Legacy Ergonomics
Work Site Visit/Ergonomic Review
ESCO Doghouse Dept
Portland, Oregon
October 2001

An ergonomic evaluation of the Doghouse Dept. was completed on site at ESCO on 10/23/01 at the request of Karin Drake, Health and Safety. A video tape and digital photos were taken during the evaluation and are available for review. Discomfort surveys were completed by employees involved in these job tasks.

Purpose/Background:

This evaluation constitutes the final ergonomic assessment following the implementation of engineering improvements which were completed under an OSHA Worksite Re-design Grant project. The purpose of this assessment is to understand the musuculo-skeletal disorder (MSD) risk factors associated with the job tasks in the department as compared to the pre-grant conditions. Please refer to the initial ergonomic evaluation reports dated May 12,1998 and Dec. 2, 1999 for an assessment of the risk factors which were present prior to the engineering improvements.

The Worksite Re-design Grant project focused on the tasks of lifting/carrying mold jackets, lifting/placing mold weights and pushing molds since these activities all contained significant MSD risk factors. The following improvements were implemented as a result of this project:

- Dog House floor surface replaced (leveled and smoothed)
- Wheels and bearings on mold carts replaced
- Mold cart tracks replaced (leveled and straightened)
- Springs added to jackets for easier release when lifted from molds
- Weight handle diameter reduced (from 1.5” to 1.25”) making grip with gloves easier
- Training video produced stressing best practices and safety tips
- Attention to housekeeping and maintenance (keeping floor swept and free of hazards)

Pertinent Data from Task Analysis

Current production: (October 2001 Ave.)= 162 molds poured per day.

Jacket weight: (1 end) 76 lb.
Force to break loose jacket: Ave. 140 lb. (momentary force)
Starting position: vertical = 16”, horizontal = 7”
Carrying distance: up to 75 feet.
Ending position: vertical = 30”, horizontal = 7”
Frequency: .17 lifts/min, (each man, working in pairs makes 81 jacket lifts/8 hours)

Weights: 46 lb.
Starting position: vertical = 33”, horizontal = 10”
Ending position: vertical = 36”, horizontal = 18”
Frequency: .32 lifts/min, (lifting 2 at a time, approx. 45/hour)

Pushing force: (moving molds on tracks)
Initial force average= 53 lb., sustained force average= 35 lb.

Observations/conclusions of re-designed tasks:

Breaking Loose and lifting jackets- The force necessary to break loose a jacket from a mold has been reduced on average by 44% by the addition of springs at the corners of the jackets. The frequency of lifting jackets has been reduced (by an unrelated decrease in production demands) by approximately 57%. These two factors taken together serve to reduce the overall physical demands related to handling the jackets.

Improvements to mold carts, floors and tracks- The pushing force necessary to move the mold carts has been reduced on average by 27% (initial force). The sustained force, on average, has remained fairly constant at 35 lb. However, because of these improvements and the improved floor cleaning and track maintenance, the push forces tend to be more consistent over the length of the pushing distance resulting in improved safety for this activity (no sudden increases in push force requirement as before, due to un-level track sections or debris on track).

Reduced weight handle diameter- The smaller handle diameter was trialed and found by employees to be easier to grasp with gloved hands, resulting in reduced hand fatigue for repetitive lifting of mold weights.

Remaining musculoseletal disorder (MSD) risk factors identified in the Dog House tasks are:

1. Forces and Loads- There have been significant, measurable reductions in the forces and loads related to breaking loose the jackets and for pushing molds. However, while improved, the loads continue to be an MSD risk factor. The Revised NIOSH Lifting Equation***** was employed to calculate the Composite Lifting index for these tasks at 4.26. This means that the job exceeds the recommended weight limit by a factor of 4.26. This is an improvement of 32% as compared to the Composite Lifting index for these same tasks (6.29) prior to improvements.

With the measured reduction in push force requirements described above, the "percent capable" (of safely performing the tasks of pushing molds) predicted by the data tables from Stover Snook's* "The Design of Manual Handling Tasks" has risen from 50-75% to 75-90% (after the improvements).

Recovery time between episodes of lifting is improved because the frequency of lifting has been diminished by a reduction in production rates. Significant energy demand remains, especially in hot and or humid weather.

2. Repetition- As indicated above, repetition of movements has been reduced by up to 57% due to a non-project related reduction in productivity. This factor is not considered to have a large impact on the over-all MSD risk. (Further reductions in repetition would not have a significant impact on reducing the MSD risk).

