NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2005-0318-3006
BlueLinx Corporation
Bellingham, Massachusetts

June 2006

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Daniel J. Habes of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS) and Thomas R. Waters, Division of Applied Research and Technology (DART). Desktop publishing was performed by Robin Smith. Editorial assistance was provided by Ellen Galloway.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

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 (HHE) at BlueLinx Corporation in Bellingham, Massachusetts. The company submitted the HHE request because they were concerned that some of their workers may get hurt from performing order-picking lifting jobs in the warehouse. NIOSH investigators conducted an evaluation in December 2005.

What NIOSH Did

- We watched and videotaped workers picking orders for customers.
- We duplicated the jobs we saw in our laboratory using special equipment to see if performing the jobs could injure workers.

What NIOSH Found

- Lifting siding, nails, and molding to fill orders may injure workers because of how heavy these objects are.
- Workers avoid injury by taking the time to work smart and lift safely.
- The amount of time workers have to pick orders helps to prevent injuries.

What BlueLinx Managers Can Do

- Continue to emphasize safe work practices.
- Reduce the weight of stock items where possible.
- Consider automated lift assists for some jobs.
- Make sure the number of orders workers pick does not increase above what we saw.

What the BlueLinx Employees Can Do

- Report injuries or unsafe work conditions to management.
- Continue to take the time to work safely and lift properly.
- Do not cut any corners when picking orders – the objects you lift are heavy and could hurt you.

CDC Workplace Safety and Health

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report #2005-0318-3006

NIOSH

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SUMMARY

On July 29, 2005, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from a Project Supervisor at the BlueLinx Corporation in Bellingham, Massachusetts. The request stated that approximately six material handlers in the company warehouse who pick orders for delivery to building supply retail outlets may have been at risk of back injuries or repetitive motion disorders.

During December 12-14, 2005, NIOSH investigators conducted an opening conference, attended by representatives of BlueLinx management and Teamsters Local 653. After a general warehouse walk-through, we observed order picking work tasks specified in the HHE request. The NIOSH team consisted of two ergonomics specialists.

The ergonomics evaluation indicated that workers generally used good ergonomics practices while picking nail, siding, and molding orders for customers. The workers took the time to avoid reaching across pallets when lifting, adjusted the height of storage and delivery pallets to enable lifting at waist height, and slid or rolled loads to the front edge of pallets before lifting. The employees were at elevated risk of injury from performing these jobs as measured by the Revised NIOSH Lifting Equation (NLE) and the Michigan 3-Dimensional Static Strength Prediction Program (3D SSPP) due to the weight of the objects lifted (which varied from 48 pounds to 64 pounds).

Due to sound work practices and the pace of work, NIOSH investigators conclude that no immediate ergonomic health hazard exists at BlueLinx. However, the lifting jobs present an elevated risk for injury and could pose a health hazard in the future if the volume of work increases or if current preventive measures are not continued. Recommendations for reducing the risk of injury from lifting are contained in this report, including the use of lifting devices and reducing the weights of bundled building materials.

Keywords: NAICS 423310 Lumber, Plywood, Millwork, and Wood Panel Merchant Wholesalers, lifting, back injuries, forklift drivers, building materials, ergonomics

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INTRODUCTION

On July 29, 2005, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from a Project Supervisor at the BlueLinx Corporation in Bellingham, Massachusetts. The request stated that approximately six material handlers in the company warehouse who picked orders for delivery to building supply retail outlets may have been at risk of back injuries or repetitive motion disorders.

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BACKGROUND

BlueLinx, headquartered in Atlanta, Georgia, is the largest distributor of building products in the industry. The company has over 3300 employees and operates in all of the major metropolitan areas of the United States.

The Bellingham, Massachusetts location employs 118 workers, 100 of whom are hourly. These workers fill warehouse orders and deliver over 6000 different building products to approximately 50 home building products retail stores in the immediate area.

BlueLinx in Bellingham, Massachusetts is an Occupational Safety and Health Administration (OSHA) Voluntary Protection Plan (VPP) site and also holds OSHA Star status. To achieve Star status, a worksite must have comprehensive and successful safety and health programs and have both total reportable and lost workday injury rates better than the industry's national average. The Bellingham plant has an OSHA recordable rate of 2.6 per 100 workers, compared to the industry average of 7.1 per 100 workers.

In 2005, the plant had three OSHA recordable injuries, one strain/sprain that resulted from a worker pulling a pallet and two falls. Employees at the company have not experienced any musculoskeletal disorders from order picking or other material handling jobs in the warehouse, but company officials feel that to maintain this record they must continue to be proactive in their prevention efforts. For this reason, they asked NIOSH to evaluate three types of order picking jobs in the warehouse that management felt could potentially result in injury at a later date. These are picking nails, picking vinyl siding orders, and picking molding.

