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Ergonomic Evaluation of Automatic Flat Sorting Machines – Colorado

*Jessica G. Ramsey, MS, CPE
Anthony Almazan, MD*

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NIOSH National Institute for Occupational
Safety and Health

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ABBREVIATIONS

"	Inches
ACT	Automation compatible tray
AFSM	Automatic flat sorting machine
ATHS	Automatic tray handling system
ERMC	Eastern regional mail container
ERRP	Ergonomic risk reduction process
FMT	Flat mail tray
FTS	Flat tray sorter
GPMC	General purpose mail container
HHE	Health hazard evaluation
MSD	Musculoskeletal disorder
NAICS	North American Industry Classification System
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PPE	Personal protective equipment
WMSD	Work-related musculoskeletal disorder

HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION

**The National Institute
for Occupational Safety
and Health (NIOSH)
received a request for a
health hazard evaluation
(HHE) at a postal facility
in Colorado. Employees
submitted the request
because of ergonomic
concerns with the
automatic flat sorting
machines (AFSMs).**

What NIOSH Did

- We evaluated the facility in April 2009.
- We observed employees working on the AFSM machines. We also videotaped employees working at the machines so we could examine their work postures.
- We measured workstation heights and reach distances.
- We asked employees about their work and medical history.
- We reviewed occupational safety and health injury and illness logs.

What NIOSH Found

- Employees are at risk for work-related shoulder, arm, wrist, and hand injuries. This risk is due to awkward postures, forceful exertions, and repetitive motions.
- Employees are at risk for work-related back injuries. This risk is due to lifting, twisting movements of the trunk, and bending at the waist.
- Employees reported injuries in their back, shoulders, arms, wrists, and hands.
- Employee rotation patterns were inconsistent between tours, machines, and supervisors.

What Managers Can Do

- Design all work areas to be 27–62 inches high. Moving the working height toward the middle of the range should reduce the risk for back and shoulder injuries.
- Design all lifts to be less than or equal to 27 pounds; this is the maximum acceptable weight for lifts that occur two or more times a minute in optimal conditions.
- Incorporate job tasks that do not require lifting or repetitive grip into current work rotations. Scheduling rotations where employees are not required to repeat the same type of task will reduce the stress on limbs and body regions. All employees should participate in the same rotation patterns.
- Implement an active routine maintenance schedule for knives and cutters used in the prepping area. Dull or broken tools should be replaced immediately.
- Allow employees to provide input on scheduling, pacing, and how jobs are designed and performed.

HIGHLIGHTS OF THE NIOSH HEALTH HAZARD EVALUATION (CONTINUED)

What Employees Can Do

- Work safely and lift properly to reduce your risk of injury.
- Become active in safety and ergonomic committees.
- Report injuries and unsafe work conditions to supervisors, union representatives, and management.

SUMMARY

On September 16, 2008, NIOSH received an HHE request from employees at a postal facility in Colorado. The request was submitted because of potential ergonomic hazards among workers using the AFSM 100 machines.

NIOSH evaluated ergonomic hazards among employees who work on AFSM 100 machines. We found that employees are exposed to risk factors for WMSDs in the upper extremities and back. Recommendations for reducing the risk of WMSDs include designing work heights 27"-62" high; designing all lifts to be less than or equal to 27 pounds; and incorporating job tasks that do not require lifting or repetitive gripping into current work rotations.

During April 1–3, 2009, NIOSH investigators evaluated the postal facility. We observed work processes, practices, and workplace conditions. We measured workstation design parameters and collected video of loading, prepping, and sweeping tasks. We also reviewed medical records related to work injuries and talked with employees privately about their health and workplace concerns.

We found that employees were exposed to risk factors for developing upper extremity WMSDs (including awkward postures, forceful exertions, and repetitive motions), and back injuries (including lifting, twisting movements of the trunk, and bending at the waist). Interviews with employees and review of OSHA Form 300 Log of Work-Related Injuries and Illnesses for 2005–2009 confirmed that the most common WMSD injuries were to the upper extremities and back. Recommendations for reducing the risk of WMSDs, including improved workplace design and rotation patterns are included in this report.

