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ERGONOMIC EVALUATION OF A CABINET MANUFACTURING FACILITY

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ABSTRACT

A Health Hazard Evaluation was conducted by researchers from the National Institute for Occupational Safety and Health, Division of Safety Research at a cabinet manufacturing facility. Company management requested the evaluation due to a high incidence of musculoskeletal disorders that were thought to be job related. Ergonomic assessments of selected jobs in raw material handling, sawing operations, frame assembly, sanding and painting, cabinet assembly, and the packaging-shipping departments were performed. Company log of injuries and company injury surveillance data were reviewed. Jobs were identified that imposed potentially stressful biomechanical demands on the workers. These included heavy lifting, pushing and transporting heavy loads, fatiguing postures, repetitive lifting involving twisting the trunk and excessive reaching, and repetitive motions of the trunk and upper limbs. Survey data indicate that manual material handling jobs, repetitive motion tasks, and operation of saws, planers, and sanders are potential hazards. Recommendations to reduce injury risk are to provide basic safety training for all employees, and redesign equipment to reduce stress during heavy lifting, transporting loads, and while performing repetitive tasks.

INTRODUCTION

This report summarizes observations and analyses of jobs and tasks made during a site visit by the National Institute for Occupational Safety and Health (NIOSH) Division of Safety Research (DSR) under a Health Hazard Evaluation (HHE) conducted at a cabinet manufacturing company.

The facility employs approximately 450 full-time workers, 425 union and 25 salaried (non-union). The 300,000 square-foot facility is situated in three different structures: two relatively new buildings where rough material is prepared for cabinet assembly and one ''turn of the century'' three-story structure with wooden floors that is used for sanding, painting, final assembly, storage, and packing-shipping operations.

Although many tasks at this manufacturing facility have been automated and new work stations have been ergonomically designed, many tasks still require the workers to push, pull, lift, and carry heavy materials. A large portion of the material is manually conveyed from department to department using small manual transport trucks with steel wheels. The loaded trucks normally weigh 300 to 1000 lb. Manual material handling tasks performed by workers stacking ''green'' or ''kiln-dried'' lumber require lifting and carrying 50 to 60 lb loads and pushing or pulling ''stacking bunks'' filled with kiln-dried lumber. These stacking bunks can weigh more than 4,000 lb. Furthermore, many of the tasks require the workers to handle these heavy loads repeatedly. These repeated motions place these workers at risk for upper extremity cumulative (repetitive) trauma disorders (CTDs), as well as musculoskeletal sprains/strains to the back.

The purpose of this paper is to present the results of a detailed ergonomic survey conducted at a cabinet manufacturing facility, and to list general recommendations to resolve some of the major work-related musculoskeletal and traumatic injury hazards associated with cabinet manufacturing.

METHODS

Facility management requested assistance in identifying and resolving potential hazards their employees were exposed to during their work shift. After a briefing and organizational overview by the plant manager, a tour of the plant was conducted by the facility's industrial and safety engineers. These engineers also presented an overview of the facility's safety and ergonomics program, and their computerized injury surveillance system. Data generated from this system for the years 1986 through 1988 were analyzed by DSR to identify those jobs and tasks that were potentially hazardous to the workers.

Following the review of injury data, a second plant tour was conducted to collect ergonomic/biomechanical data and to identify potential hazards in the workplace. Workplace analysis included: taking videotape and 35 mm photographs of the workers; collecting workstation measurements; measuring static force exertions, weights of items that had to be manually handled, and pushing force exertions with a Chatillon force transducer; and, conducting a variety of informal interviews with the workers at risk for injury. Thirty-six tasks were videotaped, 17 were reviewed. The review of the seventeen tasks, which represented all major components of a complete cycle, included a task description, a list of required job factors, and comments on the potential for musculoskeletal and traumatic injuries in each job. Once the reviews were completed, a taxonomy of selected operations with respect to risk of injury was developed. The other 19 tasks were variations of the major ones.

