An Analysis of the Adhesive Rolls Handling Task in the Warehouse Area at 3M

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Abstract

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An Ergonomic Assessment of the Manual Materials Handling Procedure at 3M
(Title)
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(Name of Style Manual Used in this Study)

The purpose of this study is to identify, evaluate, and analyze the ergonomic exposures associated with the adhesive rolls handling area in the warehouse area at 3M Cumberland, WI and recommend solutions to reduce the risk for potential loss. In order to accomplish the analysis an observation of the manual materials handling task, a task analysis, an analysis using the bio-instrument Chattanooga Lumbar Motion Monitor and an analysis of the results from the task analysis and Chattanooga Lumbar Motion Monitor will be completed. Once the risk factors have been identified, evaluated and quantified appropriate controls and solutions will be recommended.

Acknowledgement

I would like to thank my family for their support during my pursuit of this degree and through the process of this research. I would also like to thank the risk control staff and my advisor John Olson for their guidance and for giving me the opportunity to further my education. Finally, I want to thank my friends for the endless amount of help they have given me. I hope that our relationships will carry on during our professional careers in the field of Risk Control.

Table of Contents

Chapter I

Statement of the Problem

Introduction

The Minnesota Mining and Manufacturing Company (3M) is a worldwide company with locations in over 64 countries. 3M provides solutions for Architecture & Construction, Automotive, Marine and Aerospace, Electronics Manufacturing, Graphic Arts, Health Care, Home and Leisure, Manufacturing and Industrial, Office, Personal & Transportation Safety, Utilities & Telecommunications. Worldwide sales exceeded $15.659 billion in 1999 with products being sold in nearly 200 countries. Thirty-nine of the companies within the United States have manufacturing operations ranging from small converting operations to full-scale manufacturing of multiple product lines. 3M's growth has come through a desire to participate in many markets where the company can make a significant contribution from core technologies, rather than be dominant in just a few markets.

The 3M manufacturing plant located in Cumberland, Wisconsin employs approximately 3,500 employees. It is a build-to-order adhesive and abrasive manufacturing plant where customers place orders for their specific needs and applications. This requires 3M to accommodate a variety of requests and modify their processes to meet the customer's needs. It also requires 3M to utilize a large amount of material in a non-systematic manner presenting excess material and storage challenges. The plant operates 24 hours a day, 7-days a week.

Six months ago, the 3M manufacturing plant in Cumberland introduced a new manual material handling task to their facility involving large amounts of adhesive material contained in rolls. The adhesive rolls are utilized in the Micro-finishing Film (MFF) and Imperial Diamond Lapping Film (IDLF) departments and are brought from the warehouse to be cut to the specific size requested. The rolls range in weight from 5 lbs to 250 lbs and from 6 inches to 28 inches in height. There are approximately 20-25 different sizes and 30 to 35 different types of material. The storage system currently consists of tier shelving with the material being utilized in the process on the floor shelf. All of the different types of rolls and materials sit on pallets. When an order is placed various rolls from a number of pallets are needed. If a specific roll is needed in the middle or back of a pallet, a warehouse employee uses a fork truck to pull the pallet off the shelf and into the aisle. If a roll is in the middle of the pallet, the employee must maneuver a number of rolls to reach it and then lift it onto another pallet, creating an ergonomic hazard. Once the ordered rolls are properly placed on pallets, they are transported using a forklift to the end users in the MFF or IDLF departments. Upon delivery, the warehouse employee might be asked to drop off the pallet or sometimes unload it as well. All of the rolls are maneuvered by hand. If any material remains on the rolls, the warehouse employees must retrieve them from the MFF or IDLF departments and replace the rolls using the reverse of the above process.

The ergonomics team at 3M in Cumberland has identified the potential for injury in the recently introduced adhesive manufacturing line and has requested assistance to evaluate and analyze the process. No OSHA recordable injuries and illnesses or compensation claims associated with this process have been made prior to this research.

Problem Statement

The purpose of this study is to identify, evaluate, and analyze the ergonomic exposures associated with the adhesive rolls handling area in the warehouse area at 3M Cumberland, WI and recommend solutions to reduce the risk for potential loss.

Objectives

1.0 Identify the ergonomic risk factors associated with the manual material handling task through task analysis.

- 1. 1 Analyze posture required to complete the task using the Chattanooga Lumbar Motion Monitor.
- 1.2 Evaluate the results from the task analysis and Lumbar motion monitor.

2.0 Recommend solutions regarding safer more ergonomically correct procedures that will reduce and/or eliminate the potential for injury and illness.

