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Post Project Ergonomic Evaluation
Cascade Steel, McMinnville, Oregon
November 2001
By Rob Strickland, OTR

An on-site ergonomic evaluation of the task of Ladle Bricking using the new adjustable floor platform and adjustable pallet lift was completed on November 6, 2001 at the request of Pat Kraft, Manufacturing Consultant and Project Director. Videotaping and digital photos of the work in progress were performed and are available for review. Employee discomfort surveys were completed.

Purpose/Background: The purpose of this evaluation is to provide an assessment and documentation of the improvements in the Musculoskeletal Disorder (MSD) risk factors associated with the use of these new devices. This is done as part of the Oregon OSHA Worksite Redesign Program Grant which has been awarded to Cascade Steel.

General description: The following description was provided by Cascade Steel and Mr. Kraft: As part of our manufacturing process, we use large melting pots, known as "ladles", for melting materials. These ladles are lined with a fireproof brick material, which is sealed with a cement-like compound, which holds the bricks in place. These bricks are chipped out and replaced every 100 heat cycles of the ladle. It is an ongoing process to rotate used ladles in for refurbishment. The ladles average 10 feet in inside diameter, by 10 feet in inside depth. There are over 1,300 bricks used in each ladle weighing 20-25 pounds each.

New Job Steps

Ladle is put in place with overhead crane
Worker descends ladder into 10 ft. ladle
Old wall material is chipped out with an air powered chipping tool
Pallet of bricks is lowered into ladle with overhead crane
Bricks laid to form a new floor of Ladle
Remove leftover pallets with overhead crane
Lower pallet of bricks for lower section of wall into ladle with overhead crane
Place starter set of bricks for walls
Build walls with bricks setting one layer at a time
Back fill behind bricks with "macrovibe" (course sand like) material using overhead hose (generally every two rows)
Tamp macrovibe material in place with trowel
After the 2nd pallet of bricks have been placed, (when wall is approximately 40" high, remove pallet and lower adjustable floor with adjustable pallet lift into the ladle with overhead crane
Continue building brick wall to top of ladle, adjusting the floor level to maintain top of wall at an optimal height to minimize bending at the trunk. In the same way, the pallet lift is adjusted to maintain optimal trunk position.
Place ramming material (pliable clay-like substance) around top rim and tamp in place with air powered ramming tool (similar to a small jack hammer)

Device Descriptions:

Adjustable floor- Double scissors lift, 10,000 lb. capacity with 8 ft. diameter steel floor, height adjustment range= 18”- 96”

Secondary, adjustable height pallet lift- Single scissors lift, 6,000 lb. capacity, height adjustment range = 8”- 36”

2- sets of foot controls operate each device, located at the base of the secondary pallet lift.

Work Environment and Equipment: Relevant dimensions

Floor brick- 6" x 9" x 4" high (rectangle)

Small pallet of floor bricks contains 120 bricks (6 layers of 20)

Typical wall brick- 6" x 8" x 4" high (rectangle with concavity on one end, convexity on other end)

Large pallet of wall bricks contains 216 bricks (6 layers of 36), dimension of load= 36" x 48" x 24" h

With pallet placed near the center of the ladle floor, there is approximately 17" to 24" of clearance at each corner from the brick wall.

Each layer of bricks in the wall contains approximately 44 bricks.

Key physical demands: The physical stressors in this task vary somewhat depending on the stage of completion of the project, generally described as follows:

Phase 1- Floor: The worker is primarily working in a kneeling position, twisting at the trunk, reaching up to grasp a brick with one hand from the load on the pallet (approximately waist high while kneeling) turning back and placing the brick on the floor, setting it into position while bending forward at the trunk.

Phase 2- Wall: Approximately 1320 bricks (30 layers consisting of approximately 44 bricks per layer)

Stage 1- First 25% of wall (up to 30" high): The worker is primarily in a kneeling or partial bending position again, reaching to grasp a brick with one hand from the load on the pallet (approximately waist high) turning back and placing the brick to continue building a row around the perimeter of the ladle. “Macrovibe” (course sand like) material is placed behind the bricks using overhead hose (generally every two rows) then smoothed and tamped down using a trowel.

Stage 2- Remaining 75% of wall (up to 10 feet high): The worker stands and retrieves bricks from the pallet load which is now adjustable in height and places the brick on the wall, moving from left to right gradually building it up, involving grasping and reaching outward. The height of the floor platform is gradually raised to maintain an optimal trunk position as the wall rises in height.

Key Physical Demands cont

Stage 3- The concluding work involves hammering or prying away excess brick and cement from the upper rim of the old wall, followed by placement of ramming material into the top rim and behind the bricks to seal the wall. This material is then tamped into place with an air powered ramming tool resembling a small jackhammer.