Of the seventeen tasks, five were chosen for further analysis. The five tasks were: (a) performing manual material handling at the defect cut saw table, lifting and loading (b) small and (c) large cabinets, (d) pushing "stacking bunks", and (e) pushing transport trucks. These tasks were determined to be potentially hazardous by a review of injury data, identification of risk factors in each job, and by the discussions with employees and supervisors. Three tasks were chosen for biomechanical analysis using the NIOSH Work Practices Guide for Manual Lifting (1) and the University of Michigan, 2-D Static Strength Biomechanical Analysis Program (2). Two pushing tasks were analyzed by comparing pushing force data to normative tables developed by Snook (1978) (3).

Specific recommendations for reducing musculoskeletal stressors for the five previously mentioned tasks are included in the Discussion section. General considerations and recommendations to reduce the potential risk factors for the remaining 12 tasks are noted in the Summary AND Recommendations sections.

FINDINGS

Analysis of the company's injury statistics revealed that during the period January 1986 through December 1988, a total of 276 OSHA-reportable injuries were noted in the injury log for the facility. A total of 135 (49%) were related to lacerations, sprains/strains (other than back), bursitis, tendonitis or numbness in the upper extremities, 58 (21%) were back sprains/strains, and less than 10% each for foot/ankle, lower extremity, neck/head, and eye injuries. Seventy percent of the injuries sustained by the workers at the plant occurred during their first year of employment. Forty-three percent occurred within 6 months of employment, 16% occurred within the first month of employment and approximately 10% occurred the first day on the job. The analysis also revealed that the occupations of manual material handling (MMH) and machine operation had the highest rates of injury (7.8 and 6.8 per 100 FTEs, respectively).

Lifting Task Analysis

Ergonomic analyses for three lifting tasks and two pushing tasks were completed using the NIOSH Work Practices Guide. The action limit (AL) and maximum permissible limit (MPL) values for these three tasks were calculated. Those tasks which exceeded the AL and/or the MPL are shown in Table 1.

The low-back compression forces at the L5-S1 disk were calculated using the University of Michigan 2-D model. Disk compressive forces that exceed the guidelines provided by the NIOSH Work Practices Guide are shown in Table 2.

Pushing Task Analysis

An analysis of selected pushing tasks performed at the plant was completed. Direct measurements of pushing forces (using a Chattilon force transducer) that were required for the NIOSH researcher to accomplish the work task were collected. The pushes were conducted in the same postures and with the same pushing techniques that the workers used to move the carts. The pushes were duplicated until a series of three were within 10% of one another. This average value is used as the actual value (in Table 3) required to move the stacking bunks and transport carts. This actual value is compared in Table 3 to normative data developed by Snook for 50th-percentile males and females (3). Although no women were observed pushing the stacking bunks, these data are presented to provide an indication of the physical requirements if a woman would bid on this job or if management would assign a woman to this job.

Table 1. NIOSH Work Practices Guide: Action limit and maximum permissible limit values.

Small Cabinet Load Tasks	Actual Load	AL	MPL
(Weights up to 50 pounds)			
Cabinet Load (Low Height)	50	39*	117
Large Cabinet Load Tasks			
(Weights up to 150 pounds)			
Cabinet Load (Low Height)	150	39*	117**
Cabinet Load (Medium Height)	150	63*	189
Cabinet Load (Shoulder Height)	150	59*	178
Cabinet Load (Overhead)	150	54*	162

Key: * = Weight of Lift Exceeds Action Limit
** = Weight of Lift Exceeds Maximum Permissible Limit

Table 2. Low back compression forces for the 50th percentile male and female.

	L5-S1 Compression Forces, pounds	
Small Cabinet Load Tasks	Male	Female
(Weights up to 50 pounds)		
Cabinet Load (Low Height)	936*	774*
Large Cabinet Load Tasks		
(Weights up to 150 pounds)		
Cabinet Load (Low Height)	1887**	1633**
Cabinet Load (Medium Height)	1274*	1086*
Cabinet Load (Shoulder Height)	1152*	1011*
Cabinet Load (Overhead)	1158*	1015*

Key: * = Exceeds the NIOSH Action Limit (770 pounds) for disk compressive force.
** = Exceeds the NIOSH Maximum Permissible Limit (1430 pounds) for disk compressive forces.