3. Awkward postures- The primary non-neutral posture observed continues to be forward bending and twisting at the trunk, primarily while handling the mold weights. The training video "Safety on the Doghouse Pouring Floor" does correctly demonstrate how to reduce the effect of these postures by supporting the upper body with one hand on a weight, resting on the top of the mold, while lifting and gently swinging the other weight, then coming to an upright posture.

Employee Discomfort Survey: <u>Pre Project</u>

Job Title- Jacket Puller/Pourer Number of surveys completed N= **9**

Discomfort Area	Number of employees with discomfort	Percentage of total	Average Rating (0-10 scale)
Neck	5	56%	5.6
Shoulder	5	56%	5.0
Chest	4	44%	5.0
Elbow/forearm	5	56%	3.8
Hand/wrist	3	33%	2.3
Upper back	3	33%	5.0
Lower back	7	78%	6.6
Hip/thigh	4	44%	3.8
Knee	3	33%	4.7
Lower leg	2	22%	3.0
Ankle/foot	2	22%	5.5

Employee Discomfort Survey: <u>Post Project</u>

Job Title- Jacket Puller/Pourer Number of surveys completed N= **9**

Discomfort Area	Number of employees with discomfort	Percentage of total	Average Rating (0-10 scale)
Neck	0	0	NA
Shoulder	4	100%	2.3
Chest	0	0	NA
Elbow/forearm	1	25%	2.0
Hand/wrist	4	100%	3.8
Upper back	3	75%	2.3
Lower back	4	100%	3.0
Hip/thigh	2	50%	1.5
Knee	0	0	NA
Lower leg	1	25%	4.0
Ankle/foot	1	25%	5.0

Employee Discomfort Survey Summary

The pre and post project employee discomfort surveys indicate a substantial decrease in severity of discomfort (52% reduction in average over-all rating) after the project improvements were completed. This is a very positive and important measurement of the success of this project.

Worksite Redesign Project Completion Summary

While there still remain ergonomic risk factors in the Dog House mold pouring area, they are much improved compared to the conditions prior to implementation of engineering controls. under this OSHA Worksite Re-design Grant project.

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 Dog House mold pouring department have been very successful. The MSD risk factors have been substantially reduced. Employee 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, 503-413-2204.

Respectfully,

Rob Strickland, OTR
Legacy Ergonomic Specialist

Photos

Figure 1

Breaking loose and lifting a jacket from a mold- the "breaking" force has been reduced by the addition of springs at each corner of the jacket, making it easier to break free

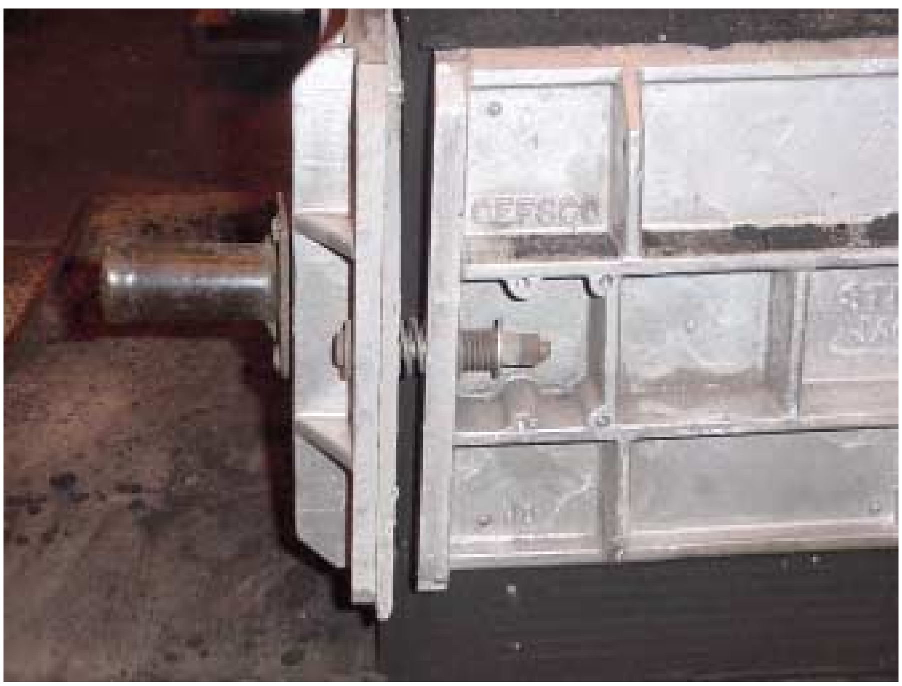

Figure 2

Close-up of springs added to corners of jackets

Figure 3

Lifting and transferring weights using the "swing" method. The worker supports his upper body by leaning on one weight while picking up the second weight to stand upright. Then, he pivots to turn and transfer the weights to an adjacent mold, again supporting the upper body again while setting them down.

