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UNITED STATES POSTAL SERVICE
DENVER GENERAL MAIL FACILITY
DENVER, COLORADO

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I. **SUMMARY**

In December 1991 and June 1992 NIOSH received confidential employee health hazard evaluation (HHE) requests to evaluate the potential for ergonomic hazards associated with three types of automated mail processing machines [the Optical Character Reader (OCR), the Bar Code Sorter (BCS), and the Delivery Bar Code Sorter (DBCS)] and the stool or "rest bar" utilized at the manual letter casing area. In August 1992 and December 1992 NIOSH investigators videotaped employees using these machines, and two NIOSH ergonomists reviewed these videotapes to assess the potential for ergonomic hazards associated with the development of work-related musculoskeletal disorders.

Manual letter sorting is a mildly repetitive job, with the pace controlled by the worker. With the adjustable sit/stand stool provided at the workstation, this task probably poses little risk for musculoskeletal disorders.

The Pitney Bowes (P-B) OCR feeding table was lower (31 inches) than the recommended work surface height (36-42 inches), thereby placing "feeders" at potential risk for low back disorders. In addition, the P-B stackers were deeper (25.5 inches) than recommended for work between the waist and shoulders (20 inches), placing "sweepers" at potential risk for low back and shoulder disorders. Finally, the vertical reaches to place sorted mail from the stackers into trays were higher (between 47-64 inches) than the recommended heights (less than 50 inches), placing employees at potential risk for shoulder disorders. The Postal Service has made efforts to replace these machines with other brands at recommended work surface heights.

Other than the low P-B feeder table, the "feeder" positions were similar for the three types of automated equipment reviewed during this evaluation.
The principle activity which placed feeders at risk for low back injury was the stooping required to retrieve trays of mail from the lowest levels of the general purpose mail carriers. Mechanisms to reduce trunk flexion while retrieving trays of mail from the mail carriers are included in this report.

The sweeping positions varied between machines due to differing 1) number and configuration of stackers, 2) methods to transfer the sorted mail into trays, and 3) methods used to transport filled trays onto mail racks. The DBCS machine, with its three rows of stackers, was noteworthy for its bottom row of stackers being just 22 inches above the floor. This feature requires trunk flexion of 90° for most employees, putting DBCS sweepers at high risk for low back disorders. The arm reaches required by sweepers to access the top row of stackers

on the DBCS machines, and place filled trays onto racks on the P-B OCR and BCS machines, pose a potential risk for shoulder disorders.

Both the sweeper and feeder positions were potentially very repetitive due to the processing capabilities of the machines (up to 35,000 letters per hour). Frequent machine jams, however, reduced the "machine-paced" time pressures and provided short rest breaks reducing the job's repetitive nature. In summary, employees operating the automated mail processing machines are exposed to moderately repetitive tasks with awkward postures, two factors associated with musculoskeletal disorders.

NIOSH investigators identified several ergonomic hazards associated with the Postal Service's Automated Mail Processing Machines. These hazards put employees at potential risk for low back and upper extremity musculoskeletal disorders. Of particular note were the design flaws at the DBCS sweeper position. Recommendations are provided in this report to reduce the ergonomic hazards associated with operating these machines.

KEYWORDS: SIC Code 4311 (United States Postal Service), ergonomics, biomechanical hazards, postal employees, musculoskeletal disorders, cumulative trauma disorders (CTDs), low back pain, tendinitis.

II. INTRODUCTION & BACKGROUND

In December 1991, the National Institute for Occupational Safety and Health (NIOSH) received a confidential health hazard evaluation (HHE) request from employees working at the Denver General Mail Facility (GMF) located in Denver, Colorado. The requesters were concerned about potential ergonomic hazards associated with the use of two types of automated mail processing machines: the Bar Code Sorter (BCS) and the Optical Character Reader (OCR). In June of 1992, NIOSH received three separate HHE requests to expand the original Denver GMF evaluation to include the Delivery Bar Code Sorter (DBCS), the Pitney-Bowes (PB) OCR, and the stool or "rest bar" utilized at the manual letter casing area.

