Analysis of XYZ Company's Powder Transfer in the Processing Department

by

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ABSTRACT

Company XYZ is a Midwestern manufacturing company located in Wisconsin. The company is involved in the manufacture of variety of breakfast, lunch and dinner food items. Several jobs at company XYZ require manual labor and, as a result, employees have been injured and several other employees complain of aches and pains resulting from Musculoskeletal Disorders (MSDs). Due to a change in regulations, the weight that employees are required to lift will soon increase by 100%. There is a need to implement controls or to redesign the work stations in order to minimize the physical labor that is required to carry the functions of each job; doing so will reduce injuries stemming from MSDs.

The purpose of the study is to collect data regarding the new lifting process, analyze the task, and recommend a lifting method that meets the recognized ergonomic standard. The researcher used the following objectives to guide this study:

- Gather workplace data and other forms of human data to make ergonomic assumptions;
- Make recommendations based on analysis of gathered data;
- Use the cost benefit analysis to justify the recommended changes.

The results collected by the researcher showed clear indication that increase in the weight employees are required to lift could result in several injuries and cost the company a large sum of money. The researcher has concluded that there is a need to implement engineering controls which will decrease the injuries and as a result decrease the cost to the company. The researcher recommends the vacuum lift system described in chapter four because it eliminates the risk totally. This system will assist the company in eliminating the injuries and, as a result, decrease the cost to the company.

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Chapter I: Introduction

Background

Companies today are losing large sums of money due to occupational and non-occupational injuries which occur in the work place on a daily basis. A major portion of the financial lost can be directly attributed to Musculoskeletal Disorders (MSDs). MSDs occur in every industry and a majority of these injuries commonly affect office workers. According to the Bureau of Labor Statistics (2004), a total of 1.3 million injuries and illnesses in the private sector required recuperation which results in days away from work. Musculoskeletal injuries accounted for 402,700 or 32% of the injuries. Furthermore, losses of this nature can result in major financial burden to companies and many companies are implementing programs and becoming more proactive in workplace safety.

Injury and illnesses can occur at any time and even employees who take proactive steps when it comes to safety are themselves victims of occupational injuries. Some of the most common injuries which occur in the workplace today are MSDs. Of the most common MSDs, sprains and strains were two of the leading ergonomic injuries which took place in the workplace in 2004 (Bureau of Labor Statistics). Injuries of this nature often result from repetition, force, posture, duration and temperature extremes on jobs, improper lifting technique and failure to follow the National Institute of Occupational Safety and Health (NIOSH) lifting equation. Thirty-five percent of all occupational injuries resulted from shoulder and back injuries (Bureau of Labor Statistics, 2004). It was also reported by the Bureau of Labor Statistics that MSDs were the major injury faced by laborers and material movers.

Company XYZ is a Midwestern manufacturing company located in Wisconsin. The company is involved in the manufacture of variety of breakfast, lunch and dinner food items. Several jobs at company XYZ require manual labor and, as a result, employees have been injured and several other employees complain of aches and pains resulting from MSDs. There is a need to implement controls or to redesign the work stations in order to minimize the physical labor that is required to carry the functions of each job; doing so will reduce injuries stemming from MSDs.

Statement of the Problem

Over the past few years, XYZ Company has experienced multiple injuries of overexertion costing the company several thousands of dollars, as a result of manually handling 50 pound (lb) bags of sugar. Due to a change in the sugar regulations the 50 lb bags will become obsolete and will be replaced by 100 lb bags of sugar. This 100% increase in weight of the sugar bags has a potential to increase the significance of this loss source.

Purpose of the Study

The purpose of the study is to collect data regarding the new lifting process, analyze the task and recommend a lifting method that meets the recognized ergonomic standard.

Research Objectives

The objectives of this study are to:

- Gather workplace data and other forms of human data to make ergonomic assumptions;
- Make recommendations based on analysis of gathered data;

- Use the cost benefit analysis to justify the recommended changes.

Significance of the Study

Companies today are implementing ergonomic programs to reduce the rate of MSDs on the job. However, the rate of injury and the percentage of illnesses and injuries that is related to MSDs are very high. According to the Bureau of Labor Statistics (2004) a total of 1.3 million injuries and illnesses in the private sector required recuperation which results in days away from work, and musculoskeletal injuries accounted for 402,700 or 32% of the injuries. Companies are paying large sums of money in workers' compensation as a result of these injuries and there is a need to prevent such injuries and illnesses or discover them before they become serious. Four out of ten injuries and illnesses resulted from overexertion or fall from the same level (Bureau of Labor Statistics). Employers need to take into consideration the job's tasks and implement procedures that will allow employees to work safely and free from occupational injuries.

Proactive measures need to be implemented to prevent injuries and illnesses and Company XYZ is trying to implement new ways in which workplace injuries can be reduced. The company needs to use methods such as the NIOSH Lifting Equation to determine the correct weight that is safe for the employee or employees performing the job to lift. Implementation of proactive measures will assist the company in reducing the number of injuries that occurs and as a result reduce the financial impact to company XYZ. Administrative and engineering controls that will be recommended will enable the employer to save money and provide a safe working environment. The employees will benefit from a working environment that is free of hazards and employees will feel more comfortable performing their job tasks.

Limitations of the Study

- The organization does not have enough safety staff on hand to evaluate the systems on a regular basis.
- The time limit did not allow a longitudinal evaluation of the job tasks.
- Training should be performed on a regular basis.
- Management is reluctant to invest the time needed to evaluate the system.
- Other engineering controls may exist that could also be used to reduce injuries.

Assumptions

- All the data collected on the job tasks were accurate.
- Data collected was not tampered with in order to validate the study.
- Assumptions were made about how the 100 lb bags would be handled

Definition of Terms

Musculoskeletal disorder (MSD). An injury or disorder of the muscles, nerves, tendons, joints, cartilage, or spinal discs (Bureau of Labor Statistics, 2004).

Overexertion. The excessive use of a muscle or body system (Parker & Harold, 1992)

Occupational injuries. Injury occurring in the course of employment and caused inherent or related hazards (Tayyari & Smith, 1997).

Sprains. A ligament is sprained when it is stretched so far that some of its fibers are torn (Tayyari & Smith, 1997).