Figure 4

New weight on right has smaller diameter handle making handling with gloves easier

Figure 5

Pushing molds now requires less force with improvements made to floor, tracks, wheels and bearings

Figure 6

Pushing the mold is often easy enough to do with a foot

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.

Snook Push/Pull Hazard Tables*

*****See "The Design of Manual Handling Tasks: Revised Tables of Maximum Acceptable Weights and Forces," Snook, S.H. and Ciriello, V.M., *Ergonomics,* 1991, 34 (9): 1197-1213. This research provides psycho-physical data useful in predicting the percentage of male or female industrial workers who are considered safe (at low risk for MSD injuries).

Ergonomics and Musculoskeletal Disorders

BACKGROUND (Adapted from Federal Register, Nov. 23,1999, Department of Labor, OSHA, Ergonomics Program; Proposed Rule)

Ergonomics is the science of fitting the workplace conditions and job demands to the capabilities of the working population. It is an applied science, incorporating engineering, anatomy, physiology, psychology, anthropology and medical sciences. Effective "fits" assure high productivity, avoidance of illness and injury risks, with increased comfort and satisfaction among the work force. A primary goal of occupational ergonomics is the prevention of work-related musculoskeletal disorders (MSDs).

What are work-related musculoskeletal disorders?

MSDs are injuries or disorders of the muscles, tendons, joints, spinal discs, nerves, ligaments or cartilage. MSDs develop as a result of repeated exposure to ergonomic risk factors. Work related MSD's are those disorders to which the work environment and the performance of work contribute significantly. Another familiar and related term is cumulative trauma disorders, (CTDs). Common examples of MSDs include carpal tunnel syndrome, tendonitis, epicondylitis, herniated spinal discs, sciatica, low back pain, trigger finger and DeQuervain's disease.

What are ergonomic risk factors?

Ergonomic risk factors are the aspects of a job or task that impose biomechanical stress on the worker. Ergonomic risk factors are the synergistic elements of MSD hazards. OSHA discusses a large body of evidence supporting the finding that exposure to ergonomic risk factors in the workplace can cause or contribute to the risk of developing an MSD. This evidence, which includes thousands of epidemiologic studies, laboratory studies, and extensive reviews of the existing scientific evidence by NIOSH and the National Academy of Science, shows that the following ergonomic risk factors are most likely to cause or contribute to and MSD:

1. Force (i.e., forceful exertions, including dynamic motions)
2. Repetition
3. Awkward postures
4. Static postures
5. Contact Stress
6. Vibration
7. Cold temperatures

These risk factors are described briefly below:

Force

Force refers to the amount of physical effort that is required to accomplish a task or motion. Tasks or motions that require application of higher force place higher mechanical loads on muscles, tendons, ligaments and joints. Tasks involving high forces may cause muscles to fatigue more quickly. High forces also may lead to irritation, inflammation, strains and tears of muscles, tendons and other tissues.Force can be internal, such as when tension develops within the muscles, ligaments and tendons during movement. Force can also be external, as when a force is applied to the body, either voluntarily or involuntarily. Forceful exertion is often associated with the movement of heavy loads, such as lifting heavy packages, pushing a heavy cart, or moving a pallet. Hand tools that involve pinch grips require more forceful exertions than those that allow other grips such as a power grip.

Repetition

Repetition refers to performing a task or series of motions over and over again with little variation. When motions are repeated frequently (e.g., every few seconds) for prolonged periods (e.g., several hours, a work shift), fatigue and strain of the muscle and tendons can occur because there may be inadequate time for recovery. Repetition often involves the use of only a few muscles and body parts, which can become extremely fatigued while the rest of the body is little used. As task cycles in jobs get shorter (and the number of repetitions per minute increases) employees are at greater risk of injury. Where tasks cycles are short, the same muscles are in constant use and the muscles get no rest from the force required to perform the task cycle.

Awkward postures

Award postures refer to positions of the body (e.g., limbs, joints, back) that deviate significantly from the neutral position while job tasks are being performed. Neutral posture is the position of a body joint that requires the least amount of muscle activity to maintain. For example, the wrist is neutral in a handshake position, the shoulder is neutral when the elbow is near the waist, the back is neutral when standing upright.

Examples of awkward postures include: bent wrists while typing, bending over to grasp or lift an object, twisting back and torso while moving heavy objects and squatting. Awkward postures often are significant contributors to MSDs because they increase the work and the muscle force that is required.