Job Descriptions

Picking Nails

Boxes of nails weighing approximately 50 pounds are stored on pallets located in warehouse racks. Orders are usually comprised of less than a full pallet of nails, so individual boxes of nails are transferred from the storage pallet to the delivery pallet. The order picker usually uses a "man-up" lift, which is a forklift that has a small platform to stand on directly behind the empty pallet onto which the order is placed. If the stored pallet is situated in a low storage location, the specified boxes of nails are transferred directly from the storage pallet to the delivery pallet. If the stored pallet is located higher up on the storage racks, the order picker raises the forks of the man-up lift to the height of the pallet from which the order is picked, and then performs the transfer. In these cases, the order picker hooks the safety harness worn on the body to a lanyard on the forklift truck for fall protection.

Picking Vinyl Siding

Boxes of vinyl siding are stored horizontally on two levels of "key racks." Each of these levels can be reached from floor level, so the man-up lift is not used. When picking an order, the worker positions the forklift holding the empty pallet in front of the desired key rack location, and slides the box onto the delivery pallet. This transfer involves more pulling and pushing motions than typical lifting. Picking from the higher of the two key rack locations requires the same pulling and pushing motions, but with the hands at or above shoulder level. It also usually requires some amount of lifting.

Picking Molding Orders

BlueLinx stocks many styles of molding, which can be up to 16 feet in length, so they are stored in bundles in stand-up racks instead of key racks to conserve warehouse space. Workers were observed picking orders and placing bundles of molding horizontally onto wheeled carts and stocking the stand-up racks by transferring bundles from incoming carts for subsequent picking for customer orders. Order picking requires that workers place their hands on the vertical bundles and "walk them out" of the stand-up racks into the aisle and then carrying the load on their shoulder before placing the bundle on the cart. Stacking the shelves requires workers to lift the bundles from a cart, carry them to the storage location, and then "walk them in" to the stand-up rack.

METHODS

Ergonomics Walk-through

The ergonomics evaluation consisted of a walk-through assessment of the warehouse to observe order picking jobs with particular attention focused on the three job categories specified in the HHE request: picking nails, picking vinyl siding, and picking molding orders. Several job cycles in each category were videotaped for subsequent analysis.

Job Analyses

Analysis Tools

The ergonomics tools used to evaluate the biomechanical and injury risk factors were the biomechanical outputs obtained from the Michigan 3-Dimensional Static Strength Prediction Program (3D SSPP)™ [1] and recommendations for acceptable lifting weights as determined by the NIOSH Revised Lifting Equation (NLE).[2] The 3D SSPP is a computerized model that can be used to evaluate the physical demands of a job. Typical inputs to the model are the magnitude and direction of forces at the hands, angles of body segments, and anthropometric selection such as gender and population size percentiles. The model outputs moments at the joints of the body, percentages of the chosen population able to sustain the inputted loads, and disc compression forces at the low back. For the purposes of this HHE, the 3D SSPP was used to evaluate the biomechanical demands of the three main order picking tasks.

The NLE is a tool for assessing the physical demands of two-handed lifting tasks. A full description of the components of the NLE is provided in Appendices A, B, and C. In brief, the equation provides a recommended weight limit (RWL) and a lifting index (LI) for a lifting task, given certain lifting conditions. The RWL is the weight that can be handled safely by almost all healthy workers in similar circumstances. The LI is the ratio of the actual load lifted to the RWL. Lifting tasks with a LI $\leq$ 1.0 pose little risk of low back injury for most workers. Tasks with a LI > 1.0 may place an increasing number of individuals at risk of low back injury. The consensus opinion of an expert panel, described in the NLE report, is that tasks with a LI > 3.0 pose a risk of back injury for most workers.

Analysis Method

To calculate the risk of injury posed by job tasks using the NLE and the Michigan 3D SSPP, physical measurements must be taken from the worker and the task being performed. Use of the NLE requires a measure of the position of the object with respect to the body at the beginning and end of the lift, the height to which the object is lifted, the frequency of the lift, and the angle of any twist the body makes while lifting. The 3D SSPP requires body segment angles as inputs so that the posture of the worker performing the task can be duplicated. In both cases, the weight of the object being lifted or moved during the job task must be recorded. Because obtaining these measurements can be tedious, time-consuming, and at times infeasible, NIOSH researchers now obtain injury risk outputs from the NLE and the 3D SSPP through input of postural information from subjects simulating job tasks in a laboratory using a position and orientation measurement system. The system features commercially available body position and orientation measurement hardware (Flock of Birds, Motion Star, Ascension Inc. 1999) and Motion Monitor software (Innovative Sport, Chicago, 2003).

The data are transmitted from thirteen sensors attached with Velcro straps to various body segments of the person simulating the job of interest. The simulator stands on a platform that is surrounded by a magnetic field and assumes the various postures of the worker performing the job task, which are projected on a screen behind the platform. The Motion Monitor software reads and processes the data collected with the sensors to calculate the parameters used for 3D SSPP and NLE. Figure 1 shows how the jobs are simulated in the lab.