In August 1992 NIOSH investigators videotaped employees using the ElectroCom Automation, Inc. (ECA) BCS and OCR machines at the GMF located in Merrifield, Virginia. In December 1992, NIOSH investigators videotaped employees at the Denver GMF using the ECA BCS, PB OCR, ECA DBCS, and rest bar. These videotapes were reviewed by two NIOSH ergonomists to assess the potential for ergonomic hazards associated with the development of work-related musculoskeletal disorders.

III. JOB DESCRIPTIONS

A. CASING MAIL (taped at the Denver GMF)

Mail that cannot be processed by machine is sorted by hand in a process known as casing mail. The casing work stations provide employees with a padded sit/stand stool which has a mechanism for adjusting seat-pan height, seat-pan tilt, and footrest location. The footrest appears most useful to employees tilting the seat-pan towards the vertical while leaning on the stool. There is a ring on the shaft of the stool for the feet of employees who choose a more horizontal seat position and use the stool like a chair.

Employees retrieve trayed mail from a staging area. After sorting the mail, employees "pigeon hole" envelopes into slots located to their front and side. A tray of mail takes approximately one hour to empty, after which employees retrieve a new, full tray from the staging area.

B. PITNEY-BOWES (PB) OCR (taped at the Denver GMF)

An Optical Character Reader (OCR) is a machine that scans the city, state, and/or zip code information on a piece of mail and places a bar code on the envelope. The bar code allows other machines to sort the mail. All OCR machines require someone to 1) feed mail into the machine (feeder), and 2) remove processed mail and place it into cardboard or plastic trays (sweeper).

1. FEEDER

The feeder on the PB OCR lifts trays of mail from a rolling cage called a "general purpose mail carrier," and places them on a tilted stand (feed table) located near the machine. The cage is a tall, thin carrier with trays as low as eight inches from the ground, or as high as five feet above the ground. Trays typically weigh 10-15 pounds, but, depending on the type of mail, can weigh up to 25-30 pounds. The feed table height is approximately 31 inches from the floor.

Two techniques are used to transfer mail from the tray onto the feed tables: grasping or flipping. Employees who use the grasping technique remove mail from the tray with their hands in three to four portions. Employees who use the flipping technique toss the entire tray contents onto the feed table in one, quick movement. Once loaded onto the feed table, the mail is pushed horizontally from right to left toward the OCR machine.

Rollers transfer individual pieces of mail to the optical eye which reads the city, state, and/or zip code information. The unit is designed to process up to 35,000 pieces of mail per hour, however irregular or damaged envelopes can jam the machine, thereby slowing the process. In addition, rubber bands binding bunches of mail must be removed by the feeder, also slowing the process. Rejected mail is manually placed in a tray located at the rear of the machine.

2. SWEEPER

The sweeper removes sorted mail from slots called "stackers" and places them into trays. The stackers are 31.5 inches above the floor height and 25.5 inches deep. The trays are arranged in a single row on racks located across the aisle from the OCR. The tray racks are slanted toward the worker, with the bottom and top edges of the tray located 47 inches and 64 inches above the floor height, respectively. One sweeper usually attends to the 60 stackers located on one side of the Pitney Bowes OCR machine. After a tray is filled with mail, the sweeper places it on a roll conveyor located below the rack and replaces it with one of the empty trays located in the work area.

C. **ECA OCR** (taped at the Merrifield GMF)

1. FEEDER

The feed table of the ECA OCR differs from the Pitney Bowes OCR in two respects. First, it is four inches higher (35"), and second, it has a vibrating jogger, as do all ECA machines (OCR, DBCS, BCS), located to the right of the optical scanner. The jogger facilitates the feeding of loose mail into the processing machines by reducing the potential for single mail pieces to jam the machines.

2. SWEEPER

Like the PB OCR, the sweeper on the ECA OCR attends to 60 stackers, all located on one side of the machine. Each stacker is 34.5 inches high and 18.5 inches deep. The sweeper removes mail from each stacker and places it into a tray located directly below the stacker. The trays are accessed using a sliding motion. When the trays are filled, they are placed on a multi-tiered rack, located across the aisle from the machine.

D. ECA BCS (taped at the Merrifield and Denver GMF)

The Bar Code Sorter (BCS) processes mail in a manner similar to that of the OCR machines.

1. FEEDER

Retrieving trayed mail, loading the feed table, and pushing the unsorted mail into the machine is identical to that of the ECA OCR machine. The feed table height is 35 inches.

