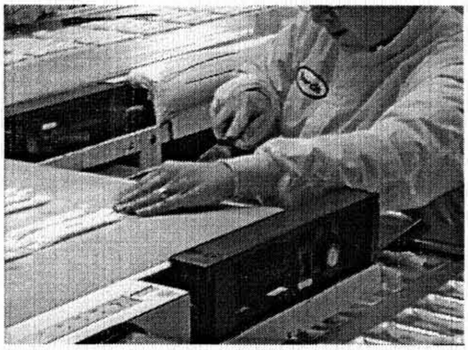
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10 °*	1
	Twisting	-
	Side-bending	-
Trunk:	*0 – 20 °*	2
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	1	0	3

GRAND SCORE / TASK RISK INDEX = 4

GAUZE SCOOPING (LONG)

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*45 – 90°*	3
	Shoulder Raised	+1
	Abducted	+1
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working across midline of body	+1
Wrist:	*15°+*	3
	Bent away from midline	+1
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
7	1	0	8

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10°*	1
	Twisting	-
	Side-bending	-
Trunk:	*0 – 20°*	2
	Twisting	-
	Side-bending	+1
Legs:	*Well supported while seated & standing*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	1	0	4

GRAND SCORE / TASK RISK INDEX = 7

GAUZE INSPECTION (LONG)

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45°*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working out to side	-
Wrist:	*15°+*	3
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	1	0	4

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10°*	1
	Twisting	-
	Side-bending	+1
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	0	0	2

GRAND SCORE / TASK RISK INDEX = 3

GAUZE SWEEPING (LONG)

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*45 – 90°*	3
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*100°+*	2
	Working out to side	+1
Wrist:	*0°*	1
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	1	0	5

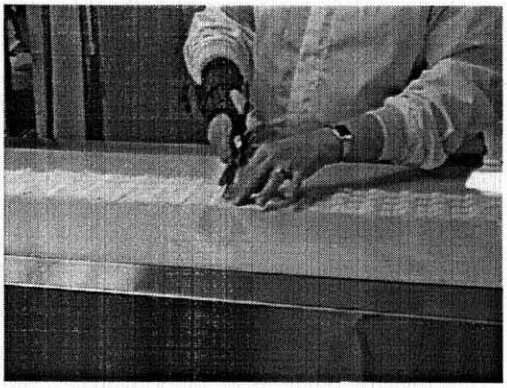
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10°*	1
	Twisting	-
	Side-bending	-
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
1	0	0	1

GRAND SCORE / TASK RISK INDEX = 4

GAUZE CUTTING (SHORT)

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45°*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working out to side	-
Wrist:	*0°*	1
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
2	1	2	5

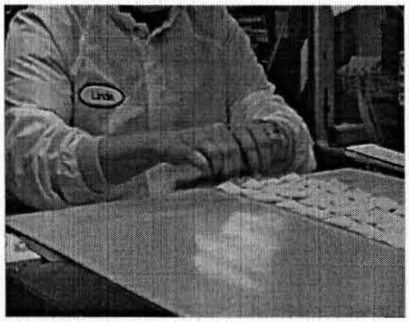
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10°*	1
	Twisting	-
	Side-bending	-
Trunk:	*0 – 20°*	2
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	1	0	3

GRAND SCORE / TASK RISK INDEX = 4

GAUZE PICKING (SHORT)


Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45°*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working across midline of body	+1
Wrist:	*15°+*	3
	Bent away from midline	+1
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	1	2	7

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20°*	2
	Twisting	-
	Side-bending	-
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Well supported while seated & standing*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	1	0	3

GRAND SCORE / TASK RISK INDEX = 6

GAUZE INSPECTION (SHORT)

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100 °*	1
	Working out to side	-
Wrist:	*15 °+*	3
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	1	0	4

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10 °*	1
	Twisting	-
	Side-bending	+1
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	0	0	2

GRAND SCORE / TASK RISK INDEX = 3

GAUZE SWEEPING (SHORT)

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*45 – 90°*	3
	Shoulder Raised	-
	Abducted	+1
	Leaning or supporting weight of arm	-
Lower Arms:	*0 – 60°*	2
	Working out to side	+1
Wrist:	*15°+*	3
	Bent away from midline	+1
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
6	1	0	7

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20°*	1
	Twisting	-
	Side-bending	-
Trunk:	*0°*	1
	Twisting	+1
	Side-bending	-
Legs:	*Well supported while seated & standing*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	1	0	3

GRAND SCORE / TASK RISK INDEX = 6

GAUZE PACK-OUT (SHORT)

