Ergonomic Evaluation of Workers at a Cabinet Mill and Assembly Plant

Jessica Ramsey, MS

Bich Dang, MD

Daniel Habes, MSE, CPE

Health Hazard Evaluation Report
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DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention

NIOSH *National Institute for Occupational Safety and Health*

The employer shall post a copy of this report for a period of 30 calendar days at or near the workplace(s) of affected employees. The employer shall take steps to insure that the posted determinations are not altered, defaced, or covered by other material during such period. [37 FR 23640, November 7, 1972, as amended at 45 FR 2653, January 14, 1980].

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Abbreviations

HHE	Health hazard evaluation
MSD	Musculoskeletal disorder
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
RCB	Revolving cabinet base
RNLE	Revised NIOSH Lifting Equation
WMSD	Work-related musculoskeletal disorder

Highlights of the NIOSH Health Hazard Evaluation

The National Institute for Occupational Safety and Health (NIOSH) received a management request for a health hazard evaluation at Yorktowne Cabinets in Mifflinburg and Red Lion, Pennsylvania. Site visits were performed in December 2006. NIOSH evaluated potential ergonomic hazards and explored ways to decrease the number of work-related musculoskeletal injuries.

What NIOSH Did

- We interviewed workers about their work and medical history, and any history of work-related musculoskeletal disorders to determine the scope of injuries occurring at the plants.
- We looked at Occupational Safety and Health Administration injury logs and workers' compensation data.
- We watched workers milling, assembling, and shipping cabinets.

What NIOSH Found

- We found that workers use high force, awkward postures, and repetitive motions that increase their risk for developing musculoskeletal disorders.
- We found that workers with work-related aches and pains usually do not report them until they are severe.

What Yorktowne Managers Can Do

- Managers should provide employees with adjustable tables and adequate workspace to complete job tasks.
- Managers should provide assist devices such as jigs, vices, and carousel stands that hold and rotate work objects to reduce awkward or extreme body postures.
- Managers should select lightweight tools, properly designed for each task, to decrease required force and improve wrist posture.
- Managers should reduce vibration exposure by providing tools with low vibration frequency and properly maintaining those tools. Managers should schedule rest breaks and rotate employees to work tasks that do not involve vibration exposure.
- Managers should create a routine maintenance program for tools and carts.
- Managers should provide training for workers so they can spot unsafe work practices and recognize early signs of injury.

What Yorktowne Employees Can Do

- Employees should promptly report injuries or unsafe work conditions to management.
- Employees should take the time to work safely and lift properly.
- Employees should become involved with safety and ergonomic groups.

Summary

Most workers are exposed to a combination of risk factors for developing musculoskeletal disorders. Risk factors include high forces, awkward postures, and repetitive motions. The use of adjustable tables and carts, as well as improved workplace and tool design would reduce physical stresses and the risk of musculoskeletal injury.

On October 24, 2006, NIOSH received an HHE request from management at Yorktowne Cabinets, Inc. to evaluate potential ergonomic hazards at the Mifflinburg, Pennsylvania mill and the Red Lion, Pennsylvania assembly plant. Continued workers' compensation claims for MSDs despite attempts by management to control injuries prompted the request.

On December 4–8, 2006, NIOSH investigators conducted site visits. On December 4, 2006, NIOSH investigators held an opening conference with management, employee, and union representatives. NIOSH ergonomists performed walk-through surveys of the work areas at both facilities to observe the typical job tasks. The NIOSH physician conducted confidential medical interviews and reviewed OSHA's Form 300 Log of Work-Related Injuries and Illnesses and workers' compensation data. NIOSH investigators held closing conferences at each facility and provided preliminary recommendations to those who attended.

NIOSH investigators found that workers are exposed to a combination of risk factors for MSDs involving the upper extremities and low back. Work tasks requiring highly repetitive motions, extreme and awkward postures, and forceful exertions for upper extremities; and heavy lifting, bending, and twisting for low back were observed. Workstation and tool designs that place workers at risk for MSDs include low work heights, non-adjustable workstations, heavy tools, and excess vibration exposure. The OSHA Log review indicated that most entries were MSDs involving the upper extremities. Thirty of the 33 interviewed workers reported work-related musculoskeletal pain or discomfort. Of these 30 injuries, 26 involved the upper extremity.

Recommendations for reducing the risk of injury are contained in this report. The use of adjustable tables and carts and improved workplace and tool design would eliminate or significantly reduce the physical stresses associated with the observed job tasks.

Keywords: NAICS 337110 (Wood Kitchen Cabinet and Countertop Manufacturing), repetitive motions, work-related musculoskeletal disorders, ergonomics, bending and reaching.

On October 24, 2006, NIOSH received a health hazard evaluation request from the Safety and Environmental Manager at Yorktowne Cabinets, Inc. in Mifflinburg, Pennsylvania, to evaluate potential ergonomic hazards among cabinet makers. The request was prompted by continued workers' compensation claims filed for MSDs despite attempts by management to decrease the number of injury occurrences.

On December 4–8, 2006, NIOSH investigators conducted site visits at the mill in Mifflinburg, Pennsylvania, and the assembly plant in Red Lion, Pennsylvania. The NIOSH team consisted of a physician and two ergonomists. On December 4, 2006, NIOSH investigators held an opening conference with management, representatives from the facilities' ergonomics team, and the President of the United Brotherhood of Carpenters Local 2837. NIOSH investigators toured the manufacturing areas to observe specific sorting, machining, sanding, and door/frame building tasks at the Mifflinburg mill; and specific assembly, parts pulling, and machining tasks at the Red Lion assembly plant. Also, NIOSH investigators conducted confidential medical interviews with the cabinet workers at both locations and reviewed OSHA Logs and workers' compensation data for the past 5 years. On December 8, 2006, NIOSH investigators held a closing conference and provided preliminary recommendations.

Process Description

Yorktowne Cabinets, Inc., owned by Elkay Manufacturing Company, is one of the nation's largest producers of semi-custom cabinetry, with distribution east of the Mississippi River. It consists of three facilities: a dimension mill in Mifflinburg, Pennsylvania and two assembly plants, one in Red Lion, Pennsylvania and another in Danville, Virginia.

