# United States Postal Service

## Delivery Bar Code Sorter (DBCS)

## Ergonomic Issues Evaluation

## and

## Field Tests of Controls

**A Report by Certified Professional Ergonomists (CPEs):**

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# Introduction

The unprecedented stresses on the US Postal Service (USPS) may cause us to look back nostalgically on simpler times – perhaps even to an era where all mail was manually cased for delivery. It was an effective system that got the mail out through the repetitive labor of hard working postal employees. However, time marched forward with the growth of mail volume that would have overwhelmed the previous system – and so letter automation was born. The Delivery Bar Code Sorter (DBCS) machines have gone through several major changes since inception and introduction to the USPS in the early 1990's. Ergonomic considerations were initially assessed prior to implementation of the machine. However, the Occupational Safety and Health Administration (OSHA) requested that the USPS continue to examine the ergonomic issues with the DBCS as a result of their inspection of nine USPS plants in 2010. Therefore, USPS operations tasked a team of postal experienced contract ergonomists to field test and evaluate DBCS ergonomic controls as suggested by OSHA.

In September 2010, the USPS received correspondence from OSHA, along with a twenty-four page report on its ergonomic evaluation of the DBCS. The report listed a number of controls with potential ergonomic impact for the operators of the DBCS machines. USPS operations selected to initially address several of the items which fell into five categories. These categories were as follows: 1. Stacking no more than two trays high on the 1226F tray rack surge shelf and issues related to accessing these trays. 2. Sweeping from the stacker bins to the 1226F tray rack. (Note: this category included maximizing the amount of mail in the two middle tiers of the tray rack and using two-hand versus one-hand sweeping techniques.) 3. Job rotation of the feeder and sweeper positions. 4. 1226F tray cart maintenance. 5. Use of a transfer mail table (TMT) for the DBCS feeder.

For each of these five categories, the USPS contract ergonomists designed a test with objectives, and their evaluations are included in this report. (It is worthy of note that the six ergonomists have worked with the USPS on its ergonomics process for some time and are well-versed in the knowledge of the Postal Service culture as well as its equipment and operations).

USPS Operations approved the test methods and selected nine plants (at least one in each area). The tests were conducted over a period of three weeks at each site. The test team was made up of the contract ergonomists, USPS ergonomic specialists, USPS training representatives, along with a member of headquarters' operations engineering. The national and local APWU membership was invited to participate with each test as their schedule permitted.

The sites selected to participate in the assessment were: Denver, CO P&DC – pilot site, Colorado Springs, CO P&DC, Providence, RI P&DC, Los Angeles, CA P&DC,

Nashville, TN P&DC, Palatine, IL P&DC, Norfolk, VA P&DC, Columbus, OH P&DC, and Tulsa, OK P&DC.

USPS Operations is working with its team of postal experienced contract ergonomists to field test and evaluate DBCS ergonomic controls as suggested by OSHA. The USPS has moved forward as part of its continuing efforts to reduce Musculoskeletal Disorders (MSDs) through its ergonomics process. The involvement of all USPS employees in ergonomics, including DBCS operators, is important to the future health of all employees. Additional benefits realized through ergonomics include a reduction of workers' compensation and other costs resulting from reductions in MSD injuries, while maintaining the productivity of postal services to customers across the country.

# Executive Overview

To help develop a response to the September 2010 OSHA report on its ergonomic evaluation of the Delivery Bar Code Sorter (DBCS), USPS Operations selected five controls for further evaluation. Tests of these controls were: 1. Evaluation of Methods for Limiting Tray Stacking to Two High on 1226F Surge Shelf; 2. Evaluation of Sweeping Operations from the DBCS Stackers to 1226F Tray Carts; 3. Evaluation of the Impact of Task Rotation; 4. Evaluation of Maintenance and Serviceability of 1226F Tray Carts; and 5. Evaluation of Feeder Station TMT and Mail Induction.

## Test 1: Evaluation of Methods for Limiting Tray Stacking to Two High on the 1226F Surge Shelf

In Test 1, a potential ergonomic control method was developed for limiting tray stacking for large volume DPS mail runs to no more than two high on top of 1226F tray carts and this method, with adjustments made at some sites to address local constraints, was tested on DBCS operations at the test locations. Three methods were identified and proved capable, during testing, for either eliminating or substantially reducing tray-stacking to no more than two high while having no unfavorable impact on a site's capabilities for feeding second pass mail in the correct sequence. These methods, as described in Appendix 1A, 1B, & 1C, are recommended for implementation based upon the site specific characteristics of each DBCS operation.