2. SWEEPER

The ECA BCS has 96 stackers arranged in a single tier on both sides of the machine. This stacker arrangement is the main difference between the BCS (96 stackers on two sides of the machine), and OCR machines (60 stackers on one side of the machine). Stackers are 34.5 inches high and 18.5 inches deep. The sweeper walks around the perimeter of the machine, stopping for brief moments to remove sorted mail from the stackers. After grasping the sorted mail, the sweeper places the mail into trays located across the aisle from the machine. This procedure is similar to those found in the Pitney Bowes OCR/CS area.

E. ECA DBCS (taped at the Denver GMF)

The Delivery Bar Code Sorter (DBCS) sorts bar-coded mail. Like the OCR and BCS, it requires mail to be fed into, and swept from, it.

1. FEEDER

Retrieving of trayed mail, loading the feed table, and pushing the unsorted mail into the machine is identical to that of the ECA OCR and ECA BCS machines. The feed table height is 35 inches.

2. SWEEPER

The ECA DBCS sorts mail to any of three tiers of stackers located on both sides of the machine. These stackers are located 22, 36.5, and 50.25 inches above the floor (Table 1). Each is 15.5 inches deep. The main distinction between the DBCS machines and the BCS machines is the arrangement and number of stackers. The DBCS has 102 stackers located in three tiers (rows) on both sides of the machines. Due to its more "compact" shape, the DBCS requires less floor space than either the BCS, or the OCR.

The DBCS stackers are not equally distributed on both sides of the machine: the feeder side has fewer stackers. If the sweeper cannot keep pace with the machine, the feeder will occasionally assist the sweeper by clearing the stackers located on his side of the machine.

After mail is sorted and removed from the stackers, the sweeper places mail into trays located across an aisle from the machine. The trays are located on a four-tiered rack called a "pie cart." The bottom rack appeared to be a foot above the floor, and the top shelf was about the same height as the top stacker (approximately 50 inches). When a tray of mail is filled, the sweeper lifts the tray from the pie cart and carries it to a general mail carrier. Conveyors serve this function for the OCR and BCS machines.

IV. EVALUATION CRITERIA AND HEALTH EFFECTS

Several case reports over the years have cited certain occupational and nonoccupational risk factors which give rise to musculoskeletal injuries.[1,2,3,4] However, only recently have epidemiologic studies attempted to examine the association between job risk factors (such as repetition, awkward postures, and force) with excess musculoskeletal morbidity. Several cross-sectional and case control retrospective studies of work-related musculoskeletal disorders (WRMDs) have been performed.[5,6,7,8,9,10] The conclusions from these studies have drawn us closer to identifying risk factors associated with disease outcome.

Work-Related Musculoskeletal Disorders

Work-related musculoskeletal disorders of the upper limbs have been associated with job tasks that include: (1) repetitive movements of the upper limbs; (2) forceful grasping or pinching of tools or other objects with the hands; (3) awkward positions of the hand, wrist, forearm, elbow, upper arm, shoulder, neck and head; (4) direct pressure over the skin and muscle tissue; and

(5) use of vibrating hand-held tools. Because repetitive movements are required in many service and industrial occupations, new occupational groups at risk for developing WRMDs of the upper limb continue to be identified.

Evaluation of work-related risk factors which may cause upper limb WRMDs should be conducted to not only aid in their recognition, but to assist with the implementation of controls measures designed to eliminate or reduce such risk factors. Engineering controls are the preferred method; however, administrative controls such as work enlargement, rotation, etc., can be used as an interim measure. Surveillance of WRMDs (including the use of health-care-provider reports) can aid in identifying high-risk workplaces, occupations, and industries and in directing appropriate preventive measures.[11]

Occupational risk factors for low back injuries include manual handling tasks,[12] twisting,[13] bending,[13] falling,[14] reaching,[15] lifting excessive weights,[13,16,17] prolonged sitting,[14] and exposure to vibration.[13,18] Some nonoccupational risk factors for low back injury include obesity,[19] genetic factors,[20] and job dissatisfaction.[21,22] Multiple approaches such as job evaluation and redesign, worker placement, and training may be the best methods for controlling back injuries and pain.[23]

V. RESULTS

A. CASING MAIL

Mail sorting is a mildly repetitive job, with the pace controlled by the worker. Task factors which could result in discomfort or fatigue are
1) reaching to case the mail, and 2) prolonged periods of standing or leaning against the sit/stand stool. By tilting the seat-pan forward, however, the employee can reduce reach distances and maintain the trunk in a neutral position. Therefore, this task probably poses little risk for musculoskeletal disorders. In addition, the padded seat appears wide enough for the majority of employees.