Static postures

Static postures (or "static loading") refer to physical exertion in which the same posture or position is held throughout the exertion. These types of exertions put increase loads or forces on the muscles and tendons, which contributes to fatigue. This occurs because not moving impedes the flow of blood that is needed to bring nutrients to the muscles and to carry away the wasted products of muscle metabolism. Examples of static postures include gripping tools that cannot be put down, holding the arms out or up to perform tasks, or standing in one place for prolonged periods.

Vibration

Vibration is the oscillatory motion of a physical body. Localized vibration, such as vibration of the hand and arm, occurs when a specific part of the body comes into contact with vibration objects such as powered hand tools (e.g., chain saw, electric drill, chipping hammer) or equipment (e.g., wood planer, punch press, packaging machine). Whole-body vibration occurs when standing or sitting in vibrating environments (e.g., driving a truck over bumpy roads) or when using heavy vibrating equipment that requires whole-body involvement (e.g., jackhammers).

Contact stress

Contact stress results from occasional, repeated or continuous contact between sensitive body tissue and a hard or sharp object. Contact stress commonly affects the soft tissue on the fingers, palms, forearms, thighs, shins and feet. This contact may create pressure over a single area of the body (e.g., wrist, forearm) that can inhibit blood flow, tendon and muscle movement and nerve function. Examples of contact stress include resting wrists on the sharp edge of a desk or workstation while performing tasks, pressing of tool handles into the palms, especially when they cannot be put down, tasks that require hand hammering, and sitting down without adequate space for the knees.

Cold temperatures

Cold temperatures refer to exposure to excessive cold while performing work tasks. Cold temperatures can reduce the dexterity and sensitivity of the hand. Cold temperatures, for example, cause the worker to apply more grip force to hold hand tools and objects. Also, prolonged contact with cold surfaces (e.g., handling cold meat) can impair dexterity and induce numbness. Cold is a problem when it is present with other risk factors and is especially problematic when it is present with vibration exposure.

Exposure to one ergonomic risk factor may be enough to cause or contribute to an MSD. For example, a job task may require exertion of so much physical force that, even though the task does not involve additional risk factors such as awkward postures or repetition, an MSD is likely to occur. However, most often ergonomic risk factors act in combination to create a hazard. Evidence shows that of these risk factors, the combination of force, repetition and awkward postures, especially when occurring at high levels are most often associated with the occurrence of MSDs. Jobs that have multiple risk factors have a greater likelihood of causing or contributing to MSDs, depending on the duration, frequency and magnitude of employee exposure to each risk factor or to a combination of them. Thus, it is important that ergonomic risk factors be considered in light of their combined effect in causing or contributing to an MSD.

Solving Ergonomic Problems

As stated above, a primary goal of ergonomics is the prevention of work-related musculoskeletal disorders (MSDs). Ideally, this is accomplished while simultaneously enhancing the productivity and job satisfaction of the employee work group. This is accomplished by identifying the ergonomic risk factors and systematically eliminating or reducing employee exposure to them. There are three approaches to this process described briefly below:

Engineering controls:

Engineering controls are physical changes to a job that eliminate or materially reduce the presence of MSD hazards. They are the primary and preferred method of improving job tasks to reduce exposure to MSD risk factors. Examples of engineering controls for MSD hazards include changing, modifying or redesigning the following:

1. Workstations
2. Tools
3. Facilities
4. Equipment
5. Materials
6. Processes

Work practice controls:

Work practice controls involve changes in the way an employee does the job. They are defined as changes in the way an employee performs the physical work activities of a job that reduce exposure to MSD hazards. Work practice controls involve procedures and methods for performing work safely. Examples of this type of control are training workers to: use good body mechanics and lifting techniques, to vary the tasks they perform throughout the day to minimize muscle fatigue and to use a new or modified tool properly. In the context of ergonomic programs, work practice controls are essential, both because they reduce ergonomic stressors in their own right and because they are critical if engineering controls are to work effectively.

Administrative controls:

Administrative controls are management-controlled work practices and policies designed to reduce exposures to MSD hazard by changing the way work is assigned or scheduled. Administrative controls reduce the frequency, magnitude, and/or duration of exposure and thus reduce the cumulative dose to any one worker. Examples of this type of control are employee rotation, job enlargement, and employer-authorized changes in the pace of work. Administrative controls should be used with caution and only after careful consideration of all reasonable engineering controls.

Ergonomic assessment tools:

- NIOSH Guide to Manual Lifting
- Postural assessments
- Risk factor check lists
- Task frequency and duration
- Force/weight measurements
- Dimension measurements
- Anthropometry data comparisons
- Energy demand
- Body mechanics assessment
- Environmental factors

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