## Test 2: Evaluation of Sweeping Operations from the DBCS Stackers to 1226F Tray Carts

In Test 2, the risk factors associated with sweeping from the DBCS stackers, namely reaching above shoulder-level to the top bins and bending down to the bottom bins, are addressed in two parts. First, a software tool has been developed that converts the "Bin Count" table of the EOR Viewer report to a detailed bin diagram. This tool can be used to check the end result of any sort program for a specific production run from any DBCS machine at any facility. A "targeted optimal percentage" (TOP) range of 71.4 to 75% of total production run volume in the middle two tiers is prescribed, with the least amount of mail in the bottom tier. Secondly, the recommended best sweeping practice is to "scoop" a comfortable quantity (7 to 9 inches) of mail using two hands as opposed to a one-hand "pinch". Ideally, if the TOP range of mail is placed into the middle bins, then the two-hand sweeping technique can be applied to the majority of mail from bins located between knuckle and shoulder-height.

## Test 3: Evaluation of Impact of Task Rotation

This evaluation focused on understanding current DBCS operator rotational practices and beliefs, and the impact on perceived rest and recovery when rotating between feeding and sweeping every hour (1-Hr) and every other hour (2-Hrs). More rest and recovery was experienced from the 1-Hr rotation than the 2-Hrs rotation; although both rotations tended to provide adequate rest. Workload and perceived rest were found to have some association on Tour 1 only. Compared to current practices, both test rotations provided ‘about-the-same’ to ‘slightly-more’ rest and recovery on Tour 1; a similar finding was found only for the 1-Hr rotation on Tour 3. Both test rotations tended to provide more perceived rest to those who normally rotate less frequently, and less perceived rest to those who normally rotate more frequently. It is recommended that a standardized rotation between DBCS operators of at least every two hours (2-Hrs) be implemented. More frequent rotation, as deemed necessary or appropriate, should be encouraged and permitted. Operators should continue to alternate between their first tasks on alternating days. Regular active managerial support should be provided.

## Test 4: Evaluation of Maintenance and Serviceability of 1226F Tray Carts

OSHA reported that MSDs may be increased due to poor 1226F tray cart maintenance and suggests sustained maintenance. The ergonomists’ ten point inspection found an average defect rate of 28.5% that spanned three MSD risk categories. MSD risk may increase in both work technique and equipment malfunctioning if the racks are not adequately maintained. Therefore, operations management must ensure tray carts are maintained so the potential for MSDs does not increase due to lack of maintenance. Several overlapping maintenance practices are offered to operations to select from in order to increase the operational efficiency and decrease the MSD risk associated with 1226F tray cart use. Common options to identify and fix racks include: labeling all racks, ”tagging” defective racks, prioritizing repairs, “red dot alerts” (mark non-opening trays), logging repairs, ensuring quality parts are available and incorporate a maintenance route at a reasonable frequency. Additionally, it is recommended that a process be implemented for sites to share information on best practices in maintaining the 1226F tray carts.

# Test 5: Evaluation of Feeder Station TMT and Mail Induction

Transfer Mail Tables or TMTs used to transfer mail trays from MTE to the DBCS jogger were evaluated to examine the effects of table height, table top tilt, and table placement on MSD risk factors (i.e., ergonomic impact). Tests of the TMTs across the 9 test sites with a total of 78 DBCS operators participating provided information on optimum table height, table top tilt, and position while feeding mail onto the jogger. The effects of back bending, reaching, and bent wrist postures while using the TMTs were assessed through direct observations and feedback from operators. In addition, overall ratings of various TMT configurations were collected from the participants. The results of the test support the overall concept of a TMT for the DBCS feed station as an alternative to feeding mail from trays placed on the jogger shelf behind the jogger and unloading trays directly onto the jogger. Details of the test methodology, results and conclusions are included in Test 5, and corresponding Appendices 5A - 5D, of this report.

# Test 1: Evaluation of Methods for Limiting Tray Stacking to Two High on the 1226F Surge Shelf

## Executive Summary

As a potential ergonomic control, a method was developed for limiting tray stacking for large volume DPS mail runs to no more than two high on top of 1226F tray carts and the method tested on DBCS operations at selected test sites.

The test plan method, as fully documented in Appendix 1A, includes placing the first full trays generated on top of the 1226F tray cart until trays are stacked two-high on the surge shelf and then off-loading any additional full trays generated to support equipment.

Based upon testing, the following methods were identified as feasible and effective in limiting tray stacking:

1) Method 1 followed the steps documented in Appendix 1A and was found to be applicable to operations using two sets of 1226F tray carts per machine and GPMCs with inserts. When GPMCs with inserts are used as support equipment, trays can be pulled in the order they become full and positioned in the correct sequence for second pass feeding utilizing both two-high stacking on top of the 1226F tray cart and positioning of trays within the GPMC.