Background and Significance

Manual materials handling tasks affect a large population of workers and industries throughout the United States. The manual handling of material can result in over-exertion injuries and disorders and present great financial risk for those industries involved. The U.S. Department of Labor estimates that over-exertion injuries involving activities such as lifting, pushing, pulling and carrying accounted for 503,900 lost work-time cases in 1998 alone. Further, it is estimated that 13 to 20 billion dollars (Bernard and Fine, 1997) in workers compensation payments and other direct costs are spent annually on work-related overexertion injuries and disorders in the United States. The total annual cost associated with work-related overexertion injuries and disorders including indirect costs, such as lost productivity, costs of hiring and training etc., is estimated to be as high as 100 billion dollars (Bernard and Fine, 1997).

The financial and human resource implications for a company with a musculoskeletal injury or illness can be dramatic. Not only do the employees face the risk of being injured, 3M faces the risk of financial and human resource loss. Although there have been no recordable injuries and illnesses or compensation claims associated with the new adhesive roll handing area in the warehouse to date, the potential does exist. The manually handling of this material presents various risk factors that need to be identified, evaluated, analyzed and controlled. By not reducing and/or eliminating the risks associated with the manual handling of these adhesive rolls, the company will continue to face the potential for employee injury and illness and financial loss.

Limitations

The study and it's recommendations apply only to manual materials handlings tasks within the warehouse at 3M in Cumberland, Wisconsin.

Assumptions

- The injury and illness information provided by 3M was accurate and correct.
- The observed work and task analyzed are indeed indicative of normal work procedure.

Definition of Terms

Anthropometry: Measurement and collection of body measurements for use as design criteria to improve functioning, efficiency, and safety of humans in the work environment.

Average Twisting Velocity: The speed in terms of degrees the back twists from neutral straight posture per second.

Coronal Plane: A vertical plane perpendicular to the medial plane that divides the body into anterior and posterior segments.

Dynamic Effort: Rhythmic alteration of contraction and extension, tension and relaxation.

Extension: The act of straightening a limb or increasing the angle between two adjacent bones.

Flexion: The act of bending a limb so that its proximal and distal parts are brought together or decreasing the angle between two adjacent bones.

Lateral: Located on the side; farther from the middle.

Medial: Relating to the middle; near the median plane of the body or an organ.

Risk Factors: Those personal and/or environmental elements which may expose an individual to injury or illness.

Chapter II

Review of Literature

Introduction

The purpose of this study is to identify, evaluate, and analyze the ergonomic exposures associated with the adhesive rolls handling area in the warehouse and recommend solutions to reduce the risk for potential loss in 3M in Cumberland, Wisconsin. The intent of the literature review is to provide information regarding the identification, analysis and control of ergonomic risk factors as they relate to the identified task.

Ergonomics

Ergonomics is the study of "people and their work" (Khalil, Abdel-Moty, Rosomoff & Rosomoff, 1993). It attempts to accommodate workers of all shapes and sizes in order to fit the task to the worker with respect to human limitations and capabilities. According to the Occupational Safety and Health Administration fitting the person to the job is achieved through evaluation and design of workplaces, environments, jobs, tasks, equipment, and processes in relationship to human capabilities and interactions in the workplace.

It is believed that that the majority of all musculoskeletal injuries and illnesses arising from the workplace may be abated through sound ergonomic strategies. According to (Grandjean, 1988) ergonomics recognizes four important strategies, which include design, stress reduction, matching the job demands and people's abilities, and education and training. When applied appropriately these strategies are an effective tool in the prevention and control of work place overexertion injury and illness. Failure to apply to sound ergonomic strategies and accommodate the limitations and capabilities of the worker may result in lower back injuries, overexertion injuries and illnesses and financial loss.

Manual Materials Handling

Bernardino Ramazinni, deemed the founder of occupational medicine, identified two types of workplace hazards: "harmful character of the materials…handled" and "certain violent and irregular motions and unnatural postures of the body, by reason of which the natural structure of the vital machine is so impaired that serious diseases gradually develop there from" (Tichauer, 1978).   Manual materials handling presents a multitude of ergonomic risk factors involving "irregular motions and unnatural postures of the body" and if left unattended can potentially lead to injury and illness. According to Vern – Putz Anderson (1988) ergonomic risk factors include force, repetition, posture and insufficient recovery time.