Keywords: NAICS 491110 (Postal Service), AFSM 100, postal workers, rotation, ergonomics, musculoskeletal disorders

INTRODUCTION

On September 16, 2008, NIOSH received an HHE request from employees at a postal facility in Colorado to evaluate potential ergonomic hazards among workers using the AFSM 100 machines.

During April 1–3, 2009, we conducted a site visit at the facility. On April 1, 2009, we held an opening conference with management, employees, and union officials from the National Postal Mail Handlers. We observed work processes, practices, and workplace conditions. We collected video of loading, prepping, and sweeping tasks and measured workstation design parameters. We also privately interviewed employees to discuss their health and workplace concerns, and reviewed medical records related to work injuries. On April 3, 2009, we held a closing conference and provided preliminary recommendations to management and union officials. Preliminary findings and recommendations were provided in a letter dated April 24, 2009.

Process Description

Each of the seven AFSM 100 machines had six stations. Employee rotation patterns through the stations varied depending on the tour (time of day), machine, number of employees working on a machine, and supervisor. Employees were supposed to rotate stations every 30 minutes, but several stated that did not regularly occur. Flat mail includes items that are larger than letter size envelopes with a flat profile such as an envelope containing a flat sheet of paper or a magazine. The following tasks associated with the AFSM 100 were observed.

Loading

Employees manually lifted mail that arrived in FMTs from GPMCs or ERMCs and placed the FMTs on an approximately waist-level take-away conveyor. Some mail arriving in FMTs was removed from larger containers and inducted into the system via the “half-prep” station adjacent to the take-away conveyor. This process was the same as the ACT process during prepping.

Prepping

Loose mail and bundles were handled on a table surface where outer bundle straps and wrappings were cut, removed, and placed into a trash receptacle. The mail was then placed into an ACT. When the ACT was filled, the employee passed a

INTRODUCTION (CONTINUED)

finger by an optical switch, and the filled ACT lowered and passed into the machine, and an empty ACT moved into the working tray position.

Sweeping

After the mail was inducted into the machine, the machine read the address information and sorted it into destination FMT bin positions along the length of the machine. With the ATHS, the system could tell when to remove a full tray and replace the location with an empty one. Full trays were directed to the end of the AFSM 100 machine. On some lines, trays were manually transferred to GPMC and ERMC at the end of the machine, while on other lines the trays were automatically sent by conveyor from the machine to the FTS. Final sweeping was the removal of all FMTs from the machine at the end of a sort run for movement to the next processing step.

Flat Tray Sorter

FMTs were manually loaded and unloaded from the FTS conveyor. The FTS sorted the FMTs to different areas for additional sorting or when ready for delivery.

ASSESSMENT

We observed the process of loading, prepping, feeding, sweeping, and FTS loading/unloading. We took digital videos to document the tasks performed by the employees and measured workstation heights. A full description of the ergonomic evaluation criteria we used to determine risk factors for WMSDs is provided in Appendix A.

We interviewed employees who worked on the AFSM privately, in a separate room. The interviews included questions on work type and duration, work-related injuries or illnesses, past or current health conditions, medications, smoking status, possible workplace exposures, and use of personal protective equipment. We reviewed medical records for injured employees and the OSHA Form 300 Log of Work-Related Injuries and Illnesses for 2005–2009.

RESULTS AND DISCUSSION

Loading

One employee was responsible for transferring mail from GPMCs or ERMCs to the conveyor line. We observed that some GPMCs or ERMCs were only half full and that in those cases the bottom half of the cart was used, eliminating overhead reaches but requiring bending at the back. The measured heights for FMT handles in a GPMC starting at the top were 59" maximum height, 30"-50" middle, and 18" bottom row. There was a 33" reach distance to the back row of FMTs in a GPMC. This reach distance resulted in repetitive bending over at the back to perform the lifts for the middle and bottom rows of FMTs. It also required extended reaches and awkward back postures for reaches from the back of the cart. Also, an employee was observed using the "half prep" station from an FMT that was close to the floor; this required excessive bending at the back.