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45°*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working out to side	+1
Wrist:	*-15 – 15°*	2
	Bent away from midline	+1
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	0	1	4

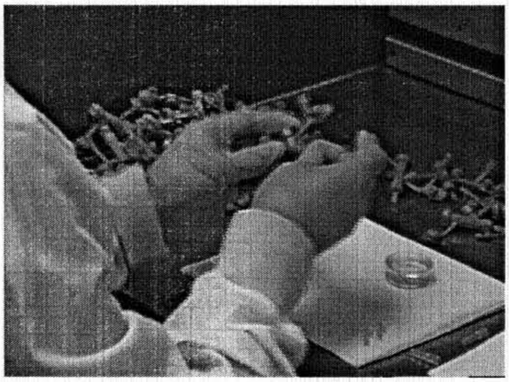
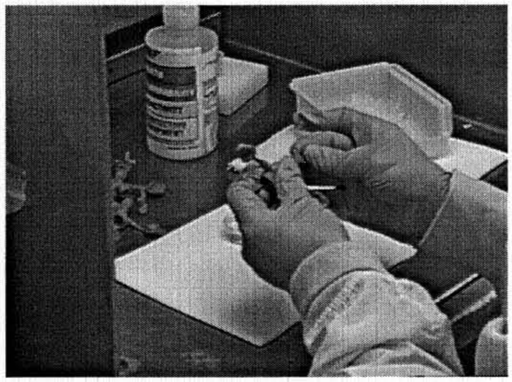
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*20°+*	3
	Twisting	-
	Side-bending	-
Trunk:	*20 – 60°*	3
	Twisting	+1
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
5	1	0	6

GRAND SCORE / TASK RISK INDEX = 6

INCUBATOR ASSEMBLY

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-1
Lower Arms:	*0 – 60 °*	2
	Working out to side	-
Wrist:	*0 °*	1
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
2	1	0	3

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*20 °+*	3
	Twisting	-
	Side-bending	-
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	1	0	4

GRAND SCORE / TASK RISK INDEX = 4

TUBE ASSEMBLY

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*-20 – 20 °*	1
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-1
Lower Arms:	*60 – 100 °*	1
	Working out to side	-
Wrist:	*0 °*	1
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
1	1	1	3

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10 °*	1
	Twisting	-
	Side-bending	-
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
1	0	0	1

GRAND SCORE / TASK RISK INDEX = 3

FIXTURE ASSEMBLY

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*-20 – 20°*	1
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-1
Lower Arms:	*60 – 100°*	1
	Working out to side	-
Wrist:	*-15 – 15°*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
2	1	0	3

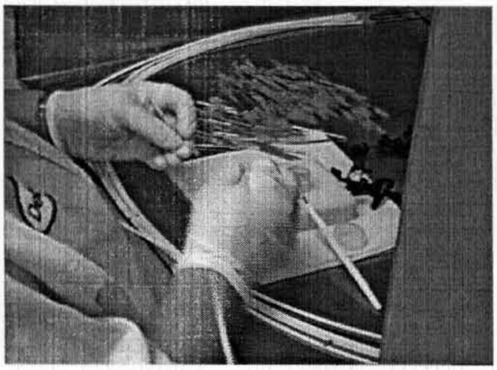
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10°*	1
	Twisting	-
	Side-bending	-
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
1	0	0	1

GRAND SCORE / TASK RISK INDEX = 3

PEDIATRIC INCUBATOR ASSEMBLY



Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	+1
	Leaning or supporting weight of arm	-1
Lower Arms:	*0 – 60 °*	2
	Working out to side	-
Wrist:	*0 °*	1
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	1	0	4

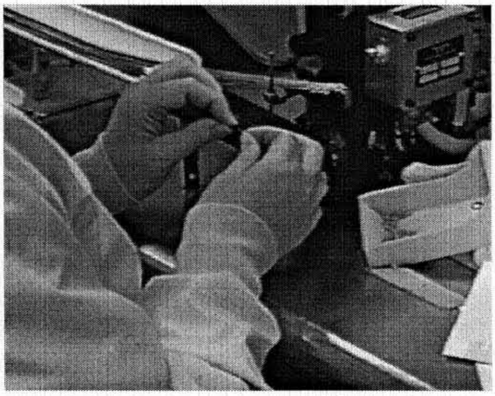
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10 °*	1
	Twisting	-
	Side-bending	-
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
1	0	0	1