There are many aspects in the manual lifting of a load that may be physically hazardous to the human body. NIOSH cites seven risk factors including weight, location/site or position of the load in respect to the worker, frequency/duration/pace, stability, coupling or handle size and location, workplace geometry (physical constraints or restriction of the workplace) and the environment (temperature, humidity, noise, vibration, illumination and frictional stability). The weight of the object often receives the most attention and is the most obvious factor. Chaffin and Park (1973) concluded that the "lifting of loads greater than about 35 pounds when held in close to the body, or equivalent conditions, such as 20 pounds between 25 and 35 inches in front of the body, would be potentially hazardous for some people."

The location and size of the load are important in terms of the biomechanical and physiological aspects of the human body. In a study by Chaffin (1977) it was observed that "the more remote the load center of gravity from the body (due to either the bulk of the object being handled or the workplace layout), the greater the frequency and severity of musculoskeletal problems and contact injuries." Lifting frequency must also be considered as Chaffin (1977) reported that "the more frequent the lifting of maximal loads on a job, the greater the frequency and severity rates of musculoskeletal problems (other than backs) and the greater the severity of contact injuries."

Ergonomic Risk Factors

Ergonomic risk factors are factors that predispose an individual to an occupational injury or illness in the workplace. According to Vern-Putz Anderson (1998), force, repetition, posture and no rest are risk factors identified with musculoskeletal injury and illness. Other ergonomic risk factors include velocity/acceleration, duration of the task, heat stress, vibration, cold stress, lighting and noise. Ergonomic risk factors can lead to a multitude of soft tissue injuries and illnesses. They include but are not limited to: strain, sprain, tendonitis, tenosynovitis, ganglionic cysts, bursitis, myositis, arthritis, lower back pain and cumulative trauma disorders (Tayyari and Smith 1997). Ergonomics attempts reduce and/or eliminate risk factors by redesign, modification and engineering controls.

Force is a physical characteristic and can be viewed as the effect of an exertion on internal body tissue. (Chaffin and Anderson, 1991). It becomes an ergonomic risk factor when the force that acts on the body is great enough to damage tissue and/or if the force is applied over a period of time. It should be noted that the amount of force and length of time required to cause injury or illness has yet to be quantified. It is however the later that is of greater interest to ergonomics. The amount of force applied to the body during a given task and how long an individual must endure that force can be reduced through task redesign and modification.

Posture is an important ergonomic risk factor to consider as the body is very sensitive to prolonged awkward postures (Roberts and Falkenberg, 1992). Posture is simply how an individual is positioned in space. Posture becomes awkward when a body is moved from an anatomical neutral position and/or deviates from normal movement. This ergonomic risk factor increases with the time the position or posture is held. For example, holding a tool with your wrist ulnarly deviated to accomplish one task may not be damaging, however if that position is held day after day as part of a job then the potential for injury and illness greatly increases. Positioning and posture is of great concern in respect to ergonomics as proper positioning can be accomplished through tooling and task redesign and modification.

Recuperation, the amount of rest a body needs after a forceful exertion or movement, is considered an ergonomic risk factor when a body doesn't experience ample rest (Anderson, 1997). Again it should be noted that exactly how much rest a body needs to recover from an exertion or movement is difficult to quantify as there are a multitude of factors which affect this variable. When a muscle contracts, it requires oxygen which is delivered via the blood stream. Blood vessels constrict during this period of contraction reducing the desirable amount of oxygen and nutrients (Richard, 1995). When that muscle relaxes the circulatory system delivers the oxygen and nutrients to that muscle, hence you have recovery for that particular muscle (Richard, 1995). Problems arise when a muscle or muscle group isn't allowed to rest or recuperate. Lack of recuperation over a period of time can lead to long term injury and illness (Rodriguez, 1997).

Chattanooga Lumbar Motion Monitor

The Chattanooga Lumbar Motion Monitor was developed in the Biodynamics Laboratory at Ohio State University. The device can be utilized to collect information concerning the acceleration, velocity and range of motion of the back while performing a given task (Murras, 1992).

The Chattanooga Lumbar Motion Monitor is worn on the back of the subject being tested. The top portion of the monitor fits between the shoulder blades of the subject and the lower portion of the monitor rests on the tailbone. There are three wires that connect the upper and lower portions of the monitor. These wires are attached to position-sensitive servos in the lower portion of the monitor and are intended to simulate the spine. Thus, any movement in the spine is paralleled by the instrument and recorded on a lap top computer containing the Chattanooga Lumbar Motion Monitor (CLMM) Software.