Strains. A muscle, ligament, or tendon insertion is strained when it is pulled or pushed to its extreme by forcing the joint beyond its normal range. It can result from lifting object or holding against an external force (Tayyari & Smith, 1997).

Days away from work. Employee absence from work due to injury or illness (Douglas, 2000).

Chapter II: Literature Review

Over the past few years as a result of manually handling 50 lb bags of sugar, XYZ Company has experienced multiple injuries of overexertion costing the company several thousands of dollars. Due to a change in the sugar regulations, the 50 lb bags will become obsolete and will be replaced by 100 lb bags of sugar. This 100% increase in weight of the sugar bags has a potential to increase the significance of this loss source.

Introduction

The purpose of this study is to evaluate the ergonomic impact the increase in the weight of the bags of sugar will have on injuries to employees, to recommend controls, and provide a cost benefit analysis to management. With the information collected in this study, management will be able to analyze and accept the risk, implement engineering and administrative controls and justify the cost that resulted from the changes. This chapter will provide background information on several types of MSDs and causes of back injuries, micro and macro economics regarding the cost of MSDs, and several methods used to determine the correct weight a worker should be allowed to lift.

Background on Musculoskeletal Disorders

MSDs, also known as cumulative trauma disorders (CTDs), occur in all occupations and industries (Tayyari & Smith, 1997). Injuries of this nature occur gradually over a period of time from over exertion to several other contributing factors. These injuries affect the back and lower and upper extremities. Injuries of this nature also occur both while sitting and standing, which is a result of the spinal motion segments, particularly in the lumbar motion segments which are susceptible to extreme postures (Bridger, 1995). The risk of injury in the muscle-joint systems is greatest when they are in extreme postures and least when around the midpoint of the range of motion. The most common symptoms of MSDs are soreness, pain, discomfort, limited range of motion, stiffness in joints, numbness, a tingling sensation, popping and cracking noise in the joints, burning sensations, redness and swelling, and weakness and clumsiness (Macleod, 1995).

MSDs injuries are the most common injuries associated with material handling task. Workers that are involved in overexertion and repetition on jobs most times suffer from this disease. There are several types of MSDs injuries which occur in manual material handling jobs. Several types of MSDs will be discussed below.

Types of Musculoskeletal Disorders

Tendonitis. This is an inflammation of the tendon which may be caused by rheumatoid arthritis, or it may be secondary to physical injury (Tayyari & Smith, 1997). Injury of this nature can result from direct blows to the tendons, strains from over stretching, or trauma from overuse due to repeated movement over a period of time. The symptoms of tendonitis are pain, burning sensation, dull ache over an affected area, swelling and reduced motion in the affected joint.

Tenosynovitis. This is a general term for a repetitive induced tendon injury involving the synovial sheath (Putz-Anderson, 1988). Excessive amount of synovial fluid is produced as a result of extreme repetition and this result in swelling and pain in the affected area. Any work which requires repetition that exceeds 1500 to 2000 per hour is known to produce identifiable symptoms of tendon sheath irritation.

Ganglionic cyst. Another name for a ganglionic cyst is a ganglion. This is a tendon disorder which resembles a hernia-like projection near the affected joint (Tayyari

& Smith, 1997). The injury is found either at the wrist or adjacent to other bony articulations of the finger and usually manifests itself as swollen nodes. Ganglionic cysts may be painless, but the affected joint may be painful and weak, and there is a tendency for the cyst to rupture and disappear. According to Putz-Anderson (1988), ganglionic cysts are also called bible bumps because in the past a bible was used to pound the ruptured ganglion. Now the ganglion can be surgically treated due to advance medicine.

Thoracic Outlet Syndrome. Thoracic outlet syndrome is a general term for the compression of the nerves and blood vessels between the neck and the shoulder (Putz-Anderson, 1998). Other names such as neurovascular compression syndrome, brachial plexus neuritis costoclavicular syndrome, hyperabduction syndrome, and cervicobrachial disorder are used depending on the exact location of the condition. The major symptoms are due to compression of nerves vessels between the neck and the shoulder, which results in numbness and weakened joints.

Carpal tunnel syndrome. This is the most common nerve entrapment of the upper extremity and can result from anything which reduces the cross sectional area of the tunnel or anything which causes the contents of the tunnel to swell (Parker & Imbus 1992). There are several different diseases which can cause carpal tunnel syndrome and in a significant amount of cases of this disease, the cause is unknown. Symptoms of carpal tunnel syndrome are pain, numbness, and tingling in the hands and these sensations are usually felt in the areas of the skin connected to the median nerve (Putz-Anderson, 1998). Carpal tunnel syndrome is also associated with several diseases that are not work related. Some of the diseases are diabetes, rheumatoid arthritis, pregnancy, trauma, hyperthyroidism, previous fractures, hunter's syndrome, and scheie's syndrome (Parker & Imbus, 1992).

Epicondylitis. The most common form of this disease is lateral epicondylitis which is known as tennis elbow (Parker & Imbus, 1992). This injury is a result of repetition and forceful twisting motions which can occur due to frequent lifting or rotary motions of the wrist. This injury is oftentimes associated with athletes, but a vast number of people who suffer with epicondylitis have never played golf or tennis (Putz-Anderson, 1998).

Bursitis. Bursae are small connective tissue sacs lined with synovial membrane that contain fluid similar to the synovial fluid (Tayyari & Smith, 1997). Bursitis is the inflammation of the bursae which are located where pressure is exerted.

Back Injuries

The normal position of the spine forms a double S-shape when the back is in natural position with none of its curvatures exaggerated or flattened (Tayyari & Smith, 1997). Movement involving sudden jerking, twisting, and lifting away from the body results in abnormal positioning for the spine and can result in injury to the back. Injuries are often times results from a single accident of improper lifting, twisting or bending, however, injuries may accumulate over time and result in injury to the back (Macleod, 1995). According to Tayyari & Smith, back injuries are a result of several different problems including the following:

- Chronic lumbar strain
- Herniated intervertebral disk by sudden or jerky movement, extreme twisting, and/or strong push or pull

- Compression fracture of vertebrae
- Muscle spasm
- Kyphosis - backward curvature of the thoracic spine (humpback appearance)
- Hyperlordosis - excessive curvature of a forward curve in the lumbar spines
- Scoliosis - abnormal curvature of the spine, usually in the lateral direction

Causes of Back Injuries

The common causes of back injuries include the following (Tayyari & Smith, 1997).