2) Method 2, as documented in Appendix 1B, is applicable to operations using two sets of tray carts per machine and support equipment other than GPMCs with inserts. Instead of placing the first full trays on top of the rack until trays are stacked two-high, as specified in Method 1, all full trays are off-loaded from the tray drawers at the same time and positioned to facilitate second pass feeding by ensuring that the tray to be fed next is always accessible without the need for un-stacking of other trays.

3) Method 3, as documented in Appendix 1C, is applicable to operations which use only one set of 1226F tray carts per machine. These operations must off-load all full and partially full trays from the 1226F tray carts into support equipment for second pass feeding, and this method allows the off-loading of trays in a manner best-suited for the specific operation.

All three of the methods proved capable during testing of either eliminating or substantially reducing tray-stacking to no more than two-high while having no unfavorable impact on a site's capabilities for feeding second pass mail in the correct sequence.

Some employees perceived the off-loading of trays to limit tray stacking to be more physically demanding than stacking trays more than two high on the 1226F tray carts. These employees typically referenced the tasks of carrying full trays to support equipment and loading and unloading trays to equipment, particularly the lower levels, as a basis for their perceptions. Other employees found the physical demands of the test methods to be either less or no different from the site's standard methods.

Based upon analysis of test results, recommendations include the following:

1) Three methods for limiting tray stacking are recommended for implementation based upon the site specific characteristics of each DBCS operation as follows:

   a. Method 1: For Operations with Two Sets of 1226F tray carts and GPMCs with Inserts
   b. Method 2: For Operations with Two Sets of 1226F tray carts and Support Equipment Other than GPMCs with Inserts
   c. Method 3: For Operations with One-Set of 1226F tray carts

2) When selecting available support equipment sites should place priority on utilizing equipment and practices that minimize physical demands and MSD risk factors involved in loading and unloading full trays to and from the equipment as specified in the Results and Recommendations sections of this report.

3) Sites should be given the option of marking new empty trays added to the 1226F tray carts with either a red strip or by using a red marker to mark on the label.

4) Sites should consider the following during heavy volume DPS mail runs:

   a. Scheduling the heaviest run volumes on machines with adequate floor space for staging the amount of support equipment needed for off-loading trays.
   b. Utilizing any available additional personnel to assist employees assigned to the feeder and sweeper positions in off-loading trays.

The testing and evaluation of tray stacking methods provided an improved understanding of site capabilities and constraints. Testing confirmed the availability of methods, that are both feasible and effective, to limit tray stacking on the 1226F tray carts.

# A. Introduction

### Problem Statement

In its September 2010 correspondence, OSHA suggested that the USPS consider implementing control measures to limit tray stacking to no more than two-high on top of 1226F tray carts in order to reduce MSD risk factors related to repeated, above-the-shoulder reaches. OSHA noted that tray stacking is primarily an issue when processing the first pass of DPS (Delivery Point Sequence) mail.

As a potential ergonomic control, a method was developed by the USPS for limiting tray stacking for large volume DPS mail runs to no more than two high on top of 1226F tray carts and the method has been tested on DBCS operations at selected test sites.

### Objectives

The objectives of testing were to evaluate methods for limiting tray stacking to no more than two high and to address issues related to supporting two high stacking, including: (a) maintaining unobstructed aisle space for staging and moving support equipment, (b) providing adequate access points to the back of the 1226F tray carts, and (c) utilizing additional support equipment, such as APCs and/or Nutting trucks for off- loading excess full trays from the surge area of 1226F tray carts.

# B. Methods

The test plan method, as documented in Appendix 1A, includes placing the first full trays generated on top of the rack until trays are stacked two-high on the 1226F surge shelf, and after the surge area is full, off-loading any additional full trays generated to support equipment.

The test plan method, referred to as Method 1, was reviewed at each test site location, and site management was given the opportunity to adjust the method, if needed, to address local constraints. It was found that sites using two sets of 1226F tray carts per machine and GPMCs with inserts could implement this method as documented with very limited adjustments needed.

Sites implementing Method 1 typically adjusted the test method to off-load only full trays from the highest two tiers of the 1226F rack onto the top of the rack instead of stacking the first full trays on top of the rack, regardless of the tiers from which they originated. Off-loading trays from specific tiers of the 1226F rack to the top of the rack and trays from the remaining two tiers into GPMCs with inserts provided improved capability for stacking trays in the proper order for second pass feeding.