The process begins at the mill in Mifflinburg where green lumber is dried and goes through a series of dimensioning processes. Molders cut various widths and lengths to finer sizes. The final process at the Mifflinburg plant involves the production of all frames, doors, and drawer components with woodworking machinery in preparation for shipment to one of the two Yorktowne assembly plants. When components arrive at the assembly plants, they are fine milled, assembled, finished, and shipped to customers.

INTRODUCTION (CONTINUED)

NIOSH investigators focused on the dimension mill in Mifflinburg, Pennsylvania and the assembly plant in Red Lion, Pennsylvania. The Mifflinburg mill employs approximately 230 workers over three shifts, with the third shift primarily involving maintenance tasks. The Red Lion assembly plant employs approximately 225 workers over three shifts, with the third shift primarily involving the finishing operations. Workers at both plants are represented by the United Brotherhood of Carpenters.

ASSESSMENT

NIOSH investigators conducted a walk-through assessment of the mill and assembly plant to observe the processes of machining and building cabinet component parts, assembling cabinets, and shipping finished components. Digital videos and measurements of work station heights and reach distances were taken to document the tasks performed by the workers.

NIOSH investigators reviewed OSHA Form 300 Logs of Work-Related Injuries and Illnesses from 2002–2006 and workers' compensation data from 2002–2006. In addition, the NIOSH physician performed confidential medical interviews with employees serially selected from an employee roster for all production departments. In cases where selected employees were not able to participate, management selected employees known to have a WMSD.

Interview questions concerned personal characteristics, medical history, job duties, and WMSDs. Employees experiencing pain or discomfort were asked whether the problem interfered with their ability to perform their job, caused them to see a physician or chiropractor, or caused them to miss days of work or to be placed on restricted work duty. Employees were also asked to identify the location of their pain or discomfort on a body map.

Ergonomic Evaluation Criteria

The term MSDs refer to conditions that involve the nerves, tendons, muscles, and supporting structures of the body. WMSDs are a major component of the cost of work-related illness in the United States. A substantial body of data exists providing strong evidence of an association between MSDs and certain work-related factors (physical, work organizational, psychosocial, individual, and sociocultural). The multifactorial nature of MSDs requires a discussion of individual factors and how they are associated with

WMSDs. There is strong evidence that working groups with high levels of static contraction, prolonged static loads, or extreme working postures involving the neck/shoulder muscles are at increased risk for neck/shoulder MSDs [NIOSH 1997]. There is also strong evidence that job tasks that require a combination of risk factors (highly repetitious, forceful hand/wrist exertions) increase risk for hand/wrist tendonitis [NIOSH 1997]. Lastly, there is strong evidence that low-back disorders are associated with work-related lifting and forceful movements [NIOSH 1997]. A number of personal factors can also influence the response to risk factors for MSDs including: age, gender, smoking, physical activity, strength, and anthropometry. Although personal factors may affect an individual's susceptibility to overexertion injuries/ disorders, studies conducted in high-risk industries show that the risk associated with personal factors is small compared to that associated with occupational exposures [NIOSH 1997].

In all cases, the preferred method for preventing and controlling WMSDs is to design jobs, workstations, tools, and other equipment to match the physiological, anatomical, and psychological characteristics and capabilities of the worker. Under these conditions, exposures to task factors considered potentially hazardous will be reduced or eliminated.

The specific criteria used to evaluate jobs were workplace and job design criteria found in the ergonomics literature and recommendations for acceptable lifting as determined by the RNLE [Waters 1994].

Workstation design should directly relate to the anatomical characteristics of the worker. Since a variety of workers may use a specific workstation, a range of work heights should be considered. Based upon female/male 50th and 95th percentile anthropometric data, workstation heights should be within a range of 27.6 inches to no higher than 60 inches [Kroemer 1989]. These heights correspond to knuckle and shoulder dimensions of U.S. civilians, age 20 to 60 years.

The RNLE is a tool for assessing the physical demands of two-handed lifting tasks. The equation provides a recommended weight limit and lifting index for a lifting task, based upon the lifting conditions [Waters 1994]. The RNLE recommends when initiating a lift that the vertical height of the hands above the floor should be 30 inches (75 cm). A height of 30 inches above the floor

is considered "knuckle height" for a worker of average height. The RNLE also states that in ideal lifting conditions, the maximum recommended weight limit is 51 pounds. Therefore, a worker should not lift anything over 51 pounds without assistance from another worker [Waters 1994].

RESULTS AND DISCUSSION

Mifflinburg, Pennsylvania Dimension Mill

Department 61 – Lumberyard

Workers at the lumberyard receive, grade, dry, and sort raw lumber. During the walk-through tour of this area, management stated that adjustable lift tables and new machines to eliminate manual material handling were expected in January 2007. Because of these planned changes, NIOSH investigators did not evaluate this area.

Department 62 – Rough Mill

Lumber is cut to appropriate lengths and widths in the rough mill. Currently, employees visually inspect and manually mark the wood with a crayon. To inspect all four sides in a timely manner, this process requires fast flipping of the wood and results in radial and ulnar deviation of the wrist. The machine reads the crayon mark with a scanner and cuts at the marks. Management stated that this area would be receiving new machines. The new machines will eliminate the manual handling; an embedded scanner will recognize defects in the material and cut without the need for flipping and marking.

In the ripping area, a worker receives a large skid of wood from a forklift truck. The worker manually lifts each piece to a roller conveyor, lines up the wood with the appropriate stop to make a specific length cut, makes the cut, and slides the cut piece down the roller conveyor to another worker who stacks the material on carts according to length. On the day we observed this task, the initial skid of wood was stacked high enough to cause the worker to fully extend the shoulder (Photo 1).

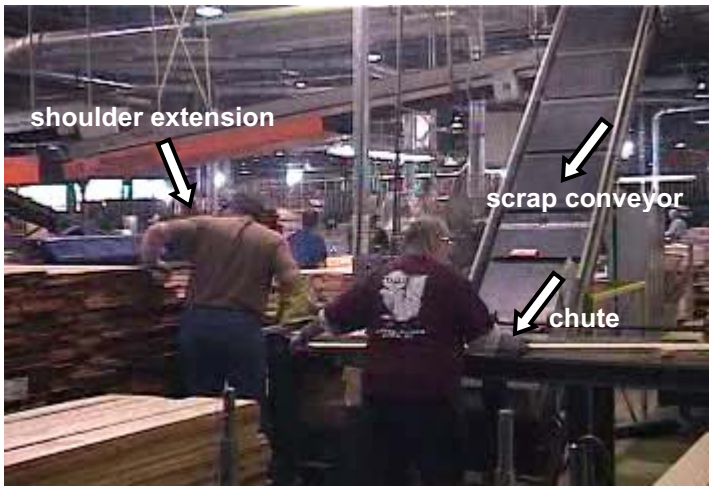

Photo 1. Stack height of wood is high, requiring full shoulder extension.