- Overexertion in manual material handling, e.g., lifting, lowering, pulling, pushing, and carrying activities
- Reaching above shoulders, especially when lifting an object
- Awkward workstation design, e.g., work is too high or too low, work is far from the body and the back is unsupported
- Poor postures in sitting and standing
- Accidents including falling, slipping and tripping
- Large abdomen with weak muscles
- Poor lifting techniques such as:
    - Extreme twisting instead of pivoting
    - Lifting object too far away from the body
    - Lifting with the back flex
    - Using weak back muscles instead of the leg muscles.

Cost of Musculoskeletal Disorders at Company XYZ

Company XYZ is a manufacturing industry and over the years MSDs have cost the company several thousands of dollars in workers' compensation payments. The cost of worker's compensation has escalated and the company attributes some of their major losses to their processing department. This job requires manual labor and several employees have been injured. A Company XYZ loss prevention specialist reported that the cost of employee injuries for the processing department for the last quarter of 2005 was approximately $40,000. Injuries that occurred were low back sprains and strains, shoulder sprains and strains, and herniated disks.

The cost of these injuries ranged from a low back strain costing $1000 to a herniated disk costing $30,000. This is a major problem for the company and a solution is needed immediately in order to reduce their workers' compensation costs.

Cost of Musculoskeletal Disorders for the Entire United States

According to Joel Cooper (1999), MSDs cost the United States 215 million dollars per year. One third of all work related injuries are MSD related (J.J. Keller, 2006). Back strains were the highest MSD and accounted for 3.6 million injuries. It was also reported that 153 million days a year were lost by injuries resulting from MSDs and 28 million people are affected by MSDs each year.

NIOSH Lifting Equation

The National Institute of Occupational Safety and Health (NIOSH) developed a Work Practice Guide in 1981 regarding safe lifting practices for manual material handling. The Work Practice Guide was updated in 1994 and changes have been made to the NIOSH Lifting Equation. This equation can assist health and safety professionals to determine an empirical weight limit for manual material lifting/lowering (NexGen Ergonomics, 2002).

The NIOSH Lifting Equation was developed to provide companies with a mathematical formula which would enable them to mathematically calculate the recommended weight limit (RWL) for manual material lifting/lowering (NIOSH, 1998). Use of this formula will allow companies to become more proactive and prevent MSDs in the workplace. The RWL is calculated using the following equation RWL = (LC x HM x VM x DM x AM x FM x CM), the formula starts with a constant load of 51 lbs and takes into account characteristics of the load and the lifting conditions such as horizontal multiplier (HM), vertical multiplier (VM), distance multiplier (DM), asymmetry multiplier (AM), frequency multiplier (FM), coupling multiplier (CM), and the length of time during which the lifting takes place.

The HM measurement should be taken when the load is at its greatest distance from the midpoint of the worker's ankles (J.J. Keller, 2006). This measurement can be taken at the start or end of the lifting or lowering of the material and is calculated in inches. The VM is the vertical distance of the hands from the floor, and it is measured at the origin or destination of the lift. The VM is calculated in inches. The DM is the vertical distance traveled between the origin and the destination of the lift and is calculated in inches. The AM is the most significant angle of rotation that occurs from either the beginning of the lift to the sagital line or the end of the sagital line. The one which is the greatest is used. The measurement is taken between the midpoint of the hands to the midpoint of the ankles and is calculated in inches. The FM and CM values are determined in Appendix A, B, C and D.

Limitations of the NIOSH Lifting Equation

There are several limitations that should be taken into consideration when using the NIOSH Lifting Equation. According to J.J. Keller (2006) the NIOSH Lifting Equation has the following limitations:

- Lifting /lowering with one hand
- Lifting /lowering for over eight hours
- Lifting /lowering while seated or kneeling
- Lifting /lowering in a restricted work space
- Lifting/lowering unstable objects
- Lifting/lowering while carrying, pushing or pulling
- Lifting/lowering with wheelbarrows or shovels
- Lifting/lowering with high speed motion (faster than about 30 inches/second)
- Lifting/lowering with unreasonable foot/floor coupling (less than 0.4 seconds coefficient of friction between the sole and the floor)

Companies should not entirely depend on the NIOSH Lifting Equation because it does not cover all possible job situations. There are several other ergonomic assessment tools that are available that can be used along with the NIOSH Lifting Equation.

Cost Benefit Analysis

A cost benefit analysis is a method used by companies to justify money spent to improve the company's systems, and the benefit that the company will gain. According to Wikipedia (2006), a cost benefit analysis is the process of weighing the total cost versus the total expected benefits of one or more actions in order to choose the best or most profitable option. This allows departmental managers to provide justification to upper management regarding the benefit that the company will obtain from the initial investment. Cost benefit analysis has both advantages and disadvantages to a company; however, the advantages outweigh the disadvantages. Departmental managers are able to use concrete figures which allow upper management to have a visual picture of the benefits that the company will be reaping in the future; however, at times it may be much more difficult to show upper management that employees are satisfied with the changes that were made.

Cost benefit analysis provides management with a payback period, in other words it is the time it takes to repay the cost for the changes which was implemented (Mindtools, 2006). Payback period can be calculated by dividing the total cost incurred in implementing the new system by the total benefits which was gained from the system that was implemented.

Ergonomic Instrumentation

Video Recorder. A video recorder is a tool used to capture the movement of the workers while they carry out their daily routine. The video recorder will assist the researcher in capturing body postures and cycle rates that would not be normally noticed. This instrument will allow the researcher to record from different angles and different views. The worker can be evaluated from the front, back, side and top, and this information will assist the researcher in the task evaluation and making recommendations. The video recorder is normally used with the goniometer to identify various angles which the body is placed in while performing a task.

Recommendations and Controls

There are many types of controls or recommendations that will be made at the end of this research. After analyzing the data, the researcher will decide which controls would be most effective and appropriate for the problem that was researched. The researcher will also take the company's financial situation into consideration. The following controls will be discussed and the most effective and appropriate controls will be recommended to assist in reducing the hazard and eventually reducing injuries to workers.