GRAND SCORE / TASK RISK INDEX = 3

WELDING STYLET



Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*-20 – 20°*	1
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-1
Lower Arms:	*60 – 100°*	1
	Working out to side	-
Wrist:	*-15 – 15°*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
2	1	0	3

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*20°+*	3
	Twisting	-
	Side-bending	-
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	0	0	3

GRAND SCORE / TASK RISK INDEX = 3

STYLET INSERTION

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*45 – 90°*	3
	Shoulder Raised	-
	Abducted	+1
	Leaning or supporting weight of arm	-
Lower Arms:	*0 – 60°*	2
	Working out to side	+1
Wrist:	*0°*	1
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	1	0	5

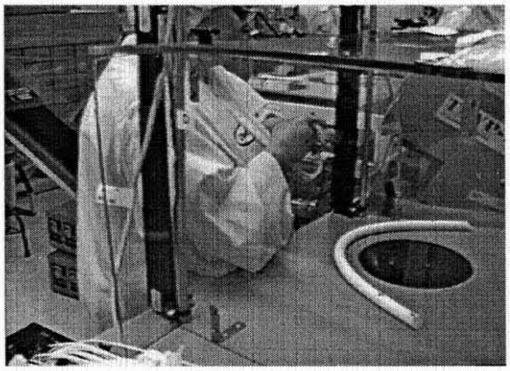
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20°*	2
	Twisting	-
	Side-bending	-
Trunk:	*0 – 20°*	2
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	0	0	2

GRAND SCORE / TASK RISK INDEX = 4

AUTOBAGGER



Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	+1
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100 °*	1
	Working out to side	-
Wrist:	*0 °*	1
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	0	0	3

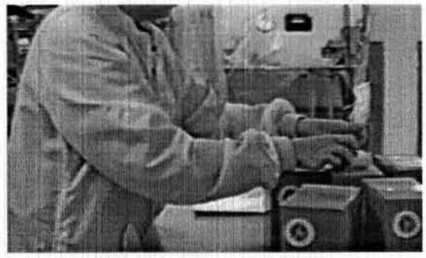
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10 °*	1
	Twisting	-
	Side-bending	-
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
1	1	0	2

GRAND SCORE / TASK RISK INDEX = 3

AUTOBAGGER LABELING AND PACKING

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*0 – 60 °*	2
	Working out to side	-
Wrist:	*-15 – 15 °*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	1	0	4

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20 °*	2
	Twisting	-
	Side-bending	-
Trunk:	*0 – 20 °*	2
	Twisting	+1
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
4	1	0	5

GRAND SCORE / TASK RISK INDEX = 5

ELASTIC WRAP ROLLING

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*-20 – 20°*	1
	Shoulder Raised	+1
	Abducted	+1
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working across midline of body	+1
Wrist:	*15°+*	3
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	0	1	5

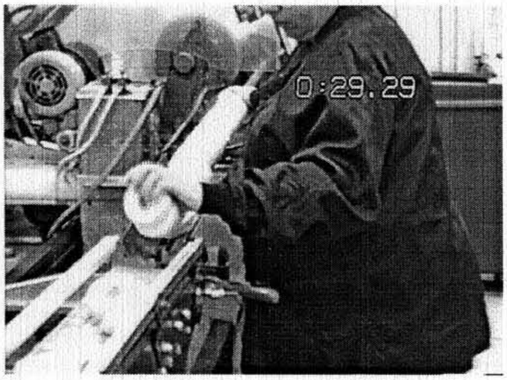
Postural Scores for Group B:

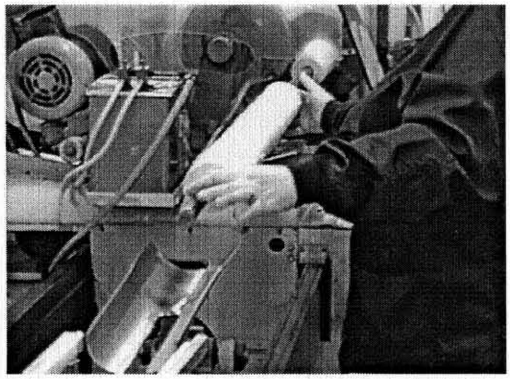
Body Part	Body/Anatomical Motion	Score
Neck:	*0 – 10°*	1
	Twisting	+1
	Side-bending	-
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	0	0	2

GRAND SCORE / TASK RISK INDEX = 4

ELASTIC WRAP CUTTING





Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45°*	2
	Shoulder Raised	-
	Abducted	+1
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working out to side	+1
Wrist:	*0°*	1
	Bent away from midline	+1
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	0	2	6