The improvements in risk of musculo-skeletal injury due to the implementation of this new tool include: There is a substantial reduction in the amount of time spent in awkward postures. With these new devices, the worker is able to efficiently make adjustments in the height of the bricks on the pallet as well as the relative height of the wall, to maintain optimal postures (working between waist to chest level) up to 75% of the time. (This compares to only 20-25% of the time in optimal positioning using the old methods prior to the implemented improvements). This also nearly eliminates lifting and handling bricks above the shoulder level to complete the higher wall sections.

Remaining musculoseletal disorder (MSD) risk factors related to the ladle bricking tasks are:

1. Repetition- of movements involving trunk bending, twisting, squatting or kneeling still occurs as indicated above, primarily in the floor building and lower wall building phases (approximately 25% of the time). The upper extremity movements of reaching outward while lifting and handling bricks at the rate of approximately 3 per minute is now less strenuous because of the improved postures.

2. Forces and Loads- While the weight of bricks remain unchanged, The Revised NIOSH lifting Equation CRWL (Composite Recommended Weight Limit***,** see appendices) for the new tasks is 15 lb. with a CLI (Composite Lifting Index) of 1.33. This compares to CRWL- 9.3 lb. and CLI- 2.16 in the old task and represents an improvement of 38% in reduced injury risk as predicted by this equation.

3. Awkward postures- trunk forward bending, twisting and side bending, continues during the first 25% of the process (floor and lower wall sections).

4. Static postures- remaining in kneeling and forward bent postures during the early building phases of floor and lower wall sections.

5. Contact stress- grasping bricks with gloved hands.

Employee Discomfort Survey: <u>Pre Project</u>
Job Title- Bricker Number of surveys completed N= **3**

Discomfort Area	Number of employees with discomfort	Percentage of total	Average Rating (0-10 scale)
Neck	1	33%	1.0
Shoulder	2	66%	2.0
Chest	0	0%	NA
Elbow/forearm	2	66%	6.5
Hand/wrist	3	100%	5.7
Upper back	0	0%	NA
Lower back	3	100%	3.0
Hip/thigh	2	66%	2.0
Knee	1	33%	2.0
Lower leg	0	0%	NA
Ankle/foot	1	33%	7.0

Average rating 3.7

Employee Discomfort Survey: <u>Post Project</u>
Job Title- Bricker Number of surveys completed N= **3**

Discomfort Area	Number of employees with discomfort	Percentage of total	Average Rating (0-10 scale)
Neck	1	33%	3.0
Shoulder	1	33%	1.0
Chest	0	0%	NA
Elbow/forearm	0	0%	NA
Hand/wrist	1	33%	3.0
Upper back	1	33%	3.0
Lower back	0	0%	NA
Hip/thigh	0	0%	NA
Knee	0	0%	NA
Lower leg	0	0%	NA
Ankle/foot	0	0%	NA

Average rating 2.5

Employee Discomfort Survey Summary

The pre and post project employee discomfort surveys indicate a substantial decrease in areas of discomfort and severity of discomfort (32% reduction in average over-all rating) after the project improvements were completed. One employee now reports no discomfort whatsoever related to the bricker job tasks following implementation of the improvements. This is a very positive and important measurement of the success of this project.

Worksite Redesign Project Completion Summary

All of the recommendations identified in the baseline ergonomic evaluation have been successfully implemented, resulting in the ability of employees to work in optimal positioning up to 75% of the time. Optimal postures with good body mechanics for these tasks would be defined as:

1. Work in standing rather than kneeling positions
2. Work with no or minimal bending or twisting of the trunk
3. Handling bricks with both hands
4. Handling bricks between knuckle height and chest height keeping elbows close to trunk
5. Minimizing reach distances

While there still remain ergonomic risk factors in the Ladle Bricking area, they are much improved compared to the conditions prior to implementation of engineering controls.

The evaluation of MSD risk factors identified above, combined with the discomfort survey results indicate that the engineering controls and related work processes instituted in the Ladle Bricking department have been very successful. The MSD risk factors have been substantially reduced without inadvertently creating any new MSD hazards. Production rates appear to be at least the same if not greater (more efficient), according to company management. Employees and management indicate satisfaction in the over-all outcome of the engineering changes.

For further assistance or questions regarding this report please contact Rob Strickland, OTR at 503-667-3564.