- Engineering
- Personal protective equipment (PPE)
- Administrative
- Safe work practices

Engineering Control

Engineering control is the most effective way of preventing injuries in the workplace and should be the first step taken to prevent injuries for workers if the control can be implemented. Manual material handling injuries can be prevented by implementing automated processes that will reduce the weight of the object being lifted or lowered. However, engineering controls can be expensive especially to smaller companies and other controls are often times used. These controls most times are temporary solutions and should be changed in order to eliminate the risk of injury. According to J.J. Keller (2006) the following engineering controls can be used to reduce injury:

- Reducing the size or weight of the object lifted
- Adjusting the height of a pallet or shelf

- Following proper lifting techniques when lifting objects below the knee and above the shoulders
- Installation of mechanical aids such as pneumatic lifts, convey and automated materials handling equipment will reduce injuries

Administrative Control

According to NIOSH (as cited in J. J. Keller, 2006), administrative control is defined as changes in the work schedule or operations that reduce exposure. Employees can use this control to protect their workers from injuries. Job rotation is a very effective tool used by employers to combat injuries. Rotation of employees from one job to another will prevent the stress or repetition in a single body part, and will prevent overexertion of a particular body part.

Administrative control is most effective when used along with another control. There is a lot time and energy spent to implement this control and the end product can be very costly. Training of employees decreases production time, and managers and supervisors spend more time overseeing employees and this reduces their productivity. According to J.J. Keller (2006), the following administrative controls can be used to reduce injuries:

- Strength testing workers before they are hired
- Training employees to utilize techniques that place minimum stress on the back
- Physical conditioning or stretching programs to reduce muscle sprains
- Using two person lift teams when mechanical lifts are not available
- Having workers take regular breaks to minimize muscle fatigue

Personal Protective Equipment (PPE)

According to J.J. Keller (2006), the purpose of PPE is to shield or isolate individuals from chemical, physical, and biologic hazards that may be encountered while on the job. OSHA (2006) general requirements 1910.132 states the following

> protective equipment, including PPE for eyes, face, head, and extremities, protective clothing, respiratory devices, and protective shields and barriers, shall be provided, used, and maintained in a sanitary and reliable condition wherever it is necessary by reason of hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact.

All of this equipment is used in industries at some point and it is the duty of management to provide PPE for their employees. As mentioned by OSHA, there many types of PPE. Their use depends on the type of job that an employee is performing. Employees in the manufacturing industry often wear goggles which reduces the risk of an eye injury. Employees performing manual lifting jobs often times wear a back belt to support their lower back; this does not prevent the injury, but it reduces the risk or the severity of the injury.

PPE is used in many industries as a temporary solution for problems which companies are facing. However, the use of PPE does not eliminate the risk of injury. PPE can reduce the injury to a worker if used according to directions that are provided. PPE should also be used with administrative control. Employees should be trained on the proper use of PPE and they should be worn at all times. Employees should be reprimanded if they are caught not wearing their PPE and, if this trend continues, harsh punishment should be given to the employee.

Chapter III: Methodology

Introduction

The purpose of the study is to collect data regarding the new lifting process, analyze the task, and recommend a lifting method that meets the recognized ergonomic standard. This chapter includes a description of the methodologies and instrument used to collect data for this research. The methodologies and instrument chosen to collect data resulted from in depth research and best practices followed from companies which have done similar work.

Data Collection

Data will be collected using the following methods for this study:

- Developing a floor plan of company XYZ processing department,
- Describing the current population in the processing department,
- Describing the design of the pallets which the bags of sugar are loaded onto, and
- Describing the design of the sugar bags.

The researcher will also make design recommendations for handling of the 100 lb bags of sugar and provide cost/benefit analyses to show the benefit which can be gained from implementing one of the design recommendations.

Floor Plan

The researcher will collect specific information from the processing department regarding the floor plan. Information collected will include measurement of the entire process department and any restrictions which may impede the workers while performing their routine task.

Current Population

The researcher will collect data regarding the number of employees in the processing department, the gender of the employee, and the height and weight of each employee.

Pallets Design and Bags of Sugar Specification

Data will be collected on the design of the pallets and the bags of sugar specification.

Cost Benefit Analysis

A cost benefit analysis is a method used by companies to justify money spent to improve the company's systems, and the benefit that the company will gain. According to Wikipedia (2006), a cost benefit analysis is the process of weighing the total cost versus the total expected benefits of one or more actions in order to choose the best or most profitable option. The cost benefit analysis will be used by the researcher to show management the benefits that can the gained from implementing a new system for the 100 lb bags of sugar. The cost benefit analysis will also provide management with payback period which can be calculated dividing the total cost incurred in implementing the new system by the total benefits gained from the system that was implemented.

Design Ideas

Several sources will be used by the researcher to find appropriate and cost effective designs for the processing department at company XYZ. The researcher will collect data on different designs of lifts. Data will be collected from the internet, catalogs and also from vendors that manufacture the lifts.

Data Analysis

The data collected will be used to make acceptable recommendations for the material handling task at company XYZ. The size of the processing department will be taken into consideration and the type of lift that would be suitable both for the room and for the task at hand. The number of employees will also be taken into consideration. The lift will be designed in order to compliment the employee. The lift will be adjustable and designed in a way that it can easily be maneuvered by both males and females regardless of height or weight. Data collected on the bags of sugar and the pallets will also be taken into consideration when designing the lift.

Chapter IV: Results

Introduction

The purpose of the study is to collect data regarding the new lifting process, analyze the task, and recommend a lifting method that meets the recognized ergonomic standard. Data was collected according to the methodologies outlined in Chapter 3, including work cell floor plan, worker data, pallet design, specification of bags, ergonomic control design ideas, and a cost benefit analyses. The task that was analyzed involved the lifting of 50 lb bags which will be increased to 100 lbs in a few months.

Analysis of Proposed Lifting Task

As stated previously, the task of lifting 100 lb bags of sugar is likely to cause an increase in MSD at company XYZ. According to the NIOSH lifting equation (1998), the maximum weight that should be lifted by any worker is 51 lbs and this lift should only take place under ideal conditions. The task at company XYZ will require one worker to lift 100 lb bags in the near future. This task will increase the number of reported MSDs to the workers and results in high workers' compensation cost to the company. There is a need to implement ergonomic controls to eliminate the injuries and cost to the company.