The CLMM software is an essential component of the system. The program combines pre-performance information with information recorded from the monitor to calculate six summarized forms of analysis. Pre-performance information includes: object starting height, object ending height, lifting frequency, distance traveled and object weight. The six summarized forms of analysis include: lift rate, average twisting velocity, maximum movement, maximum sagittal flexion, maximum lateral velocity and overall probability of low back disorder (Murras, 1992). Each form of analysis is represented numerically and by box chart format giving a visual description of the information. The numerical data is given in the form of percentages (0 – 100%) indicating the "Probability of High Risk Group Membership." The probability is derived from comparisons of the collected data to the bench marks within the software (Murras, 1992).

Job Process Hazard Analysis

The purpose of a Job Process Hazard Analysis (J/PHA) is to define the hazards associated with the job, familiarize employees and supervisors with job hazard exposures that cause loss, provide a performance standard and serve as a training tool. Through the utilization of P/JHA an organization is able to contribute to efficient and effective operations (J. Olson, 2001). The steps involved in a J/PHA are: 1. Define the job and look at key job steps. 2. Break the job down and evaluate what is done first, second, etc.. 3. Identify the potential hazards and what could happen to someone performing the job. 4. Identify safe practices and how to avoid potential loss on each step of the task. 5. Provide additional information regarding personal protective equipment, certification, medical approval, tools, etc. The adhesive rolls handling task will be defined/described, broken down into steps and analyzed for risk factors in chapter four. The identification of safe practice and additional information will be provided in chapter five.

Task Analysis

In order to establish the risk factors a particular job possesses, a task analysis must be completed. "The analysis can be used to determine job duties a healthy person or an injured person can perform based on functional capacities in relation to job demands" (Khalil et. al.). To begin, a complete description of the task being analyzed must be completed. This description may include videotapes of the job and existing written job descriptions (Putz-Anderson, 1988). Next, the task is broken into steps and the risk factors are identified. Once the risk factors have been identified, alternatives to eliminate or reduce the risks are analyzed and implemented. Finally, following implementation the changes are monitored and follow-up occurs as necessary.

Control of Ergonomic Hazards

Ergonomic risk factors or hazards can be identified, analyzed and controlled using appropriate control strategies. Those control strategies involve engineering controls and administrative controls. Engineering controls change the physical features of the work environment while administrative controls utilize methods to reduce an individual's exposure to those hazards (Putz-Anderson, 1988). Engineering controls are the preferred method of control. The focus for engineering controls is on the production system, the local workstation and the tools/equipment. The ergonomic risk factors will likely relate to one of these areas. Design and/or modification may involve adjustability and space modification. Design should consider the risk factors as to not increase one hazard by eliminating another.

Administrative controls are another control strategy and involve modifications and/or design of policy, procedure and practices that minimize the exposure to workers to hazards. Some examples of common administrative controls include providing rest breaks, training in proper technique, increasing the number of employees and altering or modifying a job practice.

Ergonomic Controls in Related Industries

Supervalu Inc., a fortune 100 company, is the 10th largest food retailer in the nation employing approximately 62,000 full and part-time employees (www.supervalu.com). They are a company that manually handles gross amounts of material on a daily basis. A review of their manual handling procedures revealed a procedure Supervalu terms, "ergonomic slotting." This is an organizational method whereby the material is divided into several categories depending on weight and use and is distributed on shelving at various heights accordingly. For example, items that are categorized as heavy and high use are ranked high in priority and placed at a shelf height that doesn't require bending and/or reaching. Items that are low in use then, regardless of weight are ranked lower in priority and placed at sub-optimal heights. Supervalu also reported the value of training and reinforcement in the area of materials handling. Employees are given initial and annual training procedures for the handling material and those procedures are consistently reinforced by supervisors and management.

Stora-Enso Inc., formerly Consolidated Papers, Inc. is North America's largest producer of coated and super-calendered printing papers for the printing and publishing industries. employing approximately 6,800 people.   Stora-Enso manipulates various rolls of paper for processing within their plant. Upon review of their manual handling procedures it was found that they utilize "clamp trucks" for the majority of their work. The clamp trucks manipulate the large calendar rolls, which weigh in excess of 1000lbs. Although they do not handle rolls smaller than 42 inches, they strongly advocate the utilization of power to decrease the amount of manual handling that occurs (www.consolidatedpapers.com).