More significant adjustments to the test plan method were made at some sites and resulted in the successful testing of two additional tray stacking methods Method 2 and Method 3 which are documented in Appendix 1B and 1C respectively.

At each location, plans included implementing the tray stacking method to be tested during high volume runs on three of the site's DBCS machines and to observe and obtain baseline data from three machines processing similar run volumes using the site's standard tray stacking methods. Additional details on the test methodology and evaluation process are included in Appendix 1D and Appendix 1E.

## C. Results

### Tray Stacking Results

Each of three methods, (Methods 1, 2, & 3) proved capable during testing of either eliminating or substantially reducing tray-stacking to no more than two high without unfavorably impacting the site's capabilities for feeding second pass mail in the correct sequence. Many of the machines utilizing a test method operated for the full test period with no stacking more than two high on top of the 1226F tray carts.

Some test machines experienced a relatively small number of tray stacks exceeding two high, but in each case, the causes of the stacking appeared to be related to factors that sites can effectively address. The most common cause of stacking exceeding two high was not having enough support equipment available to support off-loading of full trays from 1226F tray carts for the entire run.

The test plan methods for marking new empty trays placed into the 1226F tray cart by using either a red strip in the tray or by marking on the label with a red marker were found to be feasible and effective methods for maintaining trays in proper sequence for second pass feeding. Most sites preferred the marking method, and several sites marked a number (2, 3, etc.) to provide information on how many other trays must be located to maintain second pass feeding in the proper sequence.

Results in limiting tray stacking to no more than two high after implementing Method 1, 2 or 3 and the results of baseline observations made on machines utilizing each site's standard tray stacking methods are summarized in Appendix 1F.

### Feedback from Participants

Following implementation of the test methods, employees participating in operating the test machines were given the opportunity to provide input that included comparing the physical demands of the methods tested with standard tray stacking methods utilized at the site

The feedback indicates that some employees believe the additional off-loading of trays stacking is more physically demanding than stacking and removing trays more than two high. Other employees found the physical demands of the test methods to be either less or no different than the site's standard methods.

Employees who indicated the method tested to be more physically demanding than their standard tray stacking methods typically referenced the tasks of carrying full trays to support equipment and loading and unloading trays to equipment, particularly the lower levels, as a basis for their perceptions.

**Analysis of Lifting Forces**

The University of Michigan 3D Static Strength Prediction Program (3DSSPP) has been utilized to calculate low back compression forces for selected postures assumed when loading and unloading full trays from various types of support equipment for a 50th percentile Male (with other assumptions as documented in Appendix 1G) .  The objective of this evaluation is to establish the relative differences in low back compression force experienced when lowering and lifting to and from the same elevations where trays are positioned in various types of support equipment.

The levels of MSD risk factors in off-loading trays to and from support equipment are dependent upon the design characteristics of the specific equipment used and site practices in utilizing the equipment.  For example, back compression forces are lower when lifting trays from a 14" high Nutting Truck platform than when lifting from the bottom shelf of a GPMC which is 8" high. Site practices, such as limiting off-loading of trays to the upper six tiers of GPMCs with inserts and leaving the bottom two tiers empty, can also be highly effective in reducing low back compression forces.

Low back compression force calculations are based on lifting trays from various elevations.  This is encountered when lifting to or from the shelves or platforms of selected support equipment.  The calculations are summarized below:

## C. Results

| Location of Tray Lifted | Low Back Compression Forces (Pounds) | Percent of NIOSH Action Level (1) |
|---|---|---|
| Mid-Shelf of GPMC | 362 | 47.1 |
| Third Tier from Bottom of GPMC with Inserts | 538 | 69.9 |
| Second Tier from Bottom of GPMC with Inserts | 635 | 82.5 |
| Platform Level of Nutting Truck | 790 | 102.6 |
| Lowest shelf of GPMC with or without inserts | 866 | 112.5 |

Note: (1) The NIOSH Action Limit of 770 pounds is documented in the Work Practices Guide for Manual Lifting (NIOSH, 1981).

Low back compression force calculations for additional cases involving the design and utilization of support equipment are presented in Appendix 1G.

## D. Conclusions

Based upon analysis of test results the following conclusions have been reached:

1. The tray stacking methods tested can be effective in limiting tray stacking on top of the 1226F tray carts.
2. Some sites will need to adjust the test plan method, as originally documented, in order to address site specific constraints related to the number of sets of 1226F tray carts used for each machine and the types of support equipment utilized.
3. Sites can effectively reduce the level of MSD risk factors involved in off-loading trays through the selection of the type of support equipment to be used and by implementing specific practices designed to minimize low back compression forces when off-loading trays to and from the equipment.