As pieces of wood are removed, eventually the stack height decreases and causes the worker to bend obliquely at the waist when lifting wood pieces to place on the roller conveyor.

A specific job task which we believe increases the likelihood of shoulder discomfort involves the process of discarding scrap pieces onto the scrap conveyor. On the right side of the saw, the worker slides the scrap piece down a chute and it falls onto a scrap conveyor. If the scrap piece is on the left side of the saw, the worker picks up the piece and throws it onto the scrap conveyor. This repetitive left hand throwing motion can lead to shoulder strain among workers who perform this task.

Department 63 – Final Machining

Final machining is performed after the rough milling process. Workers cut the wood to final length, run the wood through molding machines, and assemble door blanks. The saw operators, machine loaders, and material handlers do not have height-adjustable carts (Photo 2). Some of the carts are modified with pallets to elevate the wood stacks to a more appropriate height.

Molders place separators between the stacks of wood on the output carts. Separators are pieces of scrap wood that divide the stacks of molded wood to prevent damage and warping. The separators are located on the floor behind the worker (Photo 3), causing the worker to walk back and forth between the separators and the output cart and to twist and bend below knee height to pick up the separators.

Photo 2. Carts without height adjustment.

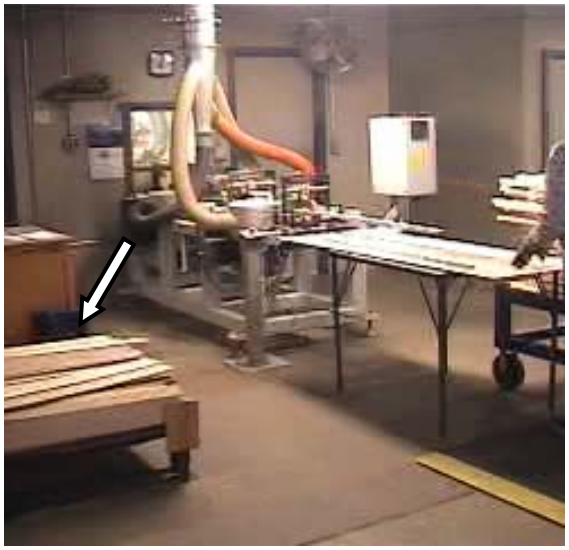

Photo 3. Separators located on floor behind worker.

Clamping machines make blanks, which are glued pieces of wood that are cut down and sanded to make a cabinet door. A worker loads pieces of wood of various sizes onto a rolling conveyor. The pieces of wood pass under an Optisizer that measures the size of the piece and picks the appropriate number of pieces of wood to make a certain size blank. The Optisizer sends those specific pieces down the conveyor, over a glue roller, to another worker who must

reach forward to pull the stacks of wood together (Photo 4a), pick them up (Photo 4b), and place them on the clamping machine. At the clamping machine, the worker reaches forward again to place the pieces toward the top (Photo 4c).

Photo 4a. Forward reaching motion to pull stacks of wood together.
Photo 4b. Wrist flexion and ulnar deviation when picking up stacks of wood.
Photo 4c. Forward reaching motion to load the clamping machine.

A frame holds the pieces while the worker pushes a button to tighten the clamp that holds the pieces in the frame while the glue dries. After the pieces are dry, the worker places the blanks onto a cart. To reduce the amount of walking, the worker usually stacks two blanks and carries both to the cart. Each blank can weigh up to 30 pounds; when workers carry two blanks at a time, the weight is up to 60 pounds.

Both of the roller conveyors have a "diverter bar" to merge wood pieces together. However, the current configuration of one of the diverter bars is not positioned correctly and requires the worker to reach forward to reposition the wood pieces closer to the edge before lifting (Photo 4a).

In one section within the area where blanks are made, an Optisizer and glue roller are not used and a worker must manually dip the pieces of wood in glue and place them on a table for another worker to load the clamping machine (Photo 5). When performing manual glue dipping, the workers use an awkward wrist posture including wrist flexion and ulnar deviation. Also, there is no pneumatic system so the workers manually tighten the clamp, resulting in high grip force and repetitive motion.

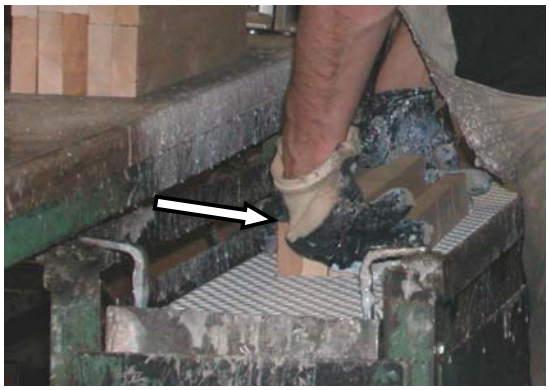

Photo 5. Wrist flexion and ulnar deviation while dipping wood in glue.

Department 64 – Front Frames

Workers in this area sand and assemble machined pieces into cabinet front frames. The tilt tables used to build the frames are angled so that workers must reach forward above shoulder height when installing screws in the top corners of the frame.

Department 65 – Door Assembly

In the parts pull area, workers retrieve pieces from storage shelves to be sanded and assembled into finished doors. Several larger pieces are located at the top of the shelves, requiring workers to climb ladders to retrieve materials and descend the ladder with heavy pieces carried overhead. Conversely, small pieces are located at the bottom of the shelves, resulting in excessive bending.

In the area where long pieces are mitered, workers balance long pieces of wood to hold them in the correct position for the miter saw. Workers mitering long pieces do not have a roller stand to hold the ends and must use their upper extremity to hold the piece in place.