Demographic Information

There are currently 3 employees working in the processing department at Company XYZ, one employee during each eight-hour shift. There are currently 3 three shifts per day, 6 days per week. There are two males and one female on staff in this department. The height and weight of the employees is listed in Table 1.

Table 1

Height and Weight of the Processing Department Employees

	Height (ft)	Weight (lb)
Employee 1 (male)	6'	180
Employee 2 (male)	5'7"	150
Employee 3 (female)	5'2"	115

Floor Plan

Data was collected on the work area floor plan (see Figure 1). This data is important in order to select the best control and provide ergonomic controls that would accommodate each worker.

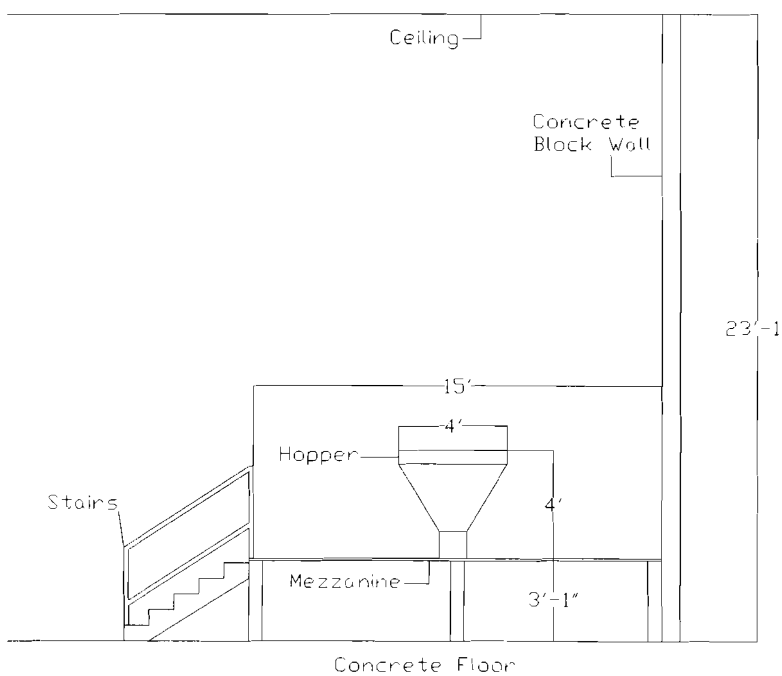

Figure 1. Work Area of Processing Department at Company XYZ

Pallet and Bag Dimensions

The researcher collected data on the size, weight and shape of the pallets (Figure 2) and bags of sugar (Figure 3). This information was used to make recommendations on the most suitable engineering control for the job.

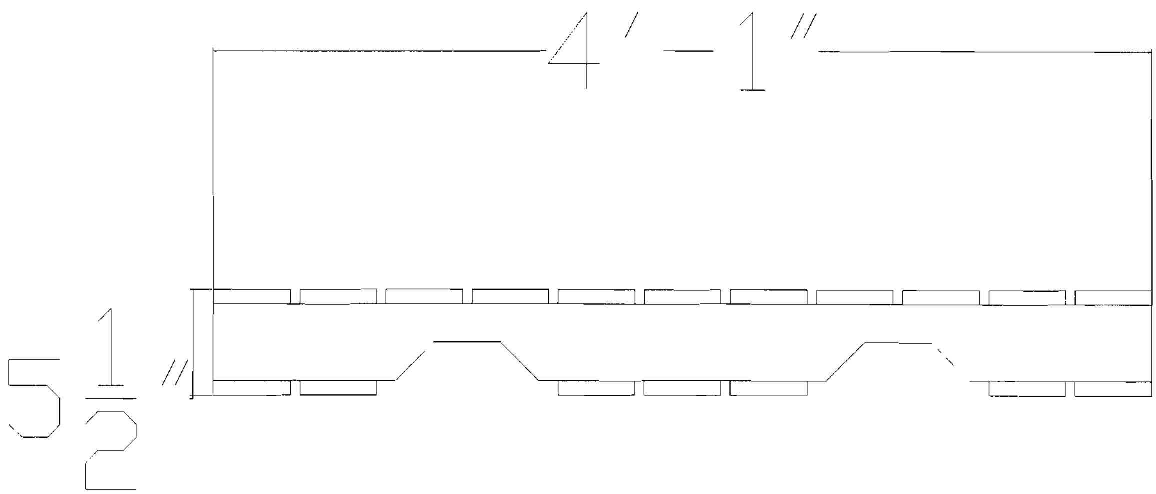

Figure 2. Dimension of Pallet

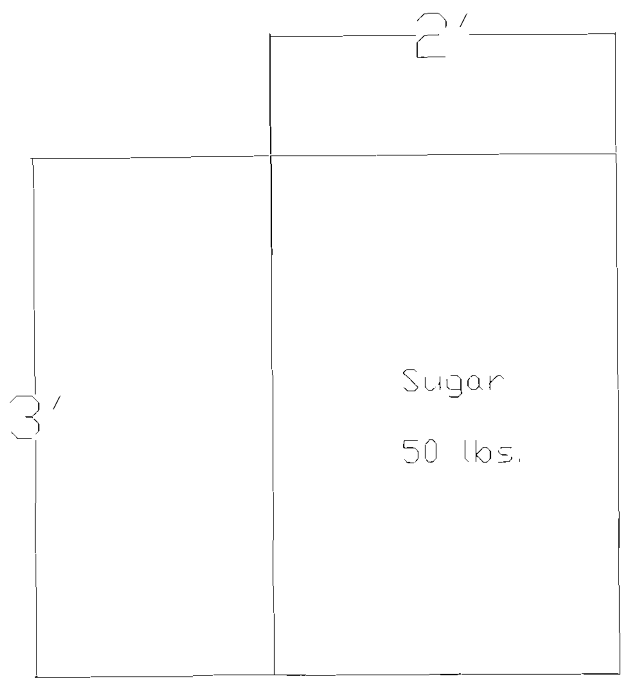

Figure 3. Dimension of Sugar Bags

Design Ideas

There are several designs considered for the lifting task at company XYZ. According to Anver (2006) and Lift Products Inc. (n. d. a; n. d. b) the following designs can be used to eliminate ergonomic hazards for a manual lifting task. The designs include a vacuum tube lifting system, a Maxx-Mini portable lift table (MMLE -100), and a Roto-Max lift table. The lifts vary in price and each lift operates in a different manner. The task at company XYZ can be performed by any of the lifts that were identified.