Prepping

Each machine had four prepping stations; however, during our visit we did not always see all four being used. Mail was received at each prep station either in an FMT or in bundles. Mail in an FMT had to be sorted and placed into the ACT. This required gripping of bundles of mail and sometimes awkward wrist postures when rotating mail to place in the ACT. Mail bundles had either plastic wrapping or bundling straps, or sometimes both. This required cutting the wrapping and bundling with a knife, then sorting and placing into the ACT. Use of the knife also caused awkward wrist postures. The prep table heights were approximately 35"; when an FMT was in the holding position at the prep station hand working heights were 39"-43". The ACT working heights were 29"-40". These working heights required bent neck postures for some taller workers when prepping mail.

Sweeping

Full FMTs were discharged from the system and traveled to the end of a conveyor system. We observed employees lifting FMTs from a roller conveyor into a wire container. The lift origin was approximately 30" at the handhold of the FMT. The destination of the lifts varied greatly depending on the location that the employee chose to place the FMT in the container. Employees had to twist at the trunk to perform lifts from the conveyor to the wire container. During final sweeps the lift frequency was much higher than during a normal sweep. The weights of the FMTs also

RESULTS AND DISCUSSION (CONTINUED)

seemed to vary greatly. The information that we received stated that weight depended upon the density and volume of the mail in the tray; generally trays weighed less than 35 pounds but they could weigh more. Employees expressed concerns that recently the ATHS settings had been changed and that more pieces of mail were in each tray before it was discharged from the system, resulting in heavier FMTs.

Flat Tray Sorter

We observed employees loading the FTS conveyor from "84c" wire containers and dollies. Lifts from these wire containers could originate from 16"-37", while lifts from dollies could originate from 24"-48". The loading jobs varied between very repetitive lifting and more sporadic lifting depending on how many FMTs were already on the FTS. Occasionally, employees had to hold an FMT until a spot became available on the FTS. Loading the FTS involved twisting movements of the trunk because of the location of the containers in relation to the FTS conveyor. We also observed employees removing FMTs from the FTS conveyor lines into GPMCs, ERMCs, or dollies. These lifting jobs did not appear to be as frequent as loading. These lifts had destination heights at FMT handles in a GPMC at 18" bottom row; 30"-50" middle; and 59" maximum height at the top. The reach distance to the back row of FMTs in a GPMC was 33".

Medical Interviews

We interviewed a convenience sample of 27 of approximately 175 employees who worked on the AFSMs. The average age was 47 years (range: 32–61). The average duration of employment as mail handlers was 12 years (range: 2–31). Twenty employees reported having a work-related injury (some had more than one) and seven reported no work-related injury. Employees reported seven shoulder injuries; four back; two each of carpal tunnel syndrome, elbow, neck, toe, and wrist injury; and one each of abdomen, cubital tunnel syndrome, eye, finger laceration, stiff fingers, inhalation, and knee injury. Employees also reported understaffing, intimidation by management, fear of discipline or warning for unsafe work practices, hazard reports getting lost, not being able to take a break until packing was done, having to pay for footwear, and feeling guilty about an injury.

RESULTS AND DISCUSSION (CONTINUED)

OSHA Logs

We reviewed OSHA Logs for 2005–2009. Forty-six reported recordable injuries involved mail handlers and clerks, including 28 WMSDs (61%). The most common WMSDs recorded were shoulder sprains/strains, followed by wrist sprain/pain/tenosynovitis, then back strain.