EVALUATION CRITERIA

Overexertion injuries and musculoskeletal disorders, such as low back pain, tendinitis, and carpal tunnel syndrome are often associated with job tasks that include: (1) repetitive, stereotyped movement about the joints; (2) forceful manual exertions; (3) lifting; (4) awkward and/or static work postures; (5) direct pressure on nerves and soft tissues; (6) work in cold environments; or (7) exposure to whole-body or segmental vibration.[3,4,5,6] The risk of injury appears to increase as the intensity and duration of exposures to these factors increases and the recovery time is reduced.[7] Although personal factors (e.g., age, gender, weight, fitness) 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.[8]

In all cases, the preferred method for preventing and controlling work-related musculoskeletal disorders (WMSDs) 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 task factors considered potentially hazardous will be reduced or eliminated.

RESULTS

Ergonomics Walk-through

Prior to collecting the information needed to analyze the siding, nail, and molding picking jobs, we took a general tour of the warehouse. The warehouse is under a roof, but is open to the outdoors, and is not heated or air-conditioned. The temperature at the time was near freezing, so the workers wore gloves, layered clothing, and heavy boots, in addition to the normal safety equipment consisting of hard hats and glasses.

In general, workers employed good lifting practices such as adjusting the height of storage and delivery pallets so that lifts from one to the other could be made at heights around waist level. This was accomplished by removing pallets from the storage racks with a forklift truck so the height could be adjusted and by placing empty pallets under the delivery pallet to achieve the desired height. Other preferred lifting practices observed were walking around pallets to lift from the edge or sliding loads to the edge of the pallet before lifting, instead of reaching across pallets to retrieve and load boxes of materials. Some heavy materials such as 100-pound rolls of steel strapping and copper flashing were stored on pallets located on the floor. We did not observe any workers picking these rolls for orders, but noted that due to their weight, each would present unacceptably high risk of injury if lifted manually under any circumstances.

Job Analyses

Table 1 shows the disc compression forces (DCF) obtained from the Michigan 3D SSPP and the LI values obtained from the NIOSH lifting equation. The table describes the tasks that were analyzed; frame numbers correspond to the pictures of the lifts found in Figures 2-8.

The weights used in the analyses were typically the heaviest for each particular product so that the worst case scenario could be obtained. Not all of the individual tasks found in Table 1 are shown in Figures 2-8, but the frame number at the origin of the lift in the figures allow the illustrated lifts to be matched to the data contained in Table 1. The frame number for each task also represents the point on the tape at which the lifting information was collected. The letters a, b, c, etc., on Table 1 refer to different cycles within the same task type that were analyzed. The DCF and LI values were calculated only at the origin of lifts because in most instances placement of the materials onto the delivery location did not require the worker to maintain significant (or careful) control of the load. Peak values for disc compression force and lifting index are bolded and the average of all lifts within a task type are located on the last line of each task cell.

Tasks 1 and 2 from Table 1 (shown in Figures 2 and 3) are analyses of two different deliveries of the same shake siding product to illustrate how slightly different lifting origin and destination parameters can affect lifting posture and the resultant LI and DCF values. Task 5a (shown in Figure 6) required a lifting and pulling force to transfer vinyl siding from the delivery to the storage rack, but only the weight of the package was used as the load in the hands because the pull force accompanying the lift could not be estimated. Due to the inability to measure pulling force, unloading vinyl siding from the upper racks to the forklift, a potentially more hazardous task (due to above shoulder lifting) than that shown in Figure 6 was not analyzed. The last task, stocking molding (shown in Figures 8a and 8b) was analyzed as two lifts: lifting from cart to shoulder, and then lifting from shoulder to the stand-up rack after walking to the delivery location. The DCF and LI values were averaged for these two phases to obtain the values shown in Table 1 for this task. Each task analyzed was assumed to be an occasional lift, defined as not more than one lift per every 5 minutes on average.

Every lifting job task evaluated exceeded the recommended LI of 1.0, but none surpassed a LI of 3.0, which is considered to be hazardous for nearly all workers. All LIs were between 1.5 and 2.6., indicating an elevated risk of injury as compared to jobs that have a lifting index of less than or equal to (≤) 1.0. Average LIs for each task, which provide a better estimate of injury risk due to the variability of performing successive repetitions of the same general lift, were just below or just above 2.0, including the molding pick and stocking jobs, which had the highest loads (64 lbs.).

Disc compression forces (DCFs) followed a similar trend as the LIs with most exceeding the value of 770 lbs., which corresponds to a LI of 1.0, but none exceeded 1430 pounds, which corresponds to a LI of 3.0. Any DCF exceeding 770 lbs indicates an elevated risk of injury, for which remedial action should be taken, as does a LI that exceeds 1.0.