Ergonomic Equipment

Pneumatic manipulators are tools used in a variety of manufacturing environments throughout the world. They are a fixed device driven by air, which allows an employee to manipulate a load without a physical interface. The employee operates two handles, which maneuvers the manipulator in space. Once the manipulator is positioned the material is grasped by the manipulator and the employee can position the material as needed (Roychodhury, 1988). The pneumatic manipulator has several attachments that can be utilized to grasp an object. In the handling of rolls an attachment is used that is inserted into the center portion of the roll. The end attachment then expands inside the roll, which allows the manipulator to grasp the roll.   3M has and utilizes these type of manipulators for other processes within their plant at Cumberland. They do not however currently utilize them for the adhesive rolls handling task in the warehouse.

Summary

This chapter was a review of literature intended to provide a basis for the objectives and recommendations contained within. A review of ergonomics, ergonomic risk factors, manual materials handling, measurement equipment, types of analysis, and controls were performed as it relates to the adhesive rolls handling task at 3M. It was established that manual materials handling presents several risk factors including weight, location/site or position of the load in respect to the worker, frequency/duration/pace, stability, coupling or handle size and location, workplace geometry (physical constraints or restriction of the workplace) and the environment (temperature, humidity, noise, vibration, illumination and frictional stability). Following the identification of risk factors that can potentially exist in the handling of the adhesive rolls, a Task Analysis was identified as a means of analyzing the associated risk factors. The Chattanooga Lumbar Motion Monitor was then identified as a means to quantify these risk factors. Finally, a review of controls was preformed in order to provide recommendations based on sound ergonomic strategies and current controls in industry.

Chapter III

Methodology

Introduction

The purpose of this study is to identify, evaluate, and analyze the ergonomic exposures associated with the adhesive rolls handling area in the warehouse and recommend solutions to reduce the risk for potential loss with this process. The purpose of this chapter is to discuss the sequence of events and procedures used to conduct the study. To accomplish the research objectives, the following outline was formed.

I. Review pertinent literature related to ergonomics, ergonomic exposures, equipment to measure exposure and methods of control.

II. Evaluate the adhesive rolls handling task in the warehouse to determine ergonomic risk factors.

- A. Utilize a task analysis
    1. Document all the steps required to accomplish the task
    2. Breakdown each step into elements of movement for further analysis.

III. Analyze the task using the bio-instrument Chattanooga Lumbar Motion Monitor.

- A. The instrumentation procedure
    1. The Chattanooga Lumbar Motion Monitor is calibrated as per manufacturer instructions.
    2. Test subject is properly fitted with the Chattanooga Lumbar Motion Monitor according to manufacturer specifications.
    3. Pre-performance data is recorded into the lap top software: Object weight, Distance traveled, Lifting frequency, Object starting height, and Object ending height.

4. Test subject is instructed to begin the task.
5. The information from the LMM is recorded by the lap top during the task.
6. At the completion of the task the program data is saved and recorded. (This procedure is repeated three times for each task.)
7. Following testing the data is analyzed assisting the researcher in evaluating the body postures as they related to the task.

IV. Analyze the results from the task analysis and Chattanooga Lumbar Motion Monitor to determine the amount of risk the risk factors pose.

A. Based upon the analysis and literature review determine solutions and recommendations to reduce and/or eliminate the risk factors.

Chapter IV

The Study

Introduction

The purpose of this chapter is to review the results of the evaluation and analysis of the adhesive rolls handling task in the warehouse at 3M. A description of the task is provided, followed by a task analysis, which was utilized to analyze the associated risk factors. The results of the Chattanooga Lumbar Motion Monitor are also provided, which were utilized as a means to quantify the associated risk factors and establish a potential injury percentage.

Task Description

The task involves the manual manipulation of adhesive rolls to and from pallets located within the warehouse. When an order is placed various rolls from a number of pallets are needed. The warehouse employee must fill the order by manually retrieving the adhesive rolls from the middle or back of a pallet located underneath the first tier of shelving within the storage system. Once the rolls are manually manipulated onto the pallets, they are transported using a forklift to the end users in the MFF or IDLF departments.

Task Analysis

In order to analyze the task described above, a task analysis was completed. This was done in order to document all the steps required to accomplish the task and identify the work elements. The task was then analyzed to determine the risk factors. See Table I for results.

Table I

Task Analysis Results

<u>**Job Steps**</u>	<u>**Risk Factors**</u>
1. Maneuver fork truck with empty transport pallet next to the storage pallet on the shelf where the material is to be retrieved.	
2. **Bend, reach** and **grasp** roll of material needed.	Trunk flexion, shoulder flexion, and elbow flexion with a load.
3. **Move** and **position** roll to the edge of storage pallet/shelf.	Trunk flexion and rotation, shoulder flexion/extension, elbow flexion/extension (awkward posture). Excessive force.
4. **Position** and **move** the roll on to the transport pallet.	Trunk flexion and rotation, shoulder flexion/extension (awkward posture). Excessive force
5. Repeat process to fill order request and transport to user department.	