Rotation Patterns

Prior to the site visit, we reviewed detailed information on work rotation patterns developed by the ERRP team for AFSM 100 employees. Employees were supposed to rotate every 30–45 minutes between lifting tasks (FTS, loader, sweep) and repetitive hand tasks (various prep stations). During interviews with management, union, and employees we found the rotation pattern varied depending on the tour/shift, machine, and supervisor. During one tour/shift, employees moved to different machines from week to week; for another tour the same crews stayed on the same machines. This can cause unequal work distribution because particular zones are assigned to particular machines, and some machines did not have conveyors to the FTS.

A recent laboratory-based study looked at the effect of task rotation on forearm and back muscle activity, the two muscle groups that are utilized during AFSM 100 tasks. In the study, four rotations were evaluated: lift-lift, lift-grip, grip-lift, and grip-grip. The researchers found that two consecutive segments of either grip or lift alone resulted in the greatest muscle effects. They also found that the forearm muscles did not benefit as much as hoped by rotating between a gripping and lifting task. This occurred because even though the handle grip differed between the tasks, the forearm muscles used during gripping were also used during lifting [Keir et al., in press].

CONCLUSIONS

Employees are exposed to a combination of risk factors for upper extremity WMSDs (including awkward postures, forceful exertions, and repetitive motions) and risk factors for back injuries (including lifting, twisting movements of the trunk, and bending at the waist). The interviews and OSHA logs confirmed that the most common WMSD injuries were upper extremity and back. Recommendations for reducing the risk of WMSDs are included in this report.

Because of concerns voiced by employees during our interviews and our observations that certain work organization factors might play an important role in the MSDs at this facility, we offered to return to gather information regarding work organization factors. Work organization refers to the way work is organized, supervised, and conducted. Examples of work organization variables include scheduling, job design, management style, and organizational characteristics. The organization of work affects employees' experiences (physical, psychological, and social). Psychological and social factors such as job satisfaction and perceived job stress levels have been strongly related to WMSDs. Increasing employee influence on decisions made about work organization may not only reduce the physical demand of the job but also create feelings of improved job control [Marras and Karwowski 2006]. As this concern was not part of the original request, the headquarters for the facility opted not to allow further evaluation.

RECOMMENDATIONS

On the basis of our findings, we recommend the actions listed below to create a more healthful workplace. We encourage the facility to use a labor-management health and safety committee or working group to discuss the recommendations in this report and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation at the facility. Our recommendations are based on the hierarchy of controls approach. This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and/or personal protective equipment may be needed.

RECOMMENDATIONS (CONTINUED)

Engineering Controls

Engineering controls reduce exposures to employees by removing the hazard from the process or placing a barrier between the hazard and the employee. Engineering controls can be very effective at protecting employees without placing primary responsibility of implementation on the employee.

- Design all work areas within a working range of 27"-62" [Humantech 2009]. Moving the working height toward the middle of the range should reduce the risk for back and shoulder WMSDs.
- Design all lifts to be \leq 27 pounds. This is the maximum acceptable lift weight for frequent lifts ($\geq 2/\text{minute}$) for optimal reach heights and distances, to reduce the risk of low back injury [Humantech 2009]. As reach distances increase, the acceptable lift weights decrease. For extended reaches with a bent back, the acceptable lift weight is only 8 pounds.
- Design a frequent reach zone (lifts $>2/\text{minute}$) $\leq 16"$ from the edge of the container or dolly. If necessary, place tubs closer to the edge of the container or dolly and then rotate them, rather than reaching to place tubs in the back of the container or dolly. This distance is also preferable when handling mail during prepping. Every 6" of additional horizontal reach distance creates 0.2 seconds of wasted time [Humantech 2009].

Administrative Controls

Administrative controls are management-dictated work practices and policies to reduce or prevent exposures to workplace hazards. The effectiveness of administrative changes in work practices for controlling workplace hazards is dependent on management commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that control policies and procedures are not circumvented in the name of convenience or production.

- Rotate employees through several jobs with different physical demands to reduce the stress on limbs and body regions. Incorporate job tasks that do not require lifting or repetitive grip into the current rotation. Do not schedule rotations where employees are required to repeat the same type of task, i.e., grip-grip or lift-lift.