B. PITNEY-BOWES (PB) OCR

1. FEEDER

Tasks which impose biomechanical stress on the employees in this job category are (1) lifting trays from the cages to the feeder table, and (2) grasping and transferring the mail from a tray to the OCR machine. Lifting trays from the lowest levels of the mail carrier poses a risk of low back injury, while lifting trays from the highest levels poses a risk of shoulder injury. Reaching across the machine to the reject mail tray (located in back of the machine) can also place stress on the back and shoulder. The pace of work dictated by the feeder is a potential risk factor because of the processing capabilities of the machine (30,000 - 35,000 pieces of mail per hour). However, this pace was never achieved during the NIOSH site visit due to frequent machine jams.

2. SWEEPER

Tasks which impose biomechanical stress on sweepers include (1) reaching horizontally to access mail in the back of the stackers, (2) grasping mail (using a pinch-grip) to remove mail from the stackers and place it in the trays, and (3) reaching up (vertically) to the trays. These tasks place the shoulders, lower forearms, and hands at risk for musculoskeletal disorders. The pace of work appeared moderate, but the potential for faster work speeds exists due to the processing capabilities of these machines and the large number of stackers attended by each sweeper.

An additional stressor common to all feeder and sweep positions on all machines is excessive bending and reaching while clearing machine jams. The frequency of machine jams cannot be estimated from our videotape, however some of the most extreme postures occurred while employees attended to jammed machines.

C. ECA OCR

1. FEEDER

Because of the similarities between the two machines, feeders on the ECA OCR are generally exposed to the same risk factors as feeders on the PB OCR (described above). The higher feed table height of the ECA machine compared to the PB machine (35 verses 31 inches) reduces the stress on the low back.

2. SWEEPER

Tasks which impose biomechanical stress on ECA OCR sweepers are (1) grasping mail using a pinch-grip to remove mail from the stackers and place it in the trays, and (2) reaching up to place mail in the trays. These tasks place the shoulders, lower forearms, and hands at risk for musculoskeletal disorders. The ECA stackers are not as deep as the PB stackers (18.5 compared to 25.5 inches), thereby posing less risk of musculoskeletal disease to the shoulder area. As with the PB, the pace of work appeared moderate, but the potential for faster work speeds exists due to the machine's processing capabilities and the large number of stackers attended by each sweeper.

D. ECA BCS

1. FEEDER

Due to similar activities, the feeder on the BCS is exposed to the same potential ergonomic hazards as the feeders on the ECA OCR machines (see above).

2. SWEEPER

At the time the video tapes were taken, the operator on the ECA BCS was performing an activity known as "sleeving." This operation involves sliding a cardboard cover over a filled tray of mail that is to be sent out of the GMF, perhaps to another city or state. The sweeper observed on videotape sleeved five trays of mail from two stacker locations during a 14 minute period. Sleeving does not appear to be physically stressful, but appeared to be time consuming since the sweeper must remove existing tags, and attach new address labels and/or other instructional tags. As a result, sleeving reduces the time available for the sweeper to clear the stackers, which could impose increased time pressures during peak sorting periods.

Except for the potential risk factors associated with sleeving and attending to stackers on both sides of the machine, the sweeper on the ECA BCS is exposed to the same ergonomic risk factors as the sweepers on the ECA OCR.

E. ECA DBCS

1. FEEDER

The task of feeding the DBCS is similar to the task of feeding the ECA OCR and BCS machines. Therefore, all ECA feeders are exposed to the same ergonomic risk factors (see above for description). [Additional functions performed by the DBCS feeder [e.g. occasionally assisting the sweeper (see below)], could reduce the monotony and repetitiveness of the job], but also increases the work load.

2. SWEEPER

If the DBCS is used to process small lots of mail, or mail that has already been sorted at least once ("zone" mail), the stackers are often allowed to fill until the feeding process is complete. Then, both the feeder and sweeper remove the sorted mail. This procedure essentially changes the sweepers job from being "machine paced" to being "self paced." Unfortunately, this practice can only occur with small lots, or zoned mail. Another desirable characteristic of zone mail lots is when the feeding is complete, the DBCS machine is shut down while the feeder and/or sweeper return the empty mail carrier to the incoming mail area and pick-up a full mail carrier to sort. This practice provides a break for the feeder and sweeper from their normal mail processing activities.