Table 3. Initial and sustained pushing forces, pounds.

Pushing Task	Actual Init./Sust.	50th-percentile Male Max. Accept. Init./Sust.*	50th-percentile Female Max. Accept. Init./Sust.*
8 ft stacking bunk (empty)	158/119	114/77	77/55
8 ft stacking bunk (full)	235/176	114/77	77/55
12 ft stacking bunk (full)	320/240	114/77	77/55
16 ft stacking bunk (full)	500**	114/77	77/55
Transport cart (low height)	58/27	103/75	70/53
Transport cart (medium height)	58/27	114/77	83/55
Transport cart (shoulder height)	58/27	114/77	77/55

Note: All "stacking bunk push" tasks are performed at shoulder height.

Key: * = Calculations are based on a single push every 5 minutes over a distance of 2.1 meters.
** = The stacking bunks that were over 12' long could not be moved by a single person. The manual push force applied to these stacking bunks exceeded the 500-pound limit of the force measurement device.

DISCUSSION

Manual Material Handling at the Defect Saw Cut Table

The calculated L5-S1 compressive forces do not exceed the AL or MPL, but the repeated manual lifting and carrying represents a risk for the material handlers (35% of injuries or 7.8 injuries per 100 workers) to develop cumulative trauma disorders, sprains/strains to back, lower extremities, and shoulders, sustaining injuries from slips, trips, and falls, and having objects fall on their feet. As part of a workplace redesign, a job analysis should be performed and the the material flow from the "gang" saw cut line should be re-evaluated. This should include the material flow onto the conveyor and also onto the defect saw cut table.

Possible solutions include:

1. Reorganize the task to have the longer boards lifted from the conveyor line first and let the shorter ones proceed to the end of the conveyor. This would minimize the need for all manual material handlers to sort through all the boards on the conveyor line.
2. Install a deflector at the end of the conveyor so the shorter boards will be forced toward the near end of the conveyor. This will eliminate the workers from stretching to grasp onto the shorter boards.

Small Cabinet Lifting Task

Loading fifty-pound cabinets that are sitting on the floor produces L5/S1 compression forces that exceed the AL. Moving these same cabinets from medium heights and shoulder heights do not present a significant problem for a single lift, but if the task is repeated more than two times per minute, then the risk of injury increases.

Possible solutions include:

1. Keep all finished cabinets on platforms or conveyors that are 18 inches above the floor.
2. Provide mechanical material handling devices to move and load the finished cabinets, e.g. overhead cranes.
3. Provide rotating platforms and roller conveyors to move the finished cabinets from shipping to packing and onto the delivery trucks.

Large Cabinet Lifting Task

Loading large, heavy (150 pound) cabinets that are sitting on the floor produces L5-S1 compression forces that exceed the MPL. Moving these same cabinets from medium heights, shoulder level, and overhead exceed the AL. Repeated lifting of these large, heavy cabinets produces significant compression forces on the L5-S1 disk of both male and female workers. Therefore, these workers are subjected to back stresses that increase their risk for injury. The tasks that exceed the AL require administrative and/or engineering controls to reduce the risk of injury, as per the 1981 Work Practices Guide. The tasks that exceed the MPL require engineering controls to reduce the risk of injury.

Possible solutions include:

1. Keep all finished cabinets on platforms or conveyors that are 18 inches above the floor.
2. Provide mechanical material handling devices to move and load the finished cabinets.
3. Provide rotating platforms and roller conveyors to move the finished cabinets from shipping to packing and onto the delivery trucks.

Stacking Bunk Push Task

Pushing the empty and fully loaded 8 ft, 12 ft, and longer length stacking bunks presents a potential risk for musculoskeletal injuries for both males and females. The forces needed to push these stacking bunks to the pick-up area are excessive when compared to maximum acceptable push/pull forces determined by Snook. Therefore, these tasks need administrative and engineering controls to reduce the risk of injury, as per the 1981 Work Practices Guide.