Vacuum Tube Lifting System

Functions include the following:

- Vacuum tube lifter with bag and sack lifting attachment
- High-flow vacuum generator with heavy duty muffler
- 25 feet of heavy duty vacuum connection

- Quick-disconnects for pad attachments
- Lifts 120 lbs (Anver, 2006)

Figure 4. Vacuum Tube Lifting System

Source: Anver, 2006,

http://www.anver.com/document/vacuum%20tube%20lifters/vt160-4_0-d5-bh90-p-c5.htm

The vacuum lift system would provide company XYZ with an efficient engineering control that will reduce the injuries in the processing department. Manual lifting of the bags of sugar and pouring them into the hopper will be eliminated. The vacuum lift will replace the manual lifting of the bags. The employee would be responsible for operating the equipment. The employee would guide the vacuum lift onto the bag and by simply pressing of button the bag will attach to the lift. The employee would guide the lift over to the hopper. This process would be less tedious for the worker and would reduce injuries.

The lift is also very easy to operate and employees can work at a steady pace which will not interfere with production. The lift also provides a handle which makes it easier to maneuver and the height of the employee is not an issue. The vacuum system also provides 25 feet of heavy duty vacuum connection hose.

However, the vacuum lift may be more expensive when compared to other controls that can also be implemented. Management may not want to implement such a system because of less expensive systems and maintenance cost.

Maxx-Mini Portable Lift Table (MMLE -100)

The Maxx-Mini lift provides a practical and economical portable lift table for manual material handling and is designed to reduce injuries to employees and enables the employees to carry out their jobs effectively and efficiently (Lift Products Inc., n. d. a).

Features include the following:

- Upper lift limit bypass
- Poly wheels and casters
- Brakes on swivel casters

- Dependable hydraulic system
- Lifts 2,200 lbs

Figure 5. Maxx-Mini Portable Lift Table

Source: Lift Products Inc., n. d. a,

http://www.liftproducts.com/LiftTables/Mobile/Max_Mini_Lift.html

The Maxx-Mini lift table is very cost effective and can lift 2,200 lbs, enabling 22 bags to be placed on the table. This lift table is also adjustable which would make it suitable for each employee. The table can be adjusted after each lift which will prevent the worker from bending. This lift could also be used in other areas for lifting and lowering of material.

However, it takes 15 seconds for the lift to take place and 6 seconds to lower it. The production process may be slowed because of the time it takes for lifting and lowering. Vertically lifting of the bags is required and injuries can occur. There is also the need for a forklift to assist the lifting of the pallet on the lift table.

Roto-Max Lift Table

Features include the following:

- Model: RTMX-30
- Capacity: 3,000 lbs
- Base: 30 by 45 inches
- Lowered height: 6.5 feet
- Turn diameter: 43 inches
- Raised height: 32.5 inches
- Lift Speed: 14 seconds
- Push button control
- Adjustable to individual operator
- 360 degree rotation

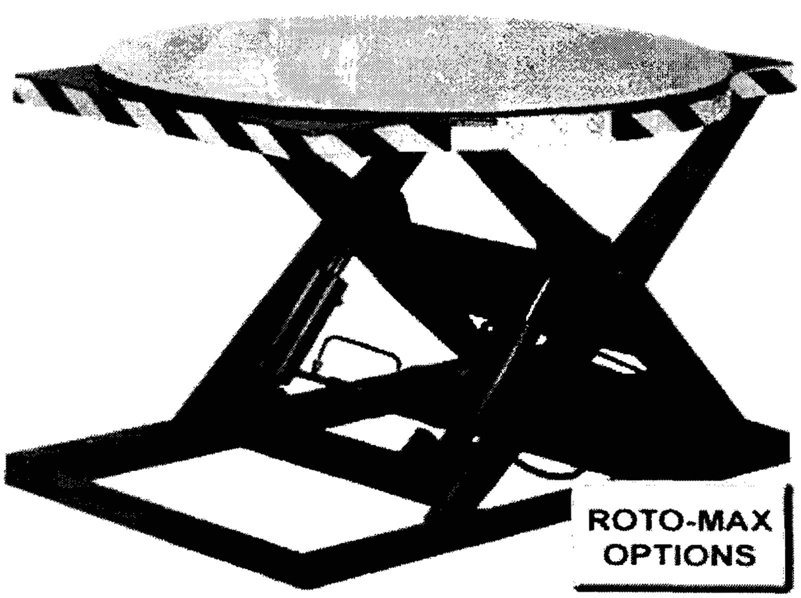

Figure 6. Roto-Max Lift Table

Source: Lift Products Inc., n. d. b,

http://www.liftproducts.com/LiftTables/Rotating/Roto_Max.html

The Roto-Max lift table will provide company XYZ with a third option which can be used to automate the manual lifting job in the processing department. The Roto-Max is cost effective and provides several features which would be suitable for the task. The top of the table rotates which allows the worker easy accessibility to each bag. The capacity of the table is 3,000 lbs and this will allow at least 30 bags to be placed on the table. The table can also be lowered or raised to complement each worker and it is operated by a push button system which makes it easy to operate. The diameter of the table is 43 inches. This will enable 4 bags to be placed at each level. However, the table takes about 14 seconds for lifting and lowering and this may cause the worker to move at a slower rate. This table does not eliminate the risk totally. Vertical lifting of the bags is required and injuries can occur. There is also the need for a forklift to assist the lifting of the pallet on the lift table. Workers may not follow the correct procedure and wait for the table to rotate. This can result in injuries resulting from the workers having to stretch.

Cost Benefit Analysis

A cost benefit analysis for each type of control presented is provided in Tables 3, 4 and 5 for each of the lifting systems outlined above. The cost for the various controls was obtained from Lift Products Inc., (n. d. a; n. d. b).