In the miter pin door line area, workers use pneumatic staplers to assemble cabinet doors. Management instructed workers to hold and flip the door with their non-dominant hand and keep their dominant wrist neutral while stapling the door components together. However, workers must fully extend their non-dominant arm above shoulder level to perform this maneuver, which increases the risk for shoulder injuries (Photo 6).

Photo 6. Worker flipping door during assembly.

To minimize shoulder fatigue, workers hold the doors stationary and rotate the stapler with their dominant wrist instead. Although this wrist bending motion alleviates shoulder discomfort, it increases the risk for wrist injuries in their dominant hand.

Sanding, including hand sanding, is performed before the pieces are shipped to the assembly plants for finishing. Some of the workers manually sand cabinet components while others use electric-powered orbital sanders. To do the job correctly, workers using orbital sanders palm-grip the top of the sander and hold palm pressure on the trigger (Photo 7). Workers exposed to continuous tool vibration and palm-grip reported upper extremity pain and numbness, as well as loss of grip strength.

Photo 7. Worker using orbital sander.

Workers performing manual sanding have sets of hand sanding tools, but reported not using them for two reasons: the tools' sanding surfaces are not properly designed to fit into intricate

grooves of the wood and/or the tools' handles are not well contoured and push into the palm of the hand. Workers overcome these issues by using small pieces of sand paper to sand within the grooves; however, this motion requires a pinch grip that they reported causing pain and discomfort.

Neither set of workers performing sanding have height-adjustable work surfaces or height-adjustable carts, and frequently bend to pick up incoming pieces and put down outgoing pieces.

Medical Interviews

The NIOSH physician interviewed 19 cabinet workers at the Mifflinburg mill. Six of 19 employees were selected by management; the others were serially selected from an employee roster. Among the employees interviewed, the average age was 48 years (range: 29 to 62 years), and the average time employed at Yorktowne was 13 years (range: 4.5 to 27.5 years). Eighty-nine percent (17 of 19) of employees interviewed reported some type of musculoskeletal pain or discomfort within the last year that they related to work. There were 15 reports of symptoms involving the upper extremity (fingers, hand/wrist, elbow/forearm, shoulder), one neck, one back, and one lower extremity. Eight of the 19 employees interviewed reported seeing a physician or chiropractor within the past year for work-related musculoskeletal pain or discomfort. Three out of the 19 interviewed employees had been diagnosed with carpal tunnel syndrome and three additional employees reported finger tingling and numbness and/or loss of grip strength, all symptoms which have been associated with nerve involvement. One employee reported missing work within the past year for work-related musculoskeletal issues. Another employee transferred to a different department because of work-related musculoskeletal problems.

OSHA 300 logs

NIOSH investigators reviewed OSHA Logs and found that most entries were MSDs (not including acute injuries such as fractures, laceration, punctures or contusions). From 2002 through 2006, 52% (38 of 73) of the OSHA-recordable MSDs at the Mifflinburg mill involved the upper extremity. OSHA Logs documented 32 MSDs in 2006 (18 upper extremity, 5 lower extremity, 4 groin, 3 back, 1 neck, 1 abdomen); 33 in 2005 (21 upper extremity, 7 back, 2 lower extremity, 2 groin, 1 neck); 25 in 2004 (15 upper extremity, 3 back, 5 lower extremity, 1 groin, 1 hip); 19 in 2003 (9 upper extremity, 6 lower extremity, 3 back, 1 unspecified body part); and

41 in 2002 (22 upper extremity, 9 lower extremity, 8 back, 1 neck, 1 pelvis).

Workers Compensation Data

The Mifflinburg mill reported 12 workers' compensation claims for MSDs in 2006, 16 in 2005, 8 in 2004, 9 in 2003, and 8 in 2002.

Red Lion, Pennsylvania Assembly Plant

Mill

Fine milling is performed on pieces received from the dimension mill in Mifflinburg, Pennsylvania. In the parts storage area, pieces are shelved at various heights. Often larger, heavier pieces are stored above shoulder level and smaller, lighter pieces are stored below knee level of the average worker. This current storage method causes workers to reach overhead or bend repeatedly during the work shift.

The flow line area contains a series of machines that cut shelf holes and other notches in the cabinet components. At the beginning of the flow line, raw materials are delivered by a roller conveyor. The roller conveyor does not transport materials directly to the first machine; therefore workers must manually lift each piece from the conveyor and carry it to the first machine (Photo 8). When the worker cannot keep up with the pace of the incoming raw materials, the raw materials travel farther down the roller conveyor line where they pile up in a section called the overflow.

Photo 8. Worker manually lifting and carrying material to the first machine.

Photo 9. Sheets of cut wood stacked on pallets.

Between each process line, workers place sheets of cut wood on pallets (Photo 9). Once an order is complete, workers push pallets over the roller conveyor to the next process. The roller conveyor is flat and the workers were observed to use quite a bit of exertion to push the pallets.

Near the end of the flow line, movement of material from one process line to another requires pushing a wheeled cart on a floor rail system. The floor rail's current design creates resistance between the wheel and the floor, requiring the workers to exert considerable force when pushing the cart. In another area with a wheeled cart/floor rail system, an angle-iron rail lifts the wheel above the floor and minimizes the resistance (Photo 10).

Photo 10. Cart on flat rail design (left); cart wheel on improved angle iron rail system (right).

Finish

In the finish department, a conveyor system moves pieces through painting, wiping, and glazing areas. At the beginning of the process, workers remove pieces from pallets/carts and place them on boxes that sit on the conveyor system. Pieces then travel through the different finish areas (Photo 11).

Photo 11. Low conveyor height placing workers at risk for low back pain.

In each of the finish areas, workers must work in a bent position to perform the various processes because of the low conveyor height which puts them at risk for low back pain (the working height of the conveyor is 25"). To compensate for the low conveyor height, pieces are placed on 5" boxes. The department supervisor explained that various sized boxes (6", 8", and 12") had been used in the past in order to elevate the work height but that the larger pieces would not fit into the oven when placed on the higher boxes. However, we learned the larger pieces comprise only 2%–3% of the total pieces that are finished.

During the finishing process, workers remove pieces from the line and place them on a higher surface for wiping. This eliminates bending during the wiping process, but requires the worker to repeatedly bend to pick up the part and place it back on the conveyor. Rags and other materials are stored underneath the work tables, again requiring bending at the waist. Some workers rotate to different workstations, but others do not, which means they stoop and bend for several hours at a time.