The key to interpreting the risk of injury for a given lifting index is to understand how injuries increase as the LI increases. A cross-sectional epidemiologic study conducted by NIOSH indicated that as the LI increased for 204 workers performing 50 different lifting jobs in four different industrial facilities, the prevalence of reported back pain also increased.[9] The prevalence of back pain lasting a week or more was highest for workers performing lifting jobs in the $2<LI\leq3$ category, nearly twice that of workers in non-lifting jobs. The risk of injury for jobs in the $1\leq LI\leq2$ category was higher than for non-lifting jobs but the increase in risk was not significant due to small sample size. The main conclusion of the study was that while more data are needed, the best approach to injury prevention is to design jobs for workers that result in LIs ≤2.

DISCUSSION

Lifting Index versus Disc Compression Force

The LIs and DCF values for each of the jobs, particularly when averaged across repetitions of the same task type, were bunched around an elevated risk of about 1000 lbs. DCF and LI = 2. This is because most of the weights handled were close to the NIOSH lifting equation constant of 51 pounds, meaning that all other factors that contribute to the LI calculation would have to be ideal to achieve a LI of 1.0 or slightly above 1.0. The molding jobs as measured by the LI are classified in the higher range of risk compared to the other jobs due to the weight of the bundles (64 lbs.).

In most cases, the LI and DCF values were in agreement regarding the risk of injury for these jobs, but it is important to note that the two measures are somewhat different. The LI for low frequency lifting such as observed at BlueLinx relies on load weight and location with respect to the body (biomechanics), worker perception of what an acceptable load is (psychophysics), and past history of what types of loads have resulted in injuries (epidemiology). The DCF is an indication of the load on the low back based on the weight of the object and the posture of the body when the load is lifted, not necessarily the position of the load itself as in the LI. In most cases when there is apparent disagreement between the two methods, there is a discrepancy between the posture of the body assumed and the position of the load with respect to the body when it is actually lifted.

Figures 2 and 3 illustrate how variability in posture or lifting technique can result in slight differences in the LI and DCF in jobs that are essentially the same. In Task 1, the worker is bent forward more at the origin of lift b than at lift a, resulting in higher DCF and LI. In Task 2, the worker is bent forward more in lift a than lift b, resulting in a slightly higher DCF, but the hand to load coupling and position of the load with respect to the body is better in lift a, resulting in a lower LI than b. The subtle differences in DCF and LI for similar tasks such as 1 and 2 support the use of the average when analyzing multiple repetitions of lifting tasks. The main point to remember about the LI and DCF is that when either is above its respective threshold (especially if both exceed acceptable levels), there is an elevated risk of injury.

Other Issues Affecting Injury Risk

As noted previously, this evaluation took place in winter, when the company's business is at its lowest. Other activities that take place during the filling of an order such as paperwork, driving or walking to the various pick locations, and wrapping loads in a staging area, give the workers adequate time for recovery between lifts during an order pick and between successive orders. During the seasons when the volume of orders is greater, the risk of injury may be higher based on the number of orders picked per worker. On the other hand, the risk of injury may be lower for orders similar to those studied during this evaluation but for which the individual loads lifted weigh less. As a rule of thumb, the jobs studied will begin to increase in risk when and if lifting frequencies approach one or two lifts per minute on average, as opposed to less than one lift per 5 minutes or less, as was the case during this evaluation. It is at this point of lifting frequency that rotation to non-lifting jobs would be a practical measure for injury control. At occasional lifting frequencies, rotation is not a practical option because each lift is at elevated risk regardless of the time interval between successive lifts.

Finally, when infrequently lifted loads approach what can only be lifted with little risk under ideal conditions (51 lbs.), the simple control measures such as rotation, improved load storage locations, and good body mechanics can only slightly reduce the risk. In such cases, the costly and more difficult to implement control measures such as use of mechanical lift assists, lowering of weights handled, and alternatives to unassisted lifting, such as two-person lifting, are the only effective means. An illustration of how weight can be feasibly reduced can be found in the molding jobs. For both the stocking and the picking jobs, reducing the bundle weights from 64 lbs. to 32 lbs. by reducing the number of pieces per bundle, the LIs would be cut in half to an average of 0.9 and 1.1, respectively.

CONCLUSIONS

1. The lifting jobs studied at BlueLinx present an elevated risk of injury for workers as measured by the NIOSH Lifting Index (LI) and the Michigan 3D SSPP (DCF) due to the weight of the loads lifted.
2. Work-related back and other musculoskeletal injuries/disorders have likely been prevented by the low frequency of lifting, adequate recovery for workers during and between order picks, and good lifting techniques and other risk factor control measures practiced by an experienced workforce.
3. Any changes in work load or patterns of work due to seasonal increases in order volume may elevate risk of injury to unacceptable and unsafe levels.