While processing large mail sorts, the sweeper frequently clears unfilled stackers to provide a buffer against the rapid accumulation of mail into a few stackers located on the opposite side of the machine. This "preventative" sweeping adds to the repetitiveness of the job, and is not unique to the DBCS machines.

Because there are fewer stackers on the feeder side of the machine, the bottom row on the tray rack is often unused. An unusual feature of the tray racks is that they are angled away from the sweeper. This orientation raises the height of the bottom tray, which is beneficial, but it also increases the reach to the top tray. Also, because the far end of the tray is lower than the leading edge, the sweeper must reach up, over and then down to place mail in the back of the tray. Finally, the rack arrangement often causes workers to bump their hands and arms while accessing the trays.

One of the specific concerns detailed in the HETA request was the manual force needed to push down each mail plate after mail is removed from an individual stacker. Mail plates are pivoting gates that provide a stop for the mail as the stackers fill. It has been suggested that heavier or counter-weighted mail plates would fall back into place after removing the sorted mail. Although returning the mail plates to the proper position is an additional work task, the forces required seemed minimal. Furthermore, if the mail plates were heavy enough to fall back into position themselves, they would be more difficult for the sweeper to lift when removing the mail. Therefore, weighting the mail plates is not recommended.

Sweepers on the ECA DBCS are not only exposed to the same ergonomic hazards as the sweeper on the ECA OCR, but they are also required to execute more trunk flexion (when sweeping the bottom tier of stackers) and long reaches (when reaching up to the top tier of stackers). A short worker would be best able to reach to the bottom tier, but would have difficulty reaching the top tier; conversely, a tall worker could more easily reach the top tier, but would have to bend excessively to sweep mail from the bottom tier. The 5'7" worker viewed on the video tape (approximately 25%ile male height)[24] appeared to have difficulty placing mail in the top row of trays. This worker also had difficulty visualizing the mail in the bottom stacker causing more trunk flexion than required by mail removal alone.

VI. DISCUSSION

The mail processing machines evaluated in this report are fast and efficient. If the jamming problems could be overcome, the machines would be even faster and more efficient. The technological breakthrough for this increased efficiency is the machine's optical scanner. In stark contrast to the high efficiency of the optical scanner is the primitive manner in which mail is loaded (feeders) and unloaded (sweepers) from these machines. Future machines should automate these tasks, particularly the sweeper position. The remainder of this report will primarily discuss the ergonomic hazards encountered by feeders and sweepers, and provide recommendations for their elimination or reduction.

A. MAIL CASING

The sit/stand or rest bar stool used in the mail casing area was well suited to the task performed. Sit/stand work stations are recommended when repetitive operations are performed with frequent reaches more than 16 inches forward and/or more than 6 inches above the work surface.[25] Both of these situations are characteristics of the mail casing task.

As noted previously, the sit/stand stool is big enough and has enough adjustability to accommodate a wide range of workers. A traditional chair or stool with a seat back, but without a tilt feature, is not recommended for this task. Although a traditional chair would provide support for the back, it would also require the worker to lean forward while placing mail in the pigeon holes. Frequent forward bending could result in back fatigue. The sit/stand stool allows the trunk to be maintained in a neutral position during the casing task.

B. AUTOMATIC MAIL PROCESSING MACHINES

1. FEEDERS

From a biomechanical and postural loading standpoint, the feeding tasks associated with the PB OCR, and the ECA OCR, BCS, and DBCS machines are similar. A problem common to all feeders working on these machines was the frequent stooping to retrieve trays of mail from the lowest levels of the general purpose mail carrier. This puts these employees at risk for low back injury. A minor difference among these machines is that the feeding table of the PB OCR is 31 inches high, 4 inches lower than that of any of the ECA machines. The recommended work surface height for a light task that may require some sideward forces (e,g., loading a machine) is 36-42 inches.[26] Lower heights could result in unnecessary trunk flexion and low back disorders, particularly among tall employees.