The conveyor system travels in a circle. In the section where the beginning and end of the processes merge, workers transfer materials from pallets to the conveyor, and vice versa. Both the low height of the conveyor line (25") and lack of height-adjustable carts for the parts cause workers to perform their work bent forward most of the work day.

The finish line repair area consists of four or five tables where repairs are performed. The repair area is close to the finish line, and workers reported odors from the finishing chemicals. None of the tables in the finish line repair area were height adjustable, and one of the tables did not have direct exhaust ventilation.

Assembly

The end product is produced in the assembly area. Various styles and sizes of cabinets are produced according to semi-custom orders. The orders are given a number and workers build the cabinets in sequential order by number. Occasionally, large cabinets are constructed back-to- back. Workers reported that assembling, lifting, and moving large cabinets back-to-back causes pain, discomfort, and muscle fatigue.

Cabinet components are brought to the work station on kit carts. The current kit cart wheels are small and create resistance with the old wooden floor, requiring workers to use a lot of force to push and pull the carts. Management has begun replacing the small wheels with larger wheels that travel with less resistance across the wood plank floor.

The assembly cells do not have any height-adjustable tables, except for one table in the repair area. Workers explained that flipping the product to staple and screw parts, as well as twisting and turning the final product to move it onto the conveyor line (especially the larger pieces) require awkward wrist postures and cause upper extremity pain and discomfort. Currently, no carousels or "lazy susan" components are available to rotate cabinets and provide workers easier access from various angles.

Most cabinets in the assembly area have a mounting fixture that holds the product while workers install parts. However, the stationary base fronts lack a door mounting fixture to hold the door while it is being installed. This is a fairly new product, and a mounting fixture has not been developed yet.

"Broomer" cabinets, similar to free-standing pantries, are made and boxed for shipment in the broomer assembly area. This area has several pneumatic hoses on the floor that pose a tripping hazard. Other assembly areas have coiled hoses, in which multiple tools can plug into one line; coiled hoses should be utilized here to eliminate the hazard (Photo 12).

Photo 12. Loose hoses pose a tripping hazard (left); coiled hoses eliminate the trip hazard (right).

The size of the broomer product requires the workers to reach down into the cabinet to staple the component together (Photo 13). No height-adjustable table is available in this area.

Photo 13. Simulation of extreme reach to staple cabinet components (broomer product).

After the broomer product is assembled, the workers make a customized box for shipping by taping two smaller boxes together. The workers then slide the broomer product into the customized box. Occasionally the product catches onto the overlap where the two boxes join, requiring the workers to use excessive push and pull force to slide the product into the box (Photo 14).

Photo 14. Overlap of the two boxes where the broomer product gets caught.

Another product with its own assembly area is the RCB. Engineers at Yorktowne designed specialized turntables with complementary edges that match the RCB cabinet components. The utility of the turntables could be enhanced by designing a pneumatic clamp structure to securely hold the RCB parts in place while the worker installs the screws. This design would eliminate the grip force currently required.

Five parallel conveyor lines attach to an elevated platform and transport the boxed RCB cabinets to a shipping area. A step between the first two conveyor lines allows workers to climb up to or down from the platform to the floor. No similar steps exist between the remaining conveyor lines, so workers must hop off the platform to reach the floor.

Shipping

Three activities take place in the shipping department: assembling boxes, placing cabinets inside the boxes, and staging boxes for delivery.

During box assembly, workers cut the cardboard boxes to size, fold them flat on a table, then carry them to nearby shelves and store them in vertical slots. These shelves are located on a platform several feet above the floor, which requires the worker to reach overhead to place the flattened boxes in the top slots (Photo 15).

Photo 15. Top shelf slots require workers to reach overhead.

Placing cabinets inside boxes takes place on the other side of the shelves and on the platform where finished cabinets ready to be boxed arrive via a conveyor system. Workers retrieve stored boxes from the shelves, unfold them, and place them over the cabinets. After the top of the box is secured, a worker manually flips the box over to secure the bottom. Currently, they do not use an automatic box closer, and workers rotate between stations to reduce fatigue from manual tilting.

Lastly, workers stage the boxed cabinets for delivery by order number. The boxed cabinets travel down a conveyor system where workers manually lift each box off the conveyor line to the floor and transport them to a staging area via a hand truck. Workers in this area reported lower back, shoulder, and neck pain.

Medical Interviews

The NIOSH medical officer interviewed 14 cabinet workers at the Red Lion assembly plant. Seven of 14 employees were selected by management. Among the interviewed employees, the average age was 43 years (range: 28 to 60 years), and the average time employed at Yorktowne was 11 years (range: 1 to 36 years). Ninety-three percent (13 of 14) of employees interviewed reported work-

related musculoskeletal pain or discomfort within the last year. There were 11 reports of work-related musculoskeletal symptoms involving the upper extremity (fingers, hand/wrist, elbow/forearm, shoulder), three neck, three back, and three lower extremity. Five of the 14 interviewed employees had been diagnosed with carpal tunnel syndrome: three underwent surgery and two transferred to a different department. Of the 14 employees interviewed at Red Lion, seven reported seeing a physician or chiropractor within the past year for work-related musculoskeletal pain or discomfort. Three employees reported missing work within the past year for work-related musculoskeletal issues. One employee reported temporary restriction of duties.

OSHA 300 logs

Review of the OSHA Logs indicated that most entries were due to MSDs (not including acute injuries such as fractures, laceration, punctures or contusions) and that most MSDs involved the upper extremity. From 2002 through 2006, 57% (85 of 149) of the OSHA recordable MSDs at the Red Lion assembly plant involved the upper extremity. At Red Lion, OSHA Logs documented 12 MSDs in 2006 (5 upper extremity, 7 back); 14 in 2005 (8 upper extremity, 5 back, 1 chest); 15 in 2004 (8 upper extremity, 6 back, 1 neck); 15 in 2003 (10 upper extremity, 3 back, 1 lower extremity, 1 neck); and 17 in 2002 (7 upper extremity, 5 back, 3 lower extremity, 1 neck, 1 chest).

Workers Compensation Data

At Red Lion, 11 workers' compensation claims were filed for MSDs in 2006, 19 in 2005, 16 in 2004, 21 in 2003, and 17 in 2002.