RECOMMENDATIONS

1. Reduce the weight of loads lifted to the extent possible and feasible. As noted in the Discussion, the best candidates for weight reduction lie in the molding area where the number of pieces per bundle can be reduced to achieve lower overall object weights.
2. Use lifting devices such as vacuum lifts or other mechanical assists for handling fixed weight products such as boxes of nails and siding, or individually heavy objects such as rolls of steel strapping and copper flashing.
3. Continue using sound approaches to moderating the risk of injury from lifting such as removing pallets from storage racks with a forklift so that the height of the pallet can be adjusted as unloading takes place, lifting from the edge of pallets by walking around instead of reaching across a pallet, or rolling loads to the front of a pallet before lifting.
4. Avoid lifting from below waist height or above shoulder height when picking objects directly from storage racks.
5. Continue work patterns and staffing levels that ensure that order picking remains an occasional lifting task (fewer than one lift per 5 minutes on average).

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Table 1: Disc Compression Force (DCF) and NIOSH Lifting Equation Values (LI)

Task 1	Frame	DCF (lbs)	LI	Task 2	Frame	DCF (lbs)	LI	Task 3	Frame	DCF (lbs)	LI
48# shake siding	79a	1109	1.5	48# shake siding	1299a	1122	1.8	50# nails	3849a	965	1.7
	333b	**1131**	**1.8**		1627b	1098	**2.1**		4091b	1164	**2.4**
					2002c	**1137**	1.9		4292c	**1205**	2.3
AVG		1120.0	1.7	AVG		1119.0	1.9	AVG		1111.3	2.1

Task 4	Frame	DCF (lbs)	LI	Task 5	Frame	DCF (lbs)	LI	Task 6	Frame	DCF (lbs)	LI
man up 48# nails	200a	839	**2.1**	50# siding	4223a	**881**	**2.1**	64# molding	700a	786	**2.5**
	491b	**848**	2.1		11889b	673	1.5		7862b	**1079**	2.3
									13065c	799	1.9
									14042d	1015	1.8
AVG		843.5	2.1	AVG		777.0	1.8	AVG		925.0	2.1

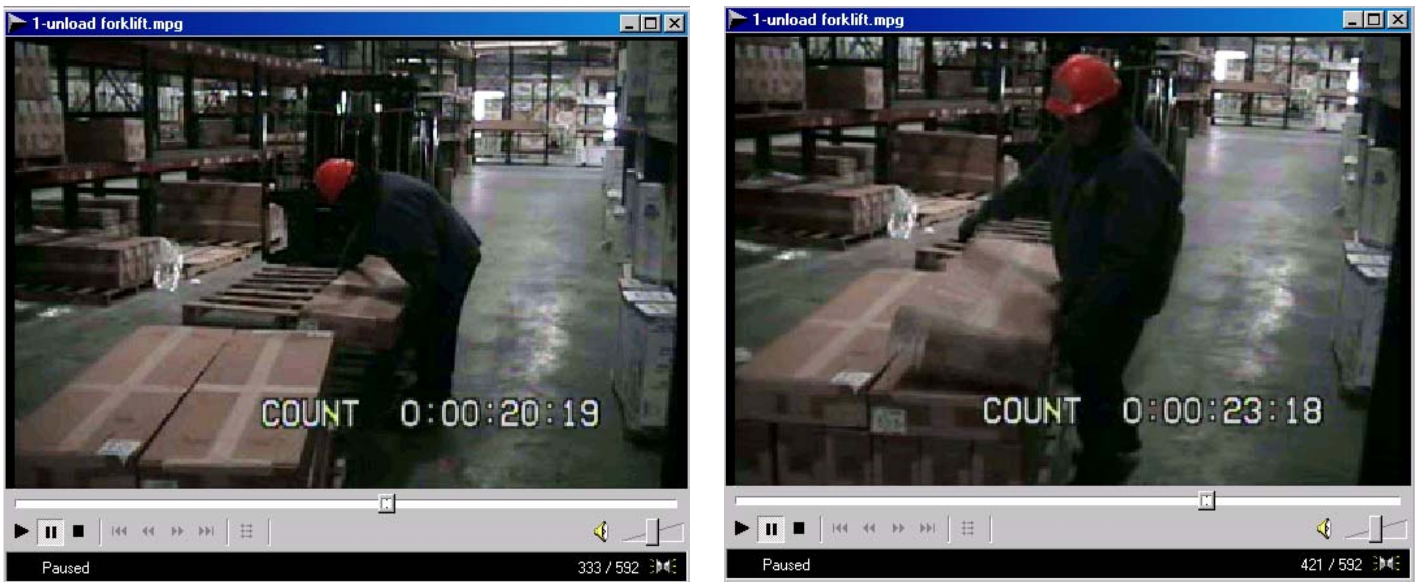
Task 7	Frame	DCF (lbs)	LI
64 # molding	1411a	**850**	**2.3**
	1503b	551	1.9
	2235c	841	**2.4**
	2311d	616	2.2
AVG		714.5	2.2