## E. Recommendations

Based upon an analysis of test results, the following recommendations are made:

1. Three methods for limiting tray stacking are recommended for implementation based upon the site specific characteristics of each DBCS operation as follows:
    a. Method 1: For Operations with Two Sets of 1226F tray carts per Machine and GPMCs with Inserts
    b. Method 2: For Operations with Two Sets of 1226F tray carts per Machine and Support Equipment Other than GPMCs with Inserts
    c. Method 3: For Operations with One-Set of 1226F tray carts per Machine

2. When selecting available support equipment for off-loading full trays, sites should place priority on utilizing equipment that minimizes the level of MSD risk factors, including the need for bending when handling full trays. Specifically:
    a. Where sufficient equipment and floor space are available, sites using GPMCs with inserts should limit off-loading to the higher tiers of each GPMC leaving the lower tier(s) empty. (i.e., leaving the bottom two tiers empty).
    b. Sites using support equipment, other than GPMCs with inserts, should select and utilize equipment based upon an order of preference that minimizes the level of MSD risk factors, with proper consideration given to any site-specific equipment or floor space constraints. The order of selection to minimize MSD risk factors should be as follows:
        1. GPMCs/ERMCs with a middle shelf and all storage above the middle-shelf.
        2. Nutting trucks
        3. GPMCs / ERMCs with storage on bottom level
3. As included in the test plan method, sites should be given the option of marking new empty trays added to the 1226F tray carts with either a red strip or by using a red marker to place a mark (2, 3, etc.) on the label for any additional empty trays added to the 1226F tray cart.
4. When feasible, during heavy volume DPS mail runs sites should consider scheduling the heaviest run volumes on machines with adequate floor space for staging the amount of support equipment needed for off-loading full trays.
5. The testing and evaluation of tray stacking methods provided an improved understanding of site capabilities and constraints. Testing confirmed the availability of methods, that are both feasible and effective, to limit tray stacking on the 1226F tray carts.

# Test 2: Evaluation of Sweeping Operations from the DBCS Stackers to 1226F Tray Carts

## Executive Summary

Sweeping mail from the DBCS stacker bins to the 1226F tray carts has been identified by OSHA as having ergonomic risk factors, namely reaching above shoulder-level to the top bins and bending down to the bottom bins. OSHA recommended that sort programs distribute most of the mail to the middle two tiers and that the operators reduce the frequency of sweeping from the bins by taking greater amounts of mail with each sweep and alternating body postures when sweeping. This report addresses OSHA's concerns in two parts.

Part 1 evaluates the effectiveness of the USPS Sort Plan Optimization (SPO) program's Field User Interface System (FUIS) to place the greatest density of mail into the middle two tiers of the DBCS machines. The result of the evaluation is an interactive tool (Excel spreadsheet macro) that converts the Bin Count table of the EOR Viewer report from http://webEOR/ to a detailed bin diagram (see example in Appendix 2A). This tool is available from In-plant Support upon request and is recommended be used as a control device to check the end result of any sort program for a specific production run from any DBCS machine at any facility. A "targeted optimal percentage" (TOP) range of 71.4 to 75% of the total production run volume in the middle two tiers is suggested (Appendix 2B), with the least volume of mail in the bottom tier.

Part 2 presents the results of observations of the sweeping methods from the test sites. The results indicate that most operators (79.2%) use the more efficient 2-hand sweep technique, but tour 1 was observed to use the 2-hand technique more frequently (89.8%) than tour 3 (69.1%). A higher rate of pieces of mail handled per hour by tour 1 (17% higher rate observed at the Denver, Colorado Springs and Columbus sites, Appendix 2C) is a likely explanation for the more frequent use of the 2-hand sweep. It is recommended that a training program be developed to encourage the best practices of sweeping that were identified during the observations at the test sites. The best practices include "scooping" a comfortable quantity (7 to 9 inches) of mail using 2 hands as opposed to a one hand "pinch" with the palm down.

The ideal result is the combination of both parts 1 and 2, that is, the higher density of mail (71.4 to 75%) should be placed, whenever possible, into the bins located on the middle tiers of the DBCS machines so that the 2-hand sweeping technique can be used for the majority mail located between knuckle and shoulder height.