Conclusions

On-site assessments and interviews at both Yorktowne facilities are the basis for the following conclusions. Most workers at both facilities are exposed to a combination of concurrent risk factors for developing upper extremity MSDs: high force, static and awkward posture, and repetitive motion. Workers were also exposed to risk factors for low back pain: lifting/forceful movements, awkward postures, and heavy physical work.

Most MSDs reported during the NIOSH medical interviews and on review of OSHA Logs and worker's compensation data involve the upper extremity, however low back pain and injury was a notable problem at both facilities.

The problems with workstation design that place workers at risk for MSD injuries include low work heights, non-adjustable workstations, and lack of space for completing the job tasks. The problems with hand tool design that place workers at risk for MSD injuries include heavy weight and/or excess vibration. The lack of an active maintenance reporting system causes and/or exacerbates existing MSDs by keeping defective power tools and carts in service.

Recommendations

The preferred method of controlling ergonomics hazards is to provide engineering controls that redesign the workstation and/or job task to reduce or eliminate the risk of WMSDs. Administrative controls or policies designed to limit workers' exposures to hazardous conditions can be used temporarily until engineering controls are implemented. In addition, NIOSH investigators recommend that employees be trained to recognize ergonomic hazards and participate in the process of identifying hazards and making job modifications. Several recommendations for job task and workstation layouts are listed below. While implementing all of these recommendations over a period of time is optimal, even implementing some of them along with other administrative controls would be beneficial in reducing workers' risk of WMSDs.

Engineering Controls – General Recommendations

General recommendations for engineering controls that would eliminate or significantly reduce the physical stresses associated with material handling activities are listed below.

RECOMMENDATIONS (CONTINUED)

1. Provide adjustable scissor lift tables and lift trucks to reduce bending and overhead reaching when transferring material, assembling material, or sanding material. Pallet carousels and collapsible carousel stands allow access to loads from various angles and eliminate reaching and bending [Chengalur et al. 2004].
2. Incorporate a minimum height range of 27.6" to 29.7" (average elbow height) and a maximum height range of 51.6" to 56.2" (average shoulder height) with respect to incoming and outgoing carts, workstations/worktables, palletized pieces, and shelving units to eliminate overhead reaching and bending [Kroemer 1989].
3. Replace older carts with new carts or, at a minimum, replace existing wheels with new polyurethane wheels that have a double ball race for smoother swiveling for turning and handling.
4. Eliminate lifting of more than 50 pounds, such as carrying multiple blanks in the clamping process and tilting/lifting cartons in the shipping department. Suggestions include making multiple trips to unload each blank and using a box closer that automatically closes and seals cartons.
5. Use jigs or vices in assembly and sanding areas to allow the rotation of work objects while keeping upper extremity postures neutral (Figure 1). For example, use jigs or fixtures in the miter pin door line to eliminate manual flipping of the doors.

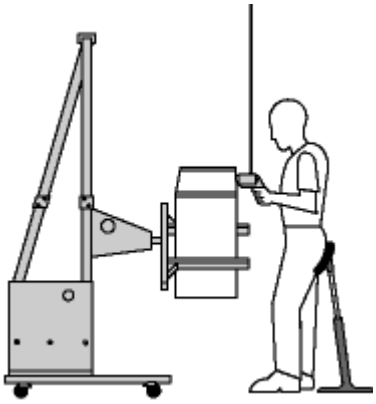

Figure 1. A jig holding and rotating the work object [Canadian Centre for Occupational Health and Safety 1998].

6. Reduce vibration exposure by providing tools with low vibration frequency, properly maintaining tools, scheduling rest breaks to allow for recovery, and alternating work tasks with other tasks that do not involve vibration exposure.
7. Select lightweight tools to decrease the force required to complete job tasks. The weight of the tool should be less than 5 pounds if it is used above the shoulder or away from the body [Chengalur et al. 2004]. If lighter tools are not available, provide a counterbalanced arm or tool balancer.
8. Select tools with the proper design for each task to improve wrist posture. Orient the tool, not the worker. Choose tools that eliminate wrist deviation [Chengalur et al. 2004]. Ensure tools are sharp, lubricated, tuned and in good repair

Engineering Controls - Job/Area-Specific Recommendations

Job/area-specific recommendations that would eliminate or significantly reduce the physical stresses associated with material handling activities are listed below.

Mifflinburg, Pennsylvania Dimension Mill

Department 62 - Rough Mill

Rough mill

- Provide a ramp or a wider chute for the scrap conveyor to eliminate the need to throw scrap pieces with the left hand.
- Reduce incoming stack size and provide adjustability for incoming skid.
- Redesign area to eliminate left shoulder extension. We suggest placing the incoming skid in-line with the roller conveyor, rather than using the current perpendicular setup.

Department 63 – Final Machining

Molding

- Incorporate a maximum height range of 51.6" to 56.2" for the output cart to minimize overhead reaching [Kroemer 1989].
- Raise cart holding separators used to divide stacks of wood to a minimum height range of 27.6" to 29.7" and move the cart closer to the worker to eliminate unnecessary walking.

If moving the cart holding the separators closer is not possible, place a small bin located closer to the worker for holding small bundles of separators [Kroemer 1989].

- Provide a scissor lift for output that can be used with a rolling truck, especially in areas where a forklift cannot get in to remove material.

Clamping

- Eliminate wrist contortion when picking up blank pieces from conveyor and hand dipping in glue. Hand dipping should be replaced by the roller glue system already in use at the mill.
- Make two trips when carrying blank components from the conveyor to the clamping machine. This will reduce the hand force required to lift the full stack of material.
- Unload one blank at a time to reduce the weight of the load carried to below 50 pounds.
- Cut the conveyor control arm to be flush with the mounting bracket (similar to the other machine) to eliminate laceration and bruising hazard.
- Adjust the diverter bar on the Optisizer to bring wood pieces closer to the worker and reduce reaching to pull pieces to the edge of the conveyor.
- Make sure an adjustable platform is available for shorter operators.
- Rotate employees between jobs to alternate muscle groups used, if possible.

Department 64 – Front Frames

Frame assembly

- Tilt the frame assembly table to a 47° angle, moving the surface about 6" closer to the worker and preventing overreaching. The current table has a 43° angle.
- Make custom chocks to raise the base at the back of the tilt tables or provide some other means of making the table more upright to reduce overreaching and improve wrist postures.