Possible solutions include:

1. Install a winch and/or pulley device to pull the stacking bunks to the pick-up area.
2. Consider other material handling equipment to minimize manual handling of these stacking bunks.
3. Purchase lighter stacking bunks.
4. Install larger wheels on the stacking bunks.
5. Repair the floor to improve the rolling surfaces on which stacking bunks move.

Transport Cart Push Task

Forces required to push the loaded transport cart do not exceed the normative data described by Snook for both males and females. However, considering the repetitive nature of the task and the uneven floor surfaces in the plant, the peak forces exerted by the workers on the carts may exceed Snook's acceptable values and increase their risk of injury.

Possible solutions include:

1. Fabricate permanent handles that are at or above knuckle height. (Approximately 36 inches from the floor.)
2. Purchase transport carts with larger diameter wheels. (Approximately 12 to 18 inches in diameter.)
3. Ensure that all transport carts are well maintained and wheel bearings are lubricated.
4. Eliminate uneven floor surfaces in the plant.

SUMMARY

In general, all tasks that require bending down (trunk flexion) while lifting, lowering, pushing, and pulling should be eliminated through job design and/or redesign. Also, all tasks that are high frequency and require forceful exertions by the upper extremities (while bending the wrist or pronating/supinating the forearm) should be redesigned since continued performance of the jobs in their current configuration may lead to cumulative trauma disorders.

RECOMMENDATIONS

The following general recommendations present ergonomic considerations for minimizing risk factors associated with sustained postures, overexertion, lifting/carrying, sudden movements, and repetitive motion or cumulative trauma disorders. Therefore, these ergonomic recommendations for job redesign are aimed at adjusting the workplace layout and requirements to better match human capabilities.

1. Provide for work station adjustability by installing work surfaces that can be individually adjusted by the worker. In general, the working height should be 1-2 inches below standing elbow height.

2. Reduce pulling and pushing tasks over rollers or flat surfaces (by either one or two hands) by installing powered conveyors that deliver the part to the place of operation.

3. Orient the materials being handled in a way that gravity may be used to assist the movement of the parts.

4. Align the assembly and production lines so horizontal and vertical positioning operations are eliminated. All material and sub-assemblies should be delivered to the place of assembly at the height that eliminates the need for lifting in general, but especially at arm's reach. The part should be oriented at the height that requires minimal muscle power to position and remove the material or sub-assembly from a given machine or jig.

5. Reduce the need to bend the trunk while lifting objects from the floor or from lower than waist level (or while lowering) by installing lift tables that rotate, if possible.

6. Install mechanical fixtures that allow the transfer of material, sub-assemblies, and finished cabinets without involvement of human power.

7. Ensure that transport carts are mechanically safe and in good working order. Also standardize the transport cart corner post heights at 36 to 40 inches and fabricate these posts out of material that is other than "scrap". The use of scrap results in a variety of handle heights and poses the possibility of the scrap pieces breaking due to inherent defects in the lumber.

8. Examine the material flow in the defect saw cut line and in the sanding operations to eliminate non-productive and hazardous unloading and loading of material, sub-assemblies, and finished cabinets.

9. Use jigs and fixtures whenever possible to hold and orient components; re-sequence jobs to reduce repetition; automate highly repetitive operations; and allow self-pacing of work when possible.

10. Provide as many tools as possible. They should be designed for minimal muscular effort and their center of gravity should be located close to the body to reduce fatigue. Power tools should be used to reduce the amount of human force and repetition required. When possible,the tools should be purchased which allow the wrist to remain in a neutral position during work tasks, i.e. bend the tool handle, not the worker's wrist. Keep the weight of the tool as low as possible, or use ceiling mounted anchors to help support the tool.

11. Provide basic safety training during job orientation. Conduct this training before the employee begins work in the factory and periodically as a refresher course. Include information on body mechanics, safe lifting, care of the back/neck, machine safety, and first aid measures for lacerations, contusions, and other musculoskeletal injuries. Periodic refesher training should be conducted for all employees.

12. Allow new employees to start at a slower pace so they can become conditioned prior to assuming full work capacity. Allow frequent rest pauses to provide relief for the most active muscles.

Additional information regarding the task analysis is contained in the full NIOSH HHE report (4).

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