## A. Introduction

### Problem Statement

Manually transferring (sweeping) mail from the DBCS stackers to the 1226F tray carts has been identified by OSHA as having the ergonomic risk factors of reaching above shoulder-level to the top bins and bending more than 90 degrees to the bottom bins. Sweeping mail requires the operators to reach repeatedly into the bins that are continuously being filled, firmly grasp stacks of mail and place them into letter trays

**Fig.1. Sweeping from top bins.**

**Fig.2. Sweeping from bottom bins**

which are located on the drawers of the 1226F tray carts. The operators often must reach over 56 inches high to grasp mail from the top bins (Fig. 1) and also must bend down to sweep mail from the bottom bins at approximately 22 inches above the floor (Fig. 2). The top tier of bins at 56 inches is above shoulder-height for persons of shorter stature than a 50th percentile male (5’9”), and the 22-inches-high bottom tier is below standing knuckle-height for even a 5th percentile female (5’0”).

### Objectives

As countermeasures, OSHA recommended that sort programs distribute most of the mail to the middle two tiers of the DBCS stackers and that the operators reduce the frequency of sweeping from the bins by taking greater amounts of mail with each sweep. Hence, this study’s objectives are to determine the extent of the ergonomic issues at test sites and to recommend practical measures to reduce risk to the DBCS operators.

## B. Methods

In order to accomplish these objectives this study is divided into two parts:

Part 1 evaluates the effectiveness of the Sort Plan Optimization (SPO) program's Field User Interface System (FUIS) for placing the greatest density of mail into the middle two tiers of the DBCS machines.

Part 2 establishes and promotes the best practices of manual sweeping based on multiple observations of the sweeping techniques of several DBCS clerks from the test sites.

### Part 1: Ergonomic Impact of Sort Plan Optimization (SPO/FUIS and Locally Modified Sort Programs)

### B.1 Methods (Part 1)

According to the Field User Interface System Guide for Local Users, July 21, 2010, “Ergonomics”, pages 13-14, “FUIS uses a bin's predicted volume to locate the bin in a way that requires the least amount of motion and lifting for people sweeping the bins. Within a block of bins, the application will try to place the highest-volume bins in the middle two tiers of the machine.”

Tier 1 (top) and tier 4 (bottom) are roughly 56 in. and 22 in. from the floor, respectively. Standing shoulder-height for a 5th percentile female is approximately 48.8 inches and standing knuckle-height for a 95th percentile male is approximately 32.4 inches. Therefore, sweeping mail from tiers 2 and 3 (45 in. and 33 in. from the floor, respectively) prevents taller (95th percentile male) operators from having to bend down to the bottom tier and shorter (5th percentile female) operators from having to reach above shoulder-level to the top tier. Sweeping mail from the middle two tiers (Fig. 3) improves operator performance by not only reducing the frequency of awkward over-reaching and bending but also improves overall motion efficiency.

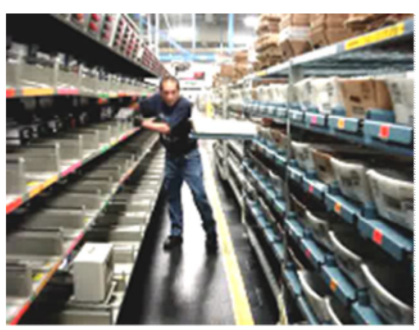


**Fig. 3 Sweeping mail from middle tiers**

The sort programs examined are the ones assigned under the SPO initiative utilizing the FUIS and any locally written sort programs. These are compared with sort programs that cannot be modified (e.g., DPS mail with operation numbers 918 and 919). DPS mail distribution into the bins of the 4-tier machines remains approximately equal (i.e., 25% of the mail onto each of the 4 tiers).

Examination of the SPO/FUIS sort programs were conducted primarily for tour 3 of the test sites since, currently, only outgoing primary and secondary mail (OGP/OGS) is compatible with the FUIS and most OGP/OGS mail is processed on tour 3. The schedule for testing any locally written sort programs was dependent on the specific types of mail affected (i.e., MMP, IP/IS, etc.).

SPO/FUIS sort programs typically are applied to the following operation numbers:

- 271 (DBCS-OSS Outgoing Primary)
- 481 (DIOSS Outgoing Primary)
- 891 (DBCS Outgoing Primary)
- 482 (DIOSS Outgoing Secondary)
- 892 (DBCS Outgoing Secondary)

Sort programs for MMP (Managed Mail Processing) mail, primarily for operation number 893, are written and controlled locally at the P&DC facilities. Facility-specific information was obtained for current operation numbers, sort programs, bin densities, and the specific DBCS machines to which the various sort programs were assigned. This information was obtained through a fact-finding questionnaire that was completed by in-plant support personnel responsible for developing and/or monitoring both FUIS and locally written sort programs. Specific sort program data, e.g., WebEOR Viewer Bin Counts, also were obtained using http://webEOR/ reports as described in Appendix 2D. From this data, a “targeted optimal percentage” (TOP) range of 71.4 to 75% of the total production run mail volume in the middle two tiers is suggested (Appendix 2B).