Department 65 – Door Assembly

Parts pull area

- Reorganize shelves to a minimum height range of 27.6" to

29.7" and a maximum height range of 51.6" to 56.2" to reduce bending and overhead reaching [Kroemer 1989].

- Store largest boards in the lowest position to eliminate the need for the worker to walk down the ladder with oversized pieces.

Mitering long pieces

- Provide support for the ends of longer wood pieces to decrease hand force requirements; a roller stand could be easily moved when not being used for longer pieces.

Sanding

- Avoid pinch grips by using hand sanding tools designed according to the shape and material sanded. Workers should help decide which handles and materials work best. Hand-to-tool coupling should be round or oblong and approximately a 1.5" diameter [Chengalur et al. 2004].
- Use height-adjustable carts for incoming and outgoing pieces. A minimum height range of 27.6" to 29.7" and a maximum height range of 51.6" to 56.2" are suggested to reduce bending and overhead reaching [Kroemer 1989].
- Provide shelves for sanding blocks and other tools to remove them from the work surface and minimize the restriction of air flow through the ventilation ducts.
- Provide tilted work surfaces and jigs to reduce bending and awkward postures while sanding, and reduce hand force requirements while holding the object.
- Select low-vibration orbital pneumatic sanders to reduce the risk of developing carpal tunnel syndrome. Schedule routine tool maintenance to ensure tools are performing at an optimal level and to preserve lower vibration acceleration levels.
- Provide anti-fatigue floor mats to reduce lower leg discomfort from prolonged standing.

Miter pin door line

- Use jigs or vices to allow the rotation of work objects while keeping upper extremity postures neutral.

This will also eliminate manual flipping of the doors and reduce shoulder fatigue.

Red Lion, Pennsylvania Assembly Plant

Mill

Incoming shelved parts

- Place lighter, smaller parts in higher positions and larger, heavier parts in lower positions to reduce stress when lifting.
- Incorporate a minimum shelf height range of 27.6" to 29.7" and a maximum shelf height range of 51.6" to 56.2" to reduce bending and overhead reaching [Kroemer 1989].

Flow line

- Move the roller conveyor rail to line up with the first machine position to eliminate the current method of manually lifting each piece from the conveyor and carrying it to the first machine; make the existing conveyor rail into an overflow line (Figure 2).

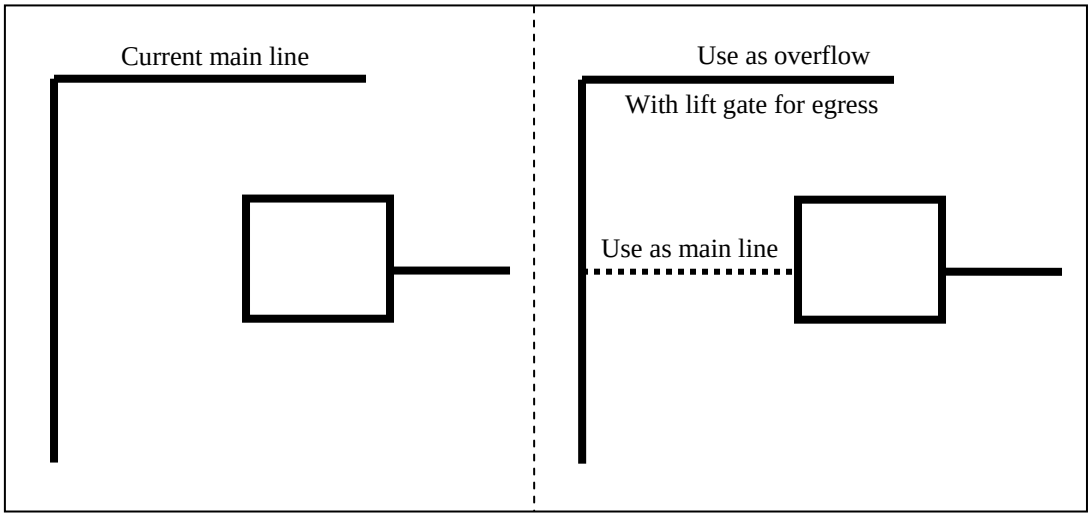

Figure 2. Current flow line layout (left), proposed flow line layout (right).

- Slope roller conveyors slightly downward between each process line to decrease the amount of force required to push pallets.
- Do not place a complete order of material on one pallet between process lines. Instead, load the order on separate pallets to reduce the height (maximum height range of 51.6" to 56.2") and weight of materials. The decreased weight will decrease the amount of force required to push the pallets [Kroemer 1989].
- Install a thicker floor rail or angle iron rail system between the conveyor line and the hole-cutting machine to reduce resistance and decrease amount of force required to push carts from one process line to another (Photo 10).
- Install a sloped conveyor to transfer material (when necessary) to the machine in the last position. If a conveyor is not feasible due to forklift truck traffic, use height-adjustable carts and leave the order on separate pallets to decrease weight and subsequently decrease push force.
- Provide height-adjustable carts at the end of conveyor lines to reduce bending and reaching when completing the full order.

Finishing

Conveyor line

- Use higher boxes on the conveyor to create a minimum height range of 27.6" to 29.7". Because only 2%–3% of the total cabinet components are larger and need to sit on a lower box in order to fit in the oven, higher boxes should be used most of the time, this elevated height range will reduce bending [Kroemer 1989].
- Raise the height of the conveyor line at the section where materials are loaded and unloaded. This elevated height will reduce bending and can be achieved by lengthening the conveyor leg supports.
- Store rags and other materials at table level, not underneath the worktables, to reduce bending.
- Use height-adjustable carts for incoming and outgoing pieces. A minimum height range of 27.6" to 29.7" and a maximum height range of 51.6" to 56.2" are suggested to reduce bending and overhead reaching [Kroemer 1989].

Finish line repair area

- Install height-adjustable tables at every position to eliminate awkward neck and wrist postures.
- Provide ventilation, similar to that at the other repair tables, to the current finish line repair table that has no direct exhaust ventilation.