Legend: Peak Values are **Bolded**
Task 1: Lift shake siding from pallet to pallet
Task 2: Lift shake siding from pallet to pallet
Task 3: Lift nails from pallet to pallet
Task 4: Lift nails from pallet to pallet using man up lift
Task 5: Lift vinyl siding from forklift to storage rack
Task 6: Lift molding from stand-up rack to delivery cart
Task 7: Lift molding from cart to stand-up rack

Figure 1: Instrumented “simulator” assuming a work posture on the simulation platform

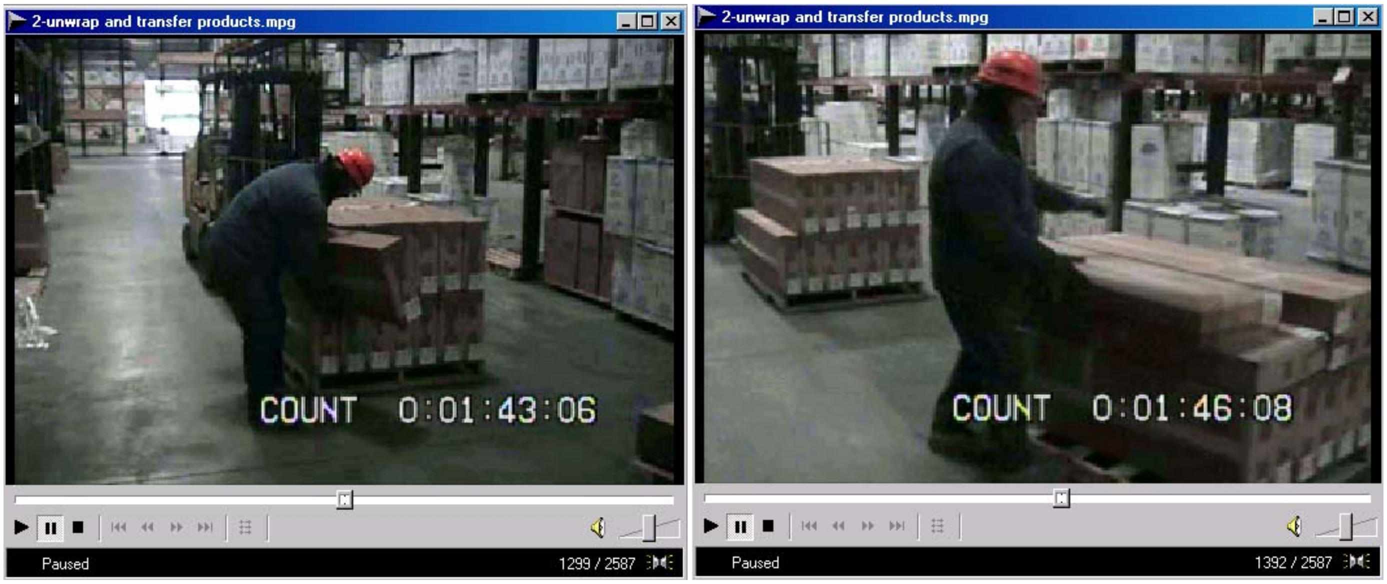
Origin Destination

Figure 2a: Task 1a – Lifting Shake Siding from Pallet to Pallet



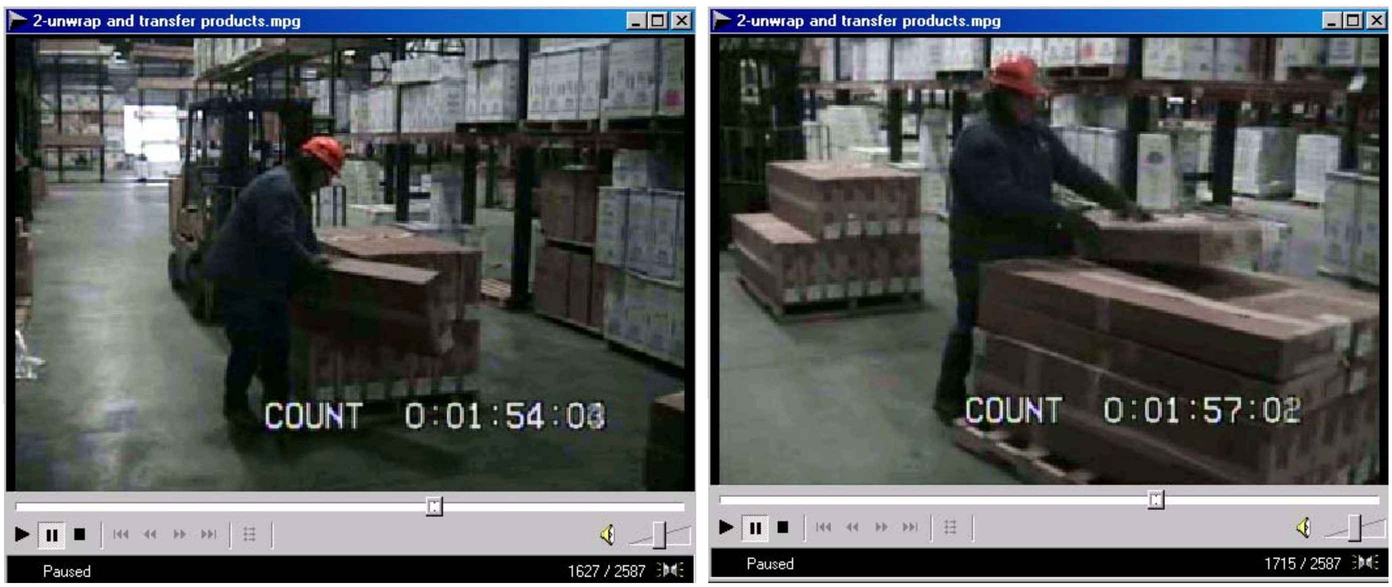
Origin Destination

Figure 2b: Task 1b – Lifting Shake Siding from Pallet to Pallet



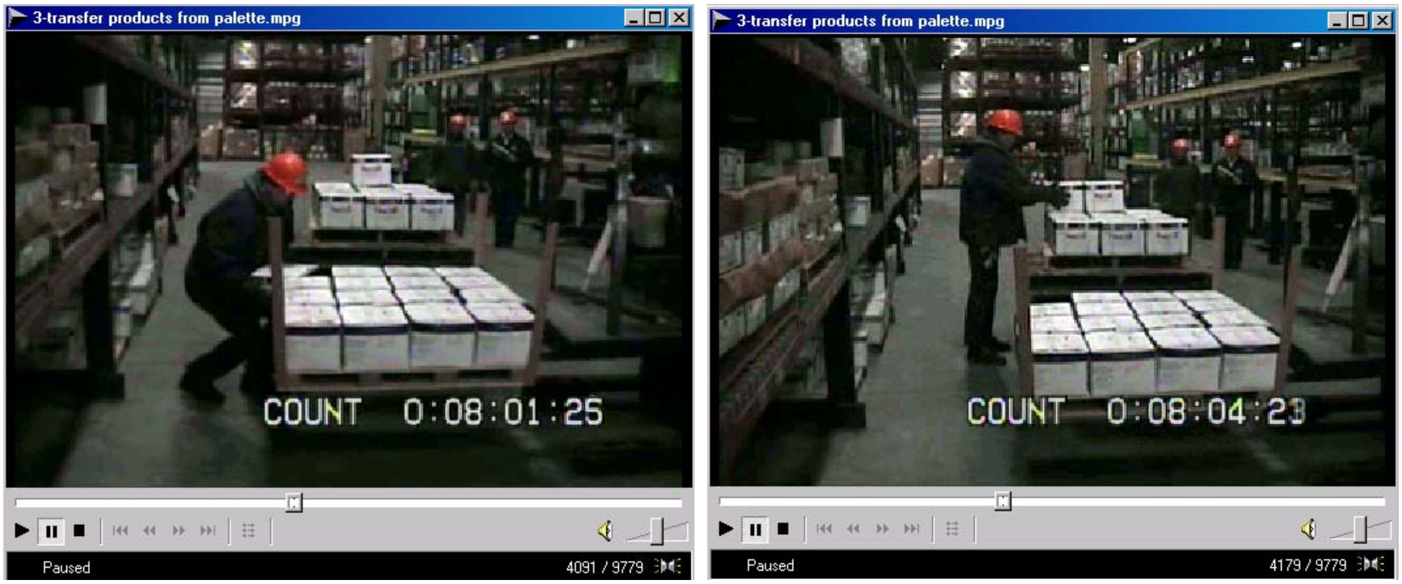
Origin Destination

Figure 3a: Task 2a – Lifting Shake Siding from Pallet to Pallet.