### C.1 Results (Part 1)

An interactive Excel spreadsheet macro (see example in Appendix 2A) was developed as a tool to convert the WebEOR “Bin Counts” into detailed Bin Density diagrams. This tool can be used as a control device to check the end result of any sort program for a specific production run from any DBCS machine at any facility. A sample of actual sort program densities, from the test sites during the 3-week test periods is displayed in Table 1.

**Table 1: SPO Bin Density Table (sample)**

| Site | Sort program | FUIS | Local (MMP) | DPS | Mach. No. | Tier 1 (56") | | Tiers 2+3 (33"- 45") | | Tier 4 (22") | | Total Pieces |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Pieces | % | Pieces | % | Pieces | % | |
| **Denver** | 271FILNG | **X** | | | 18 | 2715 | 10.2 | 19756 | 73.9 | 4270 | 16.0 | 26741 |
| | 893FF800 | | **X** | | 7 | 14584 | 24.3 | 42192 | 70.4 | 3166 | 5.3 | 59942 |
| **Colorado Springs** | 271FFSHO | **X** | | | 16 | 5697 | 7.8 | 58376 | 80.0 | 8916 | 12.2 | 72989 |
| | 891FMLNG | **X** | | | 18 | 2805 | 16.6 | 11164 | 65.9 | 2971 | 17.5 | 16940 |
| | 893FE809 | | **X** | | 7 | 13001 | 28.0 | 25541 | 55.1 | 7809 | 16.8 | 46351 |
| **Providence** | 271FEKPL | **X** | | | 77 | 12557 | 12.1 | 70458 | 67.8 | 20961 | 20.2 | 103976 |
| | 481FHMUL | **X** | | | 71 | 8424 | 14.7 | 37434 | 65.4 | 11357 | 19.8 | 57215 |
| **Los Angeles** | 271FILNG | **X** | | | 62 | 7775 | 12.9 | 39939 | 66.3 | 12535 | 20.8 | 60249 |
| | 891MHFIM | **X** | | | 39 | 24437 | 11.2 | 165762 | 76.1 | 27727 | 12.7 | 217926 |
| | 891RHPER | **X** | | | 52 | 25419 | 23.3 | 58817 | 53.9 | 24826 | 22.8 | 109062 |
| **Tulsa** | 271FJLNG | **X** | | | 86 | 3271 | 11.9 | 19148 | 69.8 | 5021 | 18.3 | 27440 |
| | 271FJKPL | **X** | | | 8 | 3957 | 6.6 | 44418 | 73.9 | 11737 | 19.5 | 60112 |
| | 481FFMUL | **X** | | | 74 | 1679 | 12.9 | 9377 | 72.3 | 1921 | 14.8 | 12977 |
| **Palatine** | 893FDMMP | | **X** | | 19 | 1316 | 2.4 | 49527 | **91.6*** | 3221 | 6.0 | 54064 |
| | 894SDSTD | | **X** | | 38 | 1099 | 3.7 | 26365 | 88.4 | 2371 | 7.9 | 29835 |
| **Columbus** | 481FHLOC | **X** | | | 45 | 16814 | 13.9 | 83278 | 68.9 | 20740 | 17.2 | 120897 |
| | 891FILNG | **X** | | | 7 | 8069 | 15.6 | 32962 | 63.9 | 10546 | 20.4 | 51577 |
| | 893SESTD | | **X** | | 1 | 1870 | 14.1 | 7507 | 56.5 | 13276 | 29.4 | 13276 |
| **Nashville** | 271FJKPL | **X** | | | 6 | 4501 | 8.9 | 36509 | 71.9 | 9761 | 19.2 | 50771 |
| | 891MJFIM | **X** | | | 7 | 7582 | 10.1 | 55775 | 74.5 | 11460 | 15.3 | 74817 |
| | 893FE3DY | | **X** | | 25 | 2350 | 4.5 | 42280 | 81.1 | 7487 | 14.4 | 52117 |
| **Norfolk** | 271FIKPL | **X** | | | 2 | 7489 | 8.2 | 71479 | 78.0 | 12648 | 13.8 | 91616 |
| | 481FHMUL | **X** | | | 21 | 9923 | 11.6 | 58253 | 68.4 | 17027 | 20.0 | 85203 |
| | 893FF235 | | **X** | | 8 | 6445 | 22.3 | 14181 | **49.1*** | 8243 | 28.6 | 28869 |

***91.6%** was the highest and **49.1%** the lowest percentages of mail observed in tiers 2+3.

## D.1 Conclusions (Part 1)

1. The EOR Viewer from the http://webEOR/ displays only a "Bin Count" table for each DBCS (including DIOSS and CIOSS) machine and the general Bin Density Report shows overall sort program bin density percentages per each of the 4-tiers, but is not machine-specific.