The benefit for each system was calculated from workers' compensation costs from injuries at company XYZ. According to the records obtained, Company XYZ incurred over $40,000 in workers' compensation costs occurred in 2005. The vacuum lift system will totally reduce the injuries in the processing department at company XYZ. However, the Roto-Max lift and the Maxx-Mini lift tables will not totally reduce the injuries to the workers. Both lift tables requires the worker to perform a vertical lift which reduces the strain placed on the employee but does not eliminate the risk of injury. The author estimates that both lift tables will reduce the injuries by 50%.

Table 2: Cost Benefit Analysis for the Vacuum Tube Lifting System

Cost:

- Vacuum Tube Lifting System @ $12,000
- Crane system @ $3,000
- Installation cost @ $1,000

Other Cost:

- Training: 3 workers @ $15 per hour for 2 hours each

Total Cost: $16,090

Benefit:

- Reduction in injuries/worker's compensation cost @ $27,000/year

Payback Time = $16,090 / $27,000 = 0.60 of a year = 7.2 months

Pros:

- Reduction in injuries to workers
- Reduction in worker's compensation cost
- Improved morale from employees
- Short payback time

Cons:

- Injuries may still occur
- Maintenance cost

Table 3: Cost Benefit Analysis for the Maxx-Mini Lift (MMLE-100)

Cost:

- Maxx-Mini Lift MMLE-100 @ $2,178
- No installation cost

Other Cost:

- Training: 3 workers @ $15 per hour for 2 hours each

Total Cost: $2,268

Benefit:

- Reduction in injuries/worker's compensation cost @ $20,000/year

Payback Time = $2,268/$20,000 = 0.08 0f a year = 1.3 months

Pros:

- Reduction in injuries to workers
- Reduction in worker's compensation cost
- Improved morale from employees
- Short payback time

Cons:

- Injuries may still occur
- A forklift is needed for placing the pallet on the lift table
- Requires the worker to manually handle the bags

Table 4: Cost Benefit Analysis for Roto-Max Positioner (RTMX-30)

Cost:

- Roto-Max Positioner (RTMX-30) @ $3,214
- No installation cost

Other Cost:

- Training: 3 workers @ $15 per hour for 2 hours each

Total Cost: $3,304

Benefit:

- Reduction in injuries/worker's compensation cost @ $20,000/year

Payback Time = $3,214/$20,000 = 0.12 0f a year = 1.9 months

Pros:

- Reduction in injuries to workers
- Reduction in worker's compensation cost
- Improved morale from employees
- Short payback time

Cons:

- Injuries may still occur
- A forklift is needed for placing the pallet on the lift table
- Requires the worker to manually handle the bags

Chapter V: Conclusions & Recommendations

Introduction

The purpose of the study is to collect data regarding the new lifting process, analyze the task and recommend a lifting method that meets the recognized ergonomic standard. With the information collected in this study, management will be able to analyze and accept the risk, implement engineering and administrative controls, and justify the cost that resulted from the changes.

Discussion

This study evaluated the manual lifting task at company XYZ and provided recommendations which will reduce the injuries that may occur in the future. Workers within the processing department manually lift 50 lb bags which have resulted in injuries. The current 50 lb bags will be eliminated and workers will be lifting 100 lb bags which can result in more serious injuries, and this will cost the company thousands of dollars in lost time and workers' compensation claims. According to the injuries and losses which were reported in Chapter 2 and the data collected in this Chapter, management needs to implement engineering controls which will reduce the injuries and the cost to the company.

Data was also collected on the size of the work area and dimension and shape of the bags and pallets. This information was used to recommend suitable and cost effective engineering controls. The researcher found three engineering controls which would fit the work space at company XYZ and will also be cost effective to the company. The three controls are the Roto-Max lift table, Maxx-Mini lift table and the vacuum lift system.

Each system has several features which are unique and which will provide a benefit to the organization and to the employees in the processing department.

The vacuum system will cost a total of $15,000 in order to get it in full operation mode. This system is the most expensive of the three systems but in the long run will provide more benefit to the organization. Employees can control the speed at which they work while using this system, while with the Roto-Max lift table and the Maxx-Mini lift table the employees will spend more time waiting for the lift to be lowered and raised. The vacuum system also provides 25 feet of extension hose and this will make it easy to use by any employee regardless of their height. This system also provides handles which makes it easier to maneuver and provides quick disconnects for pad attachments and lifting heads

The second option which can be used is the Roto-Max lift table. The cost of this table is $3,214. This system is less expensive than the vacuum lift. This system is also portable and can be used in different areas of the company. The lift provides a 360 degree rotating top which makes the bags easily accessible to the worker. The capacity of the lift is 3,000 lbs and enables at least 30 bags to be placed on the lift. However, the rate of lowering and lifting is 14 seconds and may be of concern to management.

The final option is the Maxx-Mini lift table. The cost of this table is $2,178 and is the least expensive of the three controls. This system is also portable and can be used in other areas of the company. The lift is also adjustable which makes it suitable for the job and enables the use of the system by any employee regardless of their height or other handicaps. The capacity of the lift is 2,200 lbs and this allows at least 22 bags each weighting 100 lbs each to be placed on the lift. However, the rate at which the lift is lowered and raised may slow the rate of production.

Conclusions

The results collected by the researcher showed clear indication that the manual material task at Company XYZ resulted in several injuries and cost the company a large sum of money. The researcher has concluded that there is a need to implement engineering controls which will decrease the injuries and, as a result, decrease the cost to the company. The current 50 lb bags will also be eliminated and increased to 100 lb bags and this will increase injuries if the company does not implement engineering controls which will automate the task and prevent overexertion of the worker.

Recommendations

The researcher recommends the vacuum lift system because it eliminates the risk totally. This system will assist the company in eliminating the injuries and, as a result, decrease the cost to the company. The cost of this system is $15,000 and the company can pay off the cost in 7 months. This system will provide the greatest benefit in the long run. The workers can work at their own rates and the production process would not be interrupted. The vacuum system also provides 25 feet of extension hose and this will make it easy to use by any employee regardless of his or her height. This system also provides handles which makes it easier to maneuver and provides quick disconnects for pad attachments and lifting heads.