*Note: Size and weight of material vary requiring the worker to exert varying degrees of force and attain varying degrees of posture.

The analysis indicated three work elements: bending, reaching and grasping, moving and positioning, and positioning and moving. An analysis of these elements revealed multiple risk factors including awkward trunk posture and the forceful utilization of upper extremity musculature. This awkward positioning combined with excessive force creates a significant ergonomic hazard that needs to be controlled to reduce and/or eliminate loss potential.

Force Gauge Analysis

An attempt was made to quantify the amount of force being placed on the body as a result moving the adhesive rolls. The results from this particular instrument were inconclusive, as the gauge could not be applied to the material in a manner that would accurately represent the force being applied to the body. It should be noted however that the force applied to the body is a significant factor as employees are manipulating weights ranging from 25-100% of their own body weight.

Chattanooga Lumbar Motion Monitor Analysis

The Chattanooga Lumbar Motion Monitor (CLMM) was placed on a volunteer and measurements were recorded regarding the acceleration, range of motion and velocity of the spine. Three trials were recorded while the volunteer performed the task. The smallest and heaviest rolls were analyzed to represent extremes in both posture and force associated with this task. See Table II for results.

Table II

CLMM Results: Warehouse Analysis

Job: Manual Material Handling – Adhesive Rolls
Job Description: Moving a large roll from pallet underneath shelving to transport pallet in the isle. No vertical distance traveled. Roll is "rolled and manipulated" not lifted.

Lift Frequency	8 lifts/hour
Weight	250 lbs
Start Height	25"
End Height	25"
Horizontal Distance	18"
Average Rotational Velocity	5.3 deg/sec
Maximum Moment Arm	375 ft-lb*
Maximum Sagittal Flexion	72 degrees*
Maximum Side Bend Velocity	29.7 deg/sec
Average Probability of Lower Back Injury	**45%**

Job: Manual Material Handling – Adhesive Rolls
Description: Moving medium size roll from underneath low shelf to transport pallet in isle.

Lift Frequency	8 lifts/hour
Weight	53 lbs
Start Height	11"
End Height	11"
Horizontal Distance	18"
Average Rotational Velocity	7.4 deg/sec (40%)
Maximum Moment Arm	79.5 ft-lb (90%)
Maximum Sagittal Flexion	74 degrees (90%)
Maximum Side Bend Velocity	32 deg/sec (30%)
Average Probability of Lower Back Injury	**50%**

Job: Manual Material Handling – Adhesive Rolls
Description: Lifting a roll to slightly higher surface from underneath low shelving

Lift Frequency	8 lifts/hour
Weight	54 lbs
Start Height	14"
End Height	18"
Horizontal Distance	24"
Average Rotational Velocity	6.2 deg/sec (30%)
Maximum Moment Arm	108 ft-lb (90%)
Maximum Sagittal Flexion	72 degrees (90%)
Maximum Side Bend Velocity	42.5 deg/sec (50%)
Average Probability of Lower Back Injury	**52%**

The CLMM revealed that acceleration and velocity were not significant factors when compared to the benchmarks contained within the software. Sagittal flexion however was a significant factor and was recorded at 72 degrees respectively. The Chattanooga software also offers an average probability of injury given the weight of the object, height from which it must be lifted, distance from the body and the recorded ROM, acceleration and velocity measurements. The average probability of lower back injury associated with this task was 52%.

The LMM was also used to analyze several other tasks within the plant including slitting, packaging, and shipping in order to establish a comparison between the task being evaluated and others with the plant. When the warehouse LMM analysis was compared to other areas within the plant it ranks among the higher of probabilities. Some other tasks analyzed within the plant did have higher probability of back injury according to the software however the pre-performance information should be considered, as there are many contributing factors. See Table III for results.

Table III

LMM analysis of various tasks throughout plant:

Job: 23 Maker-Packaging
Description: Placing a package from the conveyor belt to an adjacent pallet.

Lift Frequency	65 lifts/hour
Weight	3.34 lbs
Start Height	35”
End Height	19”
Horizontal Distance	17”
Average Rotational Velocity	15.4 deg/sec *
Maximum Moment Arm	4.7 ft-lb
Maximum Sagittal Flexion	70 degrees*
Maximum Side Bend Velocity	163.3 deg/sec*
Average Probability of Lower Back Injury	**56%**

Job: 23 Maker-Hole Punch
Description: Picking up abrasive wheels from the floor that have fallen from the conveyor belt.