2. 92%, or 46 of the 50, SPO/FUIS and MMP sort programs sampled had greater bin densities in the bottom tiers (tier 4) than in the top (tier 1). Therefore, there were a greater number of operators who had to bend to sweep from the bottom tier than those who had to reach above shoulder level to sweep from the top tier.

## E.1 Recommendations (Part 1)

1. The interactive Excel spreadsheet macro (see example in Appendix 2A) that converts the EOR Viewer Bin Count tables to machine-specific bin density diagrams can be used to check the actual percentage distribution of mail into each of DBCS tiers 1 through 4 for any SPO/FUIS and MMP operation number and sort program.

2. The goal is to develop a control (feedback) process for placing a “Targeted Optimal Percentage (TOP)” of mail into the middle two (2) tiers. The recommended TOP is between 71.4 and 75.0% (mid-point 73.3%) calculated as shown in Appendix 2B.

3. The tier distribution sequence, highest to lowest density, should be as follows:

1) Tier 2 (second from the top)
2) Tier 3 (third from the top)
3) Tier 1 (top)
4) Tier 4 (bottom)

**Part 2: Evaluation of Sweeping Techniques**

**B.2 Methods (Part 2)**

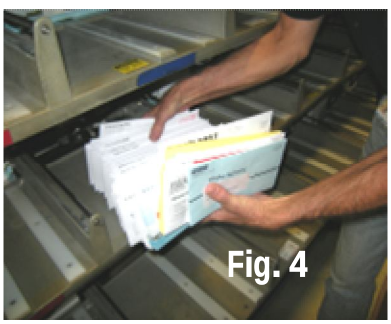


Fig. 4

Sweeping requires frequent potential stresses to the hands and wrists from grasping and releasing stacks of mail. This study attempts to establish the most efficient sweeping technique, i.e., two-hand “scooping” (Fig. 4) rather that one-handed “palm down” pinching of the mail (Fig. 5).

Fig. 5

A total of 2,955 observations of sweeps were made of 72 operators at eight of the test sites. Each observation checked whether the stacker blade was lifted, whether the 2-inch “safety” rule was followed, and whether the mail was swept using 2 hands or one hand only. A sample of the actual results of the observations is shown in the Table 2.

**Table 2: Sweeping Observations Table**

| | No. operators observed | No. Observations | 2-hand technique used | 1-hand technique used | 2” Rule Followed | Stacker blade Lifted |
|---|---|---|---|---|---|---|
| Tour 1 | 34 | 1,433 | 1,287 (89.8%) | 146 (10.2%) | 224 (15.6%) | 1,266 (88.3%) |
| Tour 3 | 38 | 1,522 | 1,052 (69.1%) | 470 (30.9%) | 441 (29.0%) | 1,117 (73.4%) |
| Total | 72 | 2,955 | 2, 339 (79.2%) | 616 (20.8%) | 665 (22.5%) | 2,383 (80.6%) |

## C.2 Results (Part 2)

Table 2 shows that the tour 1 sweepers used the 2-hand sweep a greater proportion of the time (89.8%) than the sweepers from tour 3 (69.1%). However, the tour 3 operators complied with the “2-inch rule” more often (29.0%) than the workers on tour 1 (15.6%). More than three-quarters (79.2%) of all the sweeps were 2-handed.

A higher rate of pieces of mail handled per hour by tour 1 (17% higher rate observed at the Denver, Colorado Springs and Columbus sites, Appendix 2C) is a likely explanation for the more frequent use of the 2-hand sweep. There evidently is a higher rate of pieces of mail handled per hour of run time related to the type of mail scheduled for tour 1 (primarily DPS mail).  The higher rate likely encourages a greater number of 2-handed sweeps of all the mail in the bin, thus also reducing compliance to the 2-inch rule.

## D.2 Conclusions (Part 2)

1)  The two-handed sweeping technique was used 79.2% of the 2,955 observations (89.8% on tour 1 and 69.1% on tour 3) at eight of the nine test sites, and 93.9% of the 65 observations at the Jacksonville P&DC.

2)  Operators who performed the sweeping function followed the “two-inch” rule only 22.5% of the time