Respectfully,

Rob Strickland, OTR
Ergonomic Specialist

Photos

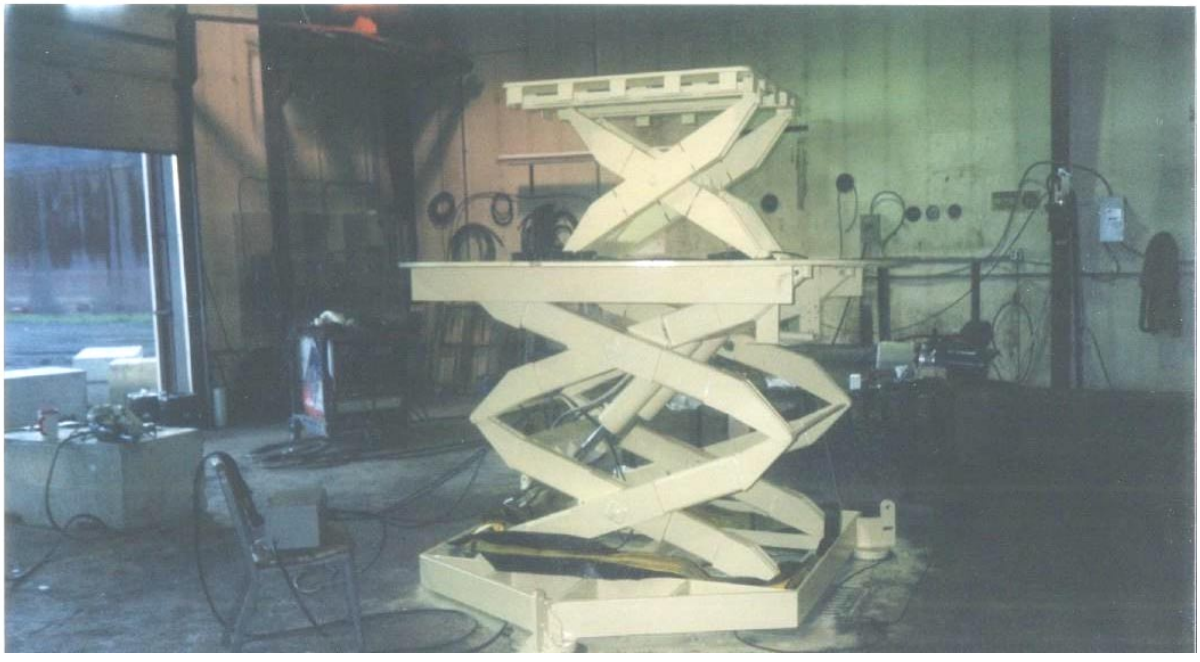

Figure 1

Double scissors lift adjustable floor platform with single scissors, adjustable height pallet lift on top.

Figure 2

Adjustable pallet lift allows worker to maintain height of brick supply at optimal position

Figure 3

Adjustable height floor platform allows worker to maintain relative height of wall at an optimal position

Appendices

NIOSH Work Practices Guide for Manual Lifting- 1991 Revised Equation

The NIOSH WPG revised equation is based on a combination of biomechanical, epidemiological, psychophysical, and physiological data. It establishes acceptable lifting limits based on selected task parameters and specifies recommended engineering controls. Proper application of the equation requires an appreciation of assumptions/limitations that underlie the equation and that characterize the job being evaluated. They can be categorized as:

A. Equation related assumptions-

1. Phychophysical laboratory studies provide the basis of much of the equation. These studies are based on perceived lifting stress as opposed to the potential for low back injury.
2. Physiological guidelines focus on preventing whole body fatigue.

B. Job related assumptions

1. Lifting and lowering tasks have the same level of risk for low back injuries. This assumption is invalid if the worker actually drops the load instead of lowering it all the way to the destination.
2. Activities other than lifting are minimal and do not require significant energy expenditure. These include holding, pushing, pulling, walking climbing. etc.
3. There are no unpredictable conditions such as an unexpected heavy load.
4. Lifting and lowering is performed with two hands.
5. Lifting and lowering is limited to no more than eight hours.
6. The worker is standing while performing the lifting/lowering.
7. The lifting/lowering occurs at a moderate pace, characterized by slow and smooth movements with constant velocity.
8. The load is stable (center of mass does not shift).
9. Equation does not apply to one handed lifting, lifting while seated or kneeling, lifting wheelbarrows or shoveling.
10. The workers are physically fit and accustomed to physical labor.
11. Favorable environmental conditions exist involving temperature (66-79 deg. Fahrenheit) and humidity (35 to 50%).
12. The floor surface is even.
13. The surface between the shoe sole and the floor has a .4 static coefficient of friction.
14. The work space is not restricted.

Recommended Weight Limit (RWL) and Lifting Index (LI)

The NIOSH equation computes the RWL which is assumed to be safe for 99% of the male population and 75% of the female population for the given task being evaluated. The lifting index (LI) is computed by dividing the actual weight being handled (numerator) by the RWL (denominator). If this resulting number is less than one (1) the task is considered safe. If the LI is greater than one it exceeds the recommended weight limit and results in increased risk of injury to employees