Assembly

- Sequence work to alternate large and small cabinets.
- Replace wheels on kit carts with larger, firm wheels that have a double ball race for smoother swiveling, turning, and handling.
- Provide height-adjustable tables, at least in the first position, to reduce awkward wrist postures.
- Make work cells larger to accommodate kit carts and to allow workers to easily move around. Building an assembly line with these ergonomic workstation features may be less costly than retrofitting existing lines.
- Install lazy susan components, similar to ones in the RCB area, to provide assemblers convenient access to staple where necessary and reduce awkward wrist postures.
- Design a door mounting fixture for the stationary base fronts to hold the door while it is being installed.
- Select lighter tools when possible.

Broomer table

- Supply coiled pneumatic hoses in which multiple tools plug into one line to eliminate trip hazard with hoses on the floor.
- Provide a height-adjustable table at the head of the assembly area to eliminate reaching down into the broomer cabinet to staple.
- Provide one-piece shipping boxes, instead of making one from two smaller boxes, reducing the force and stress to load the box.

Revolving Cabinet Base

- Design a clamp structure similar to the pneumatic clamps in the broomer area to securely hold RCB parts in place during assembly. A clamp structure will reduce the hand grip force that is currently required.

- Install steps between each of the five parallel conveyor lines to facilitate movement between the floor and the elevated platform.

Shipping

Boxing

- Install a platform in front of the shelves to eliminate the overhead reach by workers placing flattened boxes in the top slots.
- Use an automatic box closer to eliminate manual tilting.

Shipping

- Install short, downward-sloping conveyors to transition boxed cabinets from conveyor to floor; several well-spaced, short slopes would allow smooth transition and eliminate lifting every piece from the conveyor to the floor.

Administrative Controls

Administrative controls are management-dictated work practices and policies to reduce or prevent exposures to ergonomic risk factors. The effectiveness of administrative changes in work practices for controlling MSDs is dependent on management commitment and employee acceptance. Regular monitoring and reinforcement is necessary to ensure that control policies and procedures are not circumvented in the name of convenience or production. An advantage of most administrative controls is that they can be implemented quickly and easily with less expense than engineering controls. However, because administrative controls do not eliminate the hazard, they should be considered temporary solutions for controlling exposures until engineering controls can be implemented. Administrative control recommendations include the following:

1. Rotate workers through several jobs with different physical demands to reduce the stress on limbs and body regions.
2. Schedule more breaks to allow for rest and recovery.
3. Broaden or vary job content to offset certain risk factors (i.e., repetitive motions, static and awkward postures).
4. Ensure tools/carts are well maintained and in good repair. Implement an active routine maintenance system instead of a passive system in which employees mark tools for repair.

5. Provide training to employees in the recognition of WMSDs and instruction in work practices that can ease the task demands or burden. For example, in the rough mill area, the worker sometimes transfers the scrap piece from the left hand to the right hand and throws the piece onto the scrap conveyor. The worker should slide the piece into the scrap chute available on the right side, rather than throwing the piece. Another example is in the clamping area where workers use extreme wrist flexion to pick up pieces to place in the clamping machine. This motion should be eliminated. The ideal solution would be to eliminate this job task and use an automated process.

Health Care Management

Health care management emphasizes the prevention of impairment and disability through early detection, prompt treatment, and timely recovery.

1. Provide education and training to employees regarding recognition of the symptoms and signs of WMSDs, and the employer's procedures for reporting MSDs.
2. Encourage employees to report musculoskeletal symptoms to management and seek a prompt referral to a physician experienced in the evaluation and treatment of WMSDs. The earlier symptoms are identified and treated, the less likely a more serious disorder is to develop.
3. Allow healthcare providers the opportunity to tour the Yorktowne facilities and become familiar with jobs and job tasks. Being familiar with employee jobs not only assists the healthcare provider to make informed case management decisions but also assists with the identification of ergonomic hazards and alternative job tasks. Once familiar with the facilities' operations and job tasks, the healthcare provider should periodically revisit the facilities to remain knowledgeable about changing work conditions.
4. Modify jobs or accommodate employees who have functional limitations secondary to WMSDs as determined by a healthcare provider.
5. Do not use immobilization devices, such as splints or supports, to prevent the development of WMSDs. These devices should be dispensed to individuals with WMSDs

only by healthcare providers who have knowledge about the benefits and risks of these devices. Any immobilization should be monitored carefully to prevent complications (i.e., muscle atrophy from non-use). For example, wrist splints, typically worn by workers with possible carpel tunnel syndrome, should not be worn at work unless the healthcare provider determines that the employee's job tasks do not require wrist bending. Employees who struggle to perform a task requiring wrist bending with a splint designed to prevent wrist bending can exacerbate symptoms in the wrist because of the increased force needed to overcome the splint.

6. Educate employees to consult a physician if they are considering using doses of non-steroidal anti-inflammatory agents (e.g., ibuprofen, Aleve, Motrin) above the non-prescription level indicated on the manufacturer's package label. Possible side effects include gastrointestinal distress, bleeding from the stomach or small intestines, and kidney dysfunction.

Proactive Ergonomics

Proactive ergonomics emphasizes the prevention of WMSDs through recognizing, anticipating, and reducing risk factors in the design stages of new work processes. The recommended method is to design jobs, work stations, tools, and other equipment to match the physiological, anatomical, and psychological characteristics and capabilities of the worker. Under these conditions, exposures to risk factors considered potentially hazardous will be reduced or eliminated.

1. Set policies that require ergonomic considerations for any equipment to be purchased.
2. Perform job hazard analyses on all new and proposed work processes prior to implementation to target potential risk factors for WMSDs.
3. Encourage active involvement of production workers in the design and implementation of new and proposed work processes.

Safety Committee

The safety committee concept emphasizes the importance of management and employees working together to identify work hazards and propose ergonomic solutions.

1. Encourage the existing safety committee consisting of management and employee representatives to develop procedures and mechanisms to evaluate ergonomic safety goals and monitor progress. These goals and objectives should be organized into a written safety program that is endorsed by management and worker representatives and communicated to all employees. Safety committee meetings should be held on a regular basis to evaluate progress, assign responsibilities, and identify potential problem areas.
2. Continue using the Ergonomic Job Hazard Analyses and Ergonomics Referral Forms. Encourage active involvement of workers in these evaluations.
3. Provide additional training in ergonomics for the members of the safety committee. If all safety committee members cannot receive more comprehensive training, the Safety Manager should receive additional ergonomics training because he/she has overall responsibility for this committee.

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Acknowledgements and Availability of Report

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