Lift Frequency	25 lifts/hour
Weight	.5 lbs
Start Height	0”
End Height	53”
Horizontal Distance	5”
Average Rotational Velocity	7.1 deg/sec
Maximum Moment Arm	.2 ft-lb
Maximum Sagittal Flexion	74 degrees*

Maximum Side Bend Velocity	23.3 deg/sec
Average Probability of Lower Back Injury	**29%**

Job: MFF-Slitting
Description: Moving a small to medium size roll from a pallet out of reach of the manipulator to a pallet near the slitter.

Lift Frequency	1 lift/hour
Weight	16 lbs
Start Height	10”
End Height	10”
Horizontal Distance	30”
Average Rotational Velocity	18.4 deg/sec*
Maximum Moment Arm	40 ft-lb*
Maximum Sagittal Flexion	74 degrees*
Maximum Side Bend Velocity	205.7 deg/sec*
Average Probability of Lower Back Injury	**64%**

Job: MFF-Packing Operator
Description: Placing packages from conveyor belt to pallet located behind worker.

Lift Frequency	25 lifts/hour
Weight	3 lbs
Start Height	28”
End Height	15”
Horizontal Distance	12”
Average Rotational Velocity	12.3 deg/sec*
Maximum Moment Arm	3.0 ft-lb
Maximum Sagittal Flexion	72 degrees*
Maximum Side Bend Velocity	218.7 deg/sec*
Average Probability of Lower Back Injury	**54%**

Job: ILF-211 Slitter
Description: Moving the lower tape rolling bar from the machine to the bench located behind the worker.

Lift Frequency	12 lifts/hour
Weight	11 lbs
Start Height	32”
End Height	51”
Horizontal Distance	14”
Average Rotational Velocity	5.5 deg/sec
Maximum Moment Arm	12.8 ft-lb
Maximum Sagittal Flexion	64 degrees*
Maximum Side Bend Velocity	29 deg/sec
Average Probability of Lower Back Injury	**28%**

Job: Shipping-UPS
Description: Moving a package from a pallet located behind the worker to the scale located in front of the worker.

Lift Frequency	45 lifts/hour
Weight	16 lbs
Start Height	16”
End Height	34”
Horizontal Distance	12”
Average Rotational Velocity	8.6 deg/sec*
Maximum Moment Arm	16.0 ft-lb
Maximum Sagittal Flexion	71 degrees*
Maximum Side Bend Velocity	52.3 deg/sec*
Average Probability of Lower Back Injury	**46%**

Job: Superbuff-Operator
Description: Packing boxes by placing buff wheels from a cart located behind the worker to a box/sealer located in front of the worker.

Lift Frequency	35 lifts/hour
Weight	1.5 lbs
Start Height	27”
End Height	27”
Horizontal Distance	18”
Average Rotational Velocity	19.2 deg/sec*
Maximum Moment Arm	2.3 ft-lb
Maximum Sagittal Flexion	64 degrees*
Maximum Side Bend Velocity	27 deg/sec
Average Probability of Lower Back Injury	**41%**

It is important to note the following disclaimer by the manufacturer: The LMM is a device designed to assist the user in evaluating the probability or likelihood that certain types of repetitive motions performed over a period of time might result in, or contribute to, problems or injuries to the lower back. The device seeks to measure and analyze repetitive motions and compare such measurements and analysis to a fixed database of certain designated high risk bench-marks, developed from various sources or information relating to the relationship and/or effects of repetitive motion on certain types of lower back injury. The database is not exhaustive and the manufacturer does not represent that the database contains all available information with respect to the relationship or effect or repetitive motion on lower back injury, nor does it reflect all circumstances in which repetitive motion can result in lower back injury.

Symptom Survey

An internal symptom survey was designed and administered entirely by 3M. At no time was the writer involved with that survey, however the results and analysis were shared with the writer by 3M. Therefore, it will be utilized to further examine the potential for injury in this process.

Two of the seven surveys indicated pain with the manual handling task, ranging from 2 weeks to 6 months, and that it was relieved upon cessation of the task. These reports of pain may or may not be associated with the newly introduced adhesive rolls task. In either case, if the reports are accurate it should be recognized that the complaints/symptoms are relatively new, and each has the potential to become a recordable injury/illness leading to days away from work and increased workers compensation claims.