RECOMMENDATIONS (CONTINUED)

- Require all tours and all employees to participate in the same rotation patterns. Management and union representatives should work together with employees to jointly address rotation and other ergonomic issues.
- Ensure that knives/cutters are well maintained and in good repair. Implement an active routine maintenance and replacement schedule for knives/cutters used in the prepping area.
- Routinely evaluate the effectiveness of engineering and administrative controls.
- Schedule more breaks to allow for rest and recovery. Taking short breaks for 3–5 minutes every hour can give the body a rest and reduce discomfort.
- Increase employee participation and influence in work organization (i.e., the way jobs are designed and performed, work scheduling, and pacing). Targeting these factors can bring about changes that reduce the risk of WMSDs.

Personal Protective Equipment

PPE is the least effective means for controlling employee exposures. Proper use of PPE requires a comprehensive program and calls for a high level of employee involvement and commitment to be effective. The use of PPE requires the choice of the appropriate equipment to reduce the hazard and the development of supporting programs such as training, change-out schedules, and medical assessment if needed. PPE should not be relied upon as the sole method for limiting employee exposures. Rather, PPE should be used until engineering and administrative controls can be demonstrated to be effective in limiting exposures to acceptable levels.

- Provide industrial antifatigue mats for employees who stand for 90% or more of their working hours. Mats should be $\geq 0.5"$ thick, have an optimal compressibility of 3%–4%, have beveled edges to minimize trip hazards, and be placed at least 8" under a workstation to prevent uneven standing surfaces. Mats can be ordered to meet specific electrical/static requirements [Humantech 2009].
- Implement a routine replacement schedule for mats.

RECOMMENDATIONS (CONTINUED)

Healthcare Management

Healthcare management emphasizes the prevention of impairment and disability through early detection, prompt treatment, and timely recovery. Healthcare management recommendations include the following:

- Encourage employees to report musculoskeletal symptoms to their supervisors, the union, and management and to seek a prompt referral to a healthcare provider experienced in the evaluation and treatment of WMSDs. If symptoms are identified and treated early, it is less likely that a more serious disorder will develop.
- Consistently record cases of WMSDs on OSHA Logs and other incident reporting systems to analyze trends and understand the magnitude and seriousness of WMSDs. These records may also offer leads to jobs or operations that can cause or contribute to WMSDs.

Health and Safety Committee

Managers and employees working together to identify work hazards and propose ergonomic solutions is a key component to a successful health and safety committee. The following recommendation should improve the responsiveness of the committee to the ergonomic needs of the employees.

- Encourage employees to participate in health and safety committees. Health and safety committee meetings should be held regularly to evaluate progress, assign responsibilities, and identify potential problem areas. However, if employees have immediate health and safety concerns, they should be raised and addressed at any time between meetings.

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APPENDIX: METHODS

Musculoskeletal disorders are those conditions that involve the nerves, tendons, muscles, and supporting structures of the body. They can be characterized by chronic pain and limited mobility. WMSD refers to (1) musculoskeletal disorders to which the work environment and the performance of work contribute significantly, or (2) MSDs that are made worse or longer lasting by work conditions. A substantial body of data provides 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. Strong evidence shows 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]. Further strong evidence shows job tasks that require a combination of risk factors (highly repetitious, forceful hand/wrist exertions) increase risk for hand/wrist tendonitis [NIOSH 1997]. Lastly, strong evidence shows 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: age, sex, 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 employee. Under these conditions, exposures to risk factors considered potentially hazardous are reduced or eliminated.

Workstation design should directly relate to the anatomical characteristics of the employee. Because a variety of employees may use a specific workstation, a range of work heights should be considered. Based upon functional anthropometry, working heights should be within a range of 27" to no higher than 62" [Humantech 2009]. These heights correspond to hand height dimensions for the 5th percentile female and shoulder dimensions for the 95th percentile male.

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The Hazard Evaluations 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 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 employer 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.

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