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20°*	2
	Twisting	-
	Side-bending	-
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	0	0	2

GRAND SCORE / TASK RISK INDEX = 4

ELASTIC WRAP PACKING

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45°*	2
	Shoulder Raised	-
	Abducted	+1
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100°*	1
	Working out to side	-
Wrist:	*15°+*	3
	Bent away from midline	+1
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
5	1	0	6

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20°*	2
	Twisting	-
	Side-bending	-
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	0	0	2

GRAND SCORE / TASK RISK INDEX = 4

BURN PAD BELT FEEDER

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45°*	2
	Shoulder Raised	-
	Abducted	+1
	Leaning or supporting weight of arm	-
Lower Arms:	*0 – 60°*	2
	Working out to side	-
Wrist:	*-15 – 15°*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	1	0	5

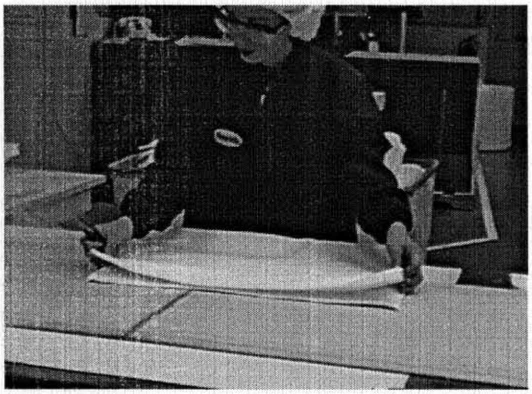
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20°*	2
	Twisting	-
	Side-bending	-
Trunk:	*0 – 20°*	2
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	1	0	3

GRAND SCORE / TASK RISK INDEX = 4

BURN PAD BELT OPERATOR

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100 °*	1
	Working across midline of body	+1
Wrist:	*-15 – 15 °*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	1	0	4

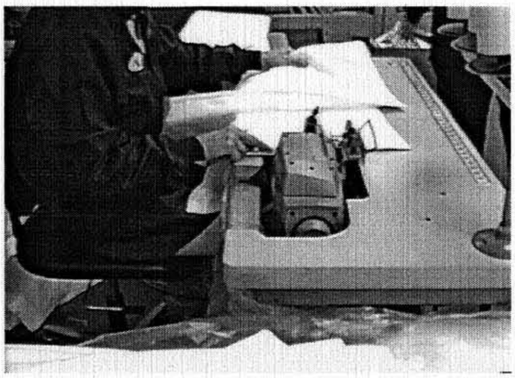
Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*20 °+*	3
	Twisting	-
	Side-bending	-
Trunk:	*0 – 20 °*	2
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	1	0	4

GRAND SCORE / TASK RISK INDEX = 4

BURN PAD SEWING



Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	+1
	Leaning or supporting weight of arm	-
Lower Arms:	*60 – 100 °*	1
	Working out to side	-
Wrist:	*-15 – 15 °*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
4	1	0	5

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*10 – 20 °*	2
	Twisting	-
	Side-bending	-
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Trunk well supported while seated*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
2	0	0	2

GRAND SCORE / TASK RISK INDEX = 4

BURN PAD PACKING

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*-20 – 20°*	1
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*0 – 60°*	2
	Working out to side	-
Wrist:	*-15 – 15°*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
2	1	0	3

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*20°+*	3
	Twisting	-
	Side-bending	-
Trunk:	*0°*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	0	0	3

GRAND SCORE / TASK RISK INDEX = 3

BURN PAD CASE PACKING

Postural Scores for Group A:

Body Part	Body/Anatomical Motion	Score
Upper Arms:	*20 – 45 °*	2
	Shoulder Raised	-
	Abducted	-
	Leaning or supporting weight of arm	-
Lower Arms:	*0 – 60 °*	2
	Working out to side	-
Wrist:	*-15 – 15 °*	2
	Bent away from midline	-
Wrist Twist:	*Mainly in mid-range of twist*	1

Group A Index Score	Frequency Score	Force Score	Total – Score C
3	1	0	4

Postural Scores for Group B:

Body Part	Body/Anatomical Motion	Score
Neck:	*20 °+*	3
	Twisting	-
	Side-bending	-
Trunk:	*0 °*	1
	Twisting	-
	Side-bending	-
Legs:	*Legs and feet in an evenly balanced posture*	1

Group B Index Score	Frequency Score	Force Score	Total – Score D
3	0	0	3

GRAND SCORE / TASK RISK INDEX = 3

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