2. SWEEPERS

Forward reaches more than 20 inches in front of the body should be avoided when standing.[27] The PB stacker depth was 25.5 inches, (4.5 inches more than recommended), and the stacker height was 31.5 inches (5.5 inches less than recommended). These dimensions could result in excessive shoulder flexion (reaching) in shorter workers and excessive trunk flexion (bending) in taller workers. With stacker depths of 18.5 inches, and heights of 34.5 inches, the ECA OCR and BCS machines appear to be of better ergonomic design.

The racks which held filled trays of mail were similar for the PB OCR and the ECA BCS machine. In general, reaches or lifts above 50 inches (shoulder height for the 25th percentile female) should be avoided.[24,27] Placing mail in the top tray requires a reach of 47-64 inches, therefore shorter workers may have difficulty reaching the top tier of trays. The trays used with the ECA OCR in Northern Virginia were superior to those used with the Pitney Bowes OCR and the ECA BCS in Denver because they were conveniently located below the stackers. Instead of reaching across the aisle with each handful of mail, the sweeper on the ECA OCR could fill the trays, then reach across the aisle (once) to put the tray onto the carts.

The tray racks used in Denver, however, were better than the multi-tiered tray carts used in Northern Virginia because the Denver racks were in a single tier, whereas those in Virginia varied in height from less than a foot to up to five feet above the floor. A better design would be to locate trays under the stackers, and provide a single-tiered row of tray racks across the aisle, with a roll conveyor located beneath the racks. The **best** design would be to provide trays under the stackers, and provide a roll conveyor located across the aisle (38-46 in. height) to carry filled trays away (no tray racks at all). This design would minimize reach distance and allow trays to be transferred laterally (without a vertical lift) to the conveyor.

The height of the top stacker of the ECA DBCS machine (50.25 inches) only slightly exceeds the maximum recommended reach height (50 inches), and the 15.5 inch depth is within that recommended for work between the waist and shoulder height (<24 inches).[27] However, the 22 inch height of the lower shelf exposes workers to excessive trunk flexion with the shortest workers bending nearly 90° to retrieve mail from the lowest stacker. Bending more than 20°, especially if repetitive, is a risk factor for musculoskeletal injury.[28] Workers could avoid trunk flexion while sweeping the bottom stacker by flexing the knees instead of their backs. This, however, is not recommended because of the asymmetric muscle and ligament forces imposed on the knee during knee flexion. Mechanical forces on the knee are almost 8 times body weight while in a deep knee bend posture.[29]

These employees were also required to reach above shoulder height, flexing their shoulders more than 90°, to sweep mail from the top stacker. Workers who are required to repetitively flex their shoulders more than 45° are considered to be at increased risk of injury.[29] The ECA DBCS machine does have a fold-down step at its base reducing the reach height to the top stacker by six inches. This step, however, was never used in the hours of videotape reviewed by NIOSH. If employees could sweep one row at a time the step would be useful. But stackers fill in no particular row sequence, therefore, raising and lowering the step was impractical. Leaving the step in the down position could pose a tripping hazard to sweepers, therefore, it is not surprising that the step was not utilized, and we do not recommended its use.

The Postal Service appears to be in the process of ordering and purchasing DBCS machines with four, rather than three, rows of stackers. This would result in greater bottom-to-top stacker height distances than observed in this evaluation, and would probably exacerbate the current problem of excessive back and shoulder flexion.

The pie carts in the DBCS area were similar to the tray carts used by the sweeper on the ECA OCR in Northern Virginia. Their poor design adds to the biomechanical hazard of the job by requiring workers to 1) bend over to reach the bottom levels, 2) reach above shoulder height with fully extended arms to place mail in the top tray, and 3) carry filled trays to a secondary mail carrier. Locating trays below the stackers (discussed above for the OCR and BCS machines) is not practical for the DBCS because of the number and the arrangement of the stackers. Furthermore, such an arrangement would require even greater trunk flexion to access the bottom row.

VII. CONCLUSIONS

Manual letter sorting probably poses little risk for musculoskeletal disorders. Work on the automatic mail processing machines is potentially hazardous to employees due to design flaws and the high volume capacities of these machines. Under moderate mail volume conditions, the feeder positions on the OCR, BCS, and DBCS machines could be improved by providing a mechanism to reduce trunk flexion while retrieving trays of mail from the mail carriers. The sweep positions on the OCR and BCS machines could be made safer by redesigning the work station to reduce the amount of trunk flexion and arm reaching. Recommended design changes to achieve these ends will be presented in the following section.