Origin Destination

Figure 3b: Task 2b – Lifting Shake Siding from Pallet to Pallet



Origin Destination

Figure 4: Task 3b – Lifting Boxes of Nails from Pallet to Pallet

Origin Destination

Figure 5: Task 4a – Lifting Nails from Pallet to Pallet on Man Up Lift

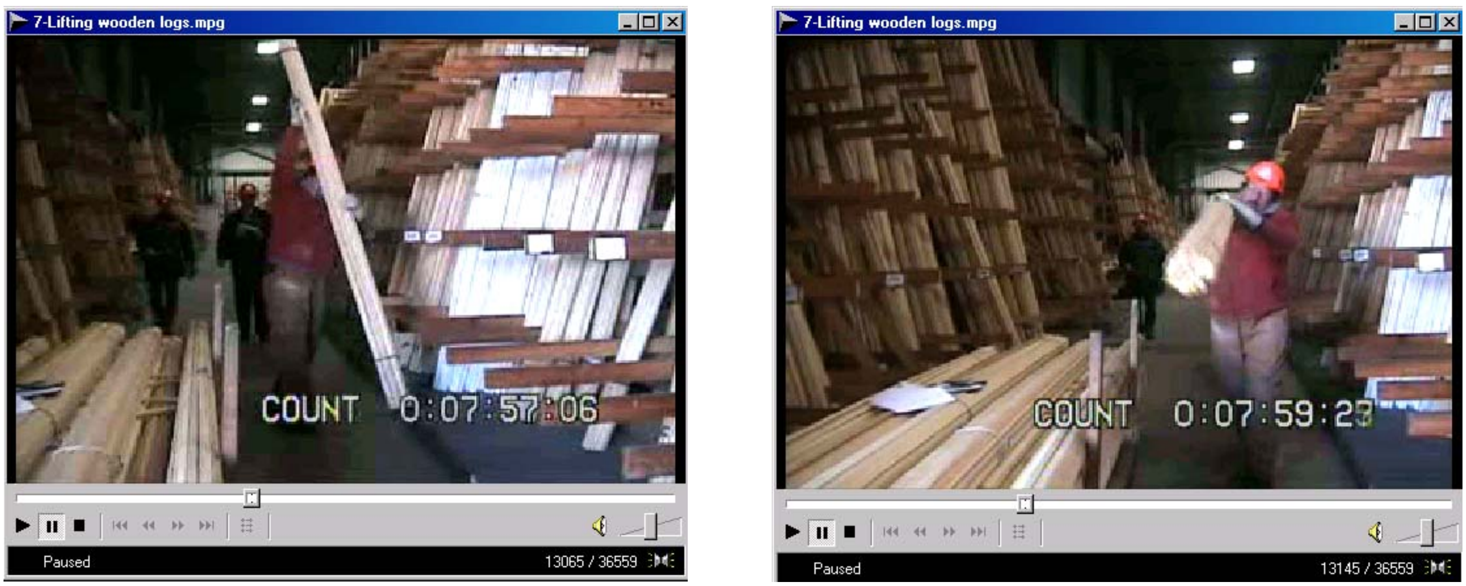
Origin

Destination

Figure 6: Task 5a – Lifting Boxes of Siding from Forklift to Rack

Origin Destination

Figure 7a: Task 6a – Lifting Bundles of Molding from Rack to Shoulder



Origin Destination

Figure 7b: Task 6c – Lifting Bundles of Molding from Rack to Shoulder

Origin Destination

Figure 8a: Task 7a - Lifting Bundles of Molding from Cart to Shoulder.

Origin Destination

Figure 8b: Task 7b - Lifting Bundles of Molding from Shoulder to Rack.

Appendix A
NIOSH Lifting Equation Calculations

Calculation for Recommended Weight Limit (RWL)

RWL = LC * HM * VM * DM * AM * FM * CM
(* indicates multiplication.)

Recommended Weight Limit

Component	METRIC	U.S. CUSTOMARY
LC = Load Constant	23 kg	51 lbs
HM = Horizontal Multiplier	(25/H)	(10/H)
VM = Vertical Multiplier	(1-(.003|V-75|))	(1-(.0075|V-30|))
DM = Distance Multiplier	(.82+(4.5/D))	(.82+(1.8/D))
AM = Asymmetric Multiplier	(1-(.0032A))	(1-(.0032A))
FM = Frequency Multiplier	See Appendix B	
CM = Coupling Multiplier	See Appendix C	

Where:

H = Horizontal location of hands from midpoint between the ankles. Measure at the origin and the destination of the lift (cm or in).

V = Vertical location of the hands from the floor. Measure at the origin and destination of the lift (cm or in).

D = Vertical travel distance between the origin and the destination of the lift (cm or in).

A = Angle of asymmetry - angular displacement of the load from the sagittal plane. Measure at the origin and destination of the lift (degrees).

F = Average frequency rate of lifting measured in lifts/min.
Duration is defined to be: $\leq$ 1 hour; $\leq$ 2 hours; or $\leq$ 8 hours assuming appropriate recovery allowances.

Appendix B
Frequency Multiplier (FM)
NIOSH Lifting Equation

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

†Values of V are in cm; 75 cm = 30 in.

Appendix C
Coupling Multiplier
NIOSH Lifting Equation

Couplings	V< 75 cm (30 in)	V ≥ 75 cm (30 in)
	Coupling Multipliers	
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

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