Summary

Through an analysis of the task, posture was identified as a significant ergonomic risk factor. The CLMM revealed that acceleration and velocity were not significant factors when compared to the benchmarks contained within the software. Sagittal flexion however was a significant factor and was recorded at 72 degrees respectively. The Chattanooga software also offers an average probability of injury given the weight of the object, height from which it must be lifted, distance from the body and the recorded

ROM, acceleration and velocity measurements. The average probability of lower back injury associated with the manual handling of the adhesive rolls was 52%. Force was also recognized as a significant risk factor, as employees are manipulating weights ranging from 25-100% of their own body weight. The weight of the objects being manipulated, in combination with awkward posture possesses significant potential for musculoskeletal injury and/or illness. Present procedure indicates the need for modification of the task and by not implementing the appropriate controls or modifying this task the company will continue to face potential financial and human resource loss.

Chapter V

Conclusions and Recommendations

Introduction

The purpose of this study was to identify, evaluate, and analyze the ergonomic exposures associated with the adhesive rolls handling area in the warehouse area at 3M, Cumberland WI and recommend solutions to reduce the risk for potential loss. The research objectives of the study were to:

Objectives

1.0 Identify the ergonomic risk factors associated with the manual material handling task through task analysis.

> 1. 1 Analyze posture required to complete the task using the Chattanooga Lumbar Motion Monitor.
>
> 1.2 Evaluate the results from the task analysis and Lumbar motion monitor.

2.0 Recommend solutions regarding safer more ergonomically correct procedures that will reduce and/or eliminate the potential for injury and illness.

Conclusions – Objective 1.0

Awkward posture and excessive force were identified as the ergonomic risk factors associated with this task. The CLMM revealed that sagittal or forward flexion was a significant factor and that the average probability of lower back injury associated with this task was 52%. It is important to note that a significant amount of force is required to move the rolls from the floor to an elevated surface given the weight of the material. And although there have been no recordable incidents and/or no recorded workers compensation claims associated with this adhesive rolls handling task the data indicates that this task possesses the potential to cause both financial and human resource loss. Therefore appropriate engineering and/or administrative controls are necessary to reduce the potential for loss within the identified area.

Conclusions – Objective 2.0

The following recommendations are based on the need to reduce risk, space availability, the safety of the workers, and the environment for which they are proposed. Quality, productivity and material were also considered in the process. Although engineering methods are preferred, administrative controls were found to be the most effective control at this time.

It is recommended that the large 2000 pound rolls stored on the second tier of shelving be moved to the lower, floor shelf and the rolls in question moved to the second tier of shelving. This necessitates the need to use a fork truck to move the pallets to the center isle and eliminates the potential for employees to bend underneath the shelving to retrieve a roll of material.

The second modification in procedure involves the use of a manipulator, which is located at the end of the warehouse. It is recommended that once the pallet of material is removed from the shelf it be transported to the manipulator. Here the employee will utilize the manipulator to remove the rolls of material from the storage pallet to a transport pallet. The storage pallet is then placed back on the shelf and the process is repeated to complete the order. Upon filling the order the transport pallet is brought to the MFF and IFF lines where a second existing manipulator is utilized to unload the material.

Recommendations

The strengths of the proposed recommendations include the elimination of excessive force and awkward posture from the task. By eliminating the risk factors the potential for injury and illness is reduced significantly. Strengths also include cost effectiveness. Costs will only arise from the time it takes workers to rearrange the pallets, which would be estimated at 2 to 3 hours. The manipulators and fork trucks mentioned earlier are already in existence thus requiring no additional equipment. Further strengths include the accommodation of all workers completing this task.

The limitations of the proposed recommendations are that potential remains for the employee to deviate from the procedure and move the rolls by the hand. The effectiveness will depend on management's commitment to procedure and improving existing ergonomic conditions. Another limitation may include an increase in time to fill an order. However, it is estimated that it can be accommodated into the job description as there is no incentive for productivity and that the additional time will only be approximately 5-8 minutes per order.

The effectiveness of these changes should be evaluated after six months and a year by the ergonomics team at 3M. They will be given criteria and evaluation based on efficiency and effectiveness. It is suggested that the ergonomics team consider the following in their evaluation.

1. Review reduced injury/illnesses potential.
2. Meet with employees who complete the task regarding satisfaction, discomfort, and suggestions (giving them an opportunity to be involved in the process).
3. Evaluate productivity for changes ie.. Increases or decreases.

It should be noted that these modifications may take time to be accepted and there may be hesitation by the workers to comply. However, keeping them informed and updated and considering their input regarding the situation will assist in acceptance. Further, satisfaction by the workers should increase, as discomfort from the task should be reduced significantly.

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