The stacker layout on the DBCS machine is a significant departure from good ergonomic design. The current design, 102 stackers arranged in three rows with no adjustable features, results in excessive flexion of the trunk and shoulders for **all employees.** These extreme postures can lead to low back and upper extremity musculoskeletal disorders.

The pie carts used by sweepers in the Denver DBCS and the Merrifield ECA OCR were not designed to accommodate the various sizes of employees and add to the biomechanical hazards of their job.

VIII.RECOMMENDATIONS

As mentioned previously, the manual operations associated with the mail processing machines should be automated, particularly the sweeping positions. One possible design to accomplish this goal would include a "weight sensitive" stacker bin. Once full, the bin could eject its contents into a container located either below or adjacent to the bin where a moving conveyor could carry the mail away. Workers would still be needed to monitor the machines, attending to malfunctions and jam-ups. Given that such automation may be infeasible or in the distant future, the following recommendations, specific to operations at the Denver GMF, are offered to prevent and/or control trunk and upper extremity cumulative trauma disorders among employees.

A. FEEDER POSITIONS ON ALL AUTOMATED MACHINES (ECA OCR, BCS, DBCS, PITNEY BOWES OCR)

To eliminate extreme trunk flexion while retrieving trays of mail, an alternative method of delivering mail to the feeders could be devised, or the mail carriers could be redesigned. Redesign options include
1) raising the bottom of the mail carrier, 2) using smaller carriers, or 3) using carriers with spring-controlled leveling systems that raise the load as trays are removed. The lowest load height should be in the range of 26-32 inches, and total stack heights should not exceed
60 inches.

B. SWEEPER POSITIONS ON ALL AUTOMATED MACHINES (ECA OCR, BCS, DBCS, PITNEY BOWES OCR)

Locate empty trays under the stackers (except DBCS) to minimize the number of reaches to the tray racks while sweeping. Also, provide an expedient means of dispensing filled trays. Possible options include providing general mail carriers (modified as recommended in "A" above), or a roll conveyor that leads to a central location (38-46 in. height).

C. **OCR MACHINES**

Continue to replace the older PB OCR with the ECA OCR. The ECA OCR reduces worker exposure to ergonomic stressors in three ways: 1) the feed table is higher, 2) the stackers are higher and more shallow, and 3) the tray racks are located below the stackers. These design features decrease reaching, bending, and lifting during mail processing tasks.

D. **ALL AUTOMATED MAIL PROCESSING MACHINES**

Recognize that handling bulk mail is a moderately repetitive task which poses a risk of injury to the back and upper extremity. Administrative controls to reduce hazards and minimize injuries need to be implemented. Some measures to be considered are:

1. Assign additional sweepers to the machines (particularly the DBCS).

2. Limit the time spent working on machines (particularly DBCS). This control measure could require identification of lighter duty work activities for workers rotating out of the feeder and sweeper positions.

3. Provide additional rest breaks for employees working on machines (particularly DBCS). One way to increase rest time is to process more mail in the way that zones are run: sort mail in smaller lots so that the machines are periodically shut down, with both the feeder and sweeper clearing out the stackers, and then allow one or both to leave the work area to return empty mail carriers in exchange for filled ones.

4. Eliminate job tasks performed by the machine operators that could be completed in other areas of the mail facility. An example activity is mail sleeving, which could be performed in the tray binding area.

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TABLE 1

STACKER CHARACTERISTICS BY TYPE OF MACHINE
Denver General Mail Facility
HETA 92-073

	P-B[1] OCR[2]	ECA[3] OCR	ECA BCS[4]	ECA DBCS[5]
# of Stacker Rows Total # of Stackers	1 60	1 60	1 96	3 102
Stacker Row Height	31.5"	34.5"	34.5"	22.0" 36.5" 50.25"
Stacker Depth	25.5"	18.5"	18.5"	15.5"
Tray Racks: Bottom Top	47" 64"	Below Stacker	47" 64"	≈12" ≈50"

1 Pitney Bowes
2 Optical Character Reader
3 ElectroCom Automation
4 Bar Code Sorter
5 Delivery Bar Code Sorter

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