References

Anver. (2006). *Vacuum tube lifting systems.* Retrieved 4/24/2006, from http://www.anver.com/document/vacuum%20tube%20lifters/vt160-4_0-d5-bh90-p-c5.htm

Bailey, R. W. (year). *Human performance engineering: Using human factors/ergonomics to achieve computer system usability*

Bridger, R. S. (1995). *Introduction to ergonomics.* New York: McGraw-Hill, Inc.

Bureau of Labor Statistics. (2004, December). BLS issues report on lost work-time injuries, illnesses: Characteristics, resulting time away from work. *US Fed News,* 100, 35. Retrieved on February 10, 2006 from Lexis-Nexis

Cooper, J. (1999). *Musculoskeletal conditions in the US.* Retrieved 3/6/2006 from http://medicalreporter.health.org/tmr1099/orthopaedics.html

Douglas, J. R., *Integrated disability management 2000 (an employer's guide)*

J. J. Keller & Associates. (2006). *Ergonomics, Lifting, Materials handling and storage ,NISOH Lifting Equation.* Retrieved 3/6/2006, from http://kelleronline.com

J. J. Keller & Associates. (2006). *Applications Manual for the Revised NIOSH Lifting Equation.* Retrieved 3/6/2006, from http://kelleronline.com

Lift Products, Inc. (n. d. a). *Maxx mobile series.* Retrieved 4/24/2006, from http://www.liftproducts.com/LiftTables/Mobile/Max_Mini_Lift.html

Lift Products, Inc. (n. d. b). *Roto-max.* Retrieved 4/24/2006, from http://www.liftproducts.com/LiftTables/Rotating/Roto_Max.html

Macleod, D. (1995). *The ergonomics edge: improving safety, quality, and productivity.*

New York: Van Nostrand Reinhold.

Mindtools Ltd. (2006). *Cost benefit analysis.* Retrieved 4/10/2006, from http://www.mindtools.com/pages/article/newTED_08.htm

NexGen Ergonomics. (2002). *ErgoIntelligence manual materials handling.* Retrieved 3/2/2006, from http://www.nexgenergo.com/ ergonomics/ergointelmmh.html

NIOSH. (1998). *Applications manual for the revised NIOSH lifting equation.* Retrieved 4/12/2006, from http://www.cdc.gov/niosh/94-110.html

OSHA. (2006). *29 CFR 1910.132(a) general requirements.* Retrieved 3/2/2006, from http://www.osha.gov

Parker, K. G. & Imbus, H. R. (1992). *Cumulative trauma disorders.* Chelsea, 121 South Main Street: Lewis Publishers.

Putz-Anderson, V. (1988). *Cumulative trauma disorders: A manual for musculoskeletal diseases of the upper limbs.* Bristol,1900 Frost Road: Taylor & Francis Inc.

Tayyari, F. & Smith, J. L. (1997). *Occupational ergonomics: Principles and applications.* London, SE1 8HN: Chapman & Hall.

Wikipedia. (2006). *Cost benefit analysis.* Retrieved 3/6/2006, from http://en.wikipedia.org/wiki/Cost-benefit_analysis

Appendix A: Frequency Multiplier Table

Table 5
Frequency Multiplier Table (FM)

Frequency Lifts/min (F) ‡	Work Duration					
	≤1 Hour		>1 but ≤2 Hours		>2 but ≤8 Hours	
	V < 30†	V ≥ 30	V < 30	V ≥ 30	V < 30	V ≥ 30
≤0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

†Values of V are in inches. ‡For lifting less frequently than once per 5 minutes, set F = .2 lifts/minute.

Appendix B: Coupling Multiplier Table

1.3.6.2. Coupling Multiplier

Based on the coupling classification and vertical location of the lift, the Coupling Multiplier (CM) is determined from Table 7.

Table 7
Coupling Multiplier

Coupling Type	Coupling Multiplier	
	V< 30 inches (75 cm)	V ≥ 30 inches (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

Appendix C: Hand –to – Container Coupling Classification Table

Table 6
Hand-to-Container Coupling Classification

GOOD	FAIR	POOR
1. For containers of optimal design, such as some boxes, crates, etc., a "Good" hand-to-object coupling would be defined as handles or hand-hold cut-outs of optimal design [see notes 1 to 3 below].	1. For containers of optimal design, a "Fair" hand-to-object coupling would be defined as handles or hand-hold cut-outs of less than optimal design [see notes 1 to 4 below].	1. Containers of less than optimal design or loose parts or irregular objects that are bulky, hard to handle, or have sharp edges [see note 5 below].
2. For loose parts or irregular objects, which are not usually containerized, such as castings, stock, and supply materials, a "Good" hand-to-object coupling would be defined as a comfortable grip in which the hand can be easily wrapped around the object [see note 6 below].	2. For containers of optimal design with no handles or hand-hold cut-outs or for loose parts or irregular objects, a "Fair" hand-to-object coupling is defined as a grip in which the hand can be flexed about 90 degrees [see note 4 below].	2. Lifting non-rigid bags (i.e., bags that sag in the middle).

Appendix D: Notes on Table 6

1. An optimal handle design has .75 - 1.5 inches (1.9 to 3.8 cm) diameter, ≥ 4.5 inches (11.5 cm) length, 2 inches (5 cm) clearance, cylindrical shape, and a smooth, non-slip surface.

2. An optimal hand-hold cut-out has the following approximate characteristics: ≥ 1.5 inch (3.8 cm) height, 4.5 inch (11.5 cm) length, semi-oval shape, ≥ 2 inch (5 cm) clearance, smooth non-slip surface, and ≥ 0.25 inches (0.60 cm) container thickness (e.g., double thickness cardboard).

3. An optimal container design has ≤ 16 inches (40 cm) frontal length, ≤ 12 inches (30 cm) height, and a smooth non-slip surface.

4. A worker should be capable of clamping the fingers at nearly 90° under the container, such as required when lifting a cardboard box from the floor.

5. A container is considered less than optimal if it has a frontal length > 16 inches (40 cm), height > 12 inches (30 cm), rough or slippery surfaces, sharp edges, asymmetric center of mass, unstable contents, or requires the use of gloves. A loose object is considered bulky if the load cannot easily be balanced between the hand-grasps.

6. A worker should be able to comfortably wrap the hand around the object without causing excessive wrist deviations or awkward postures, and the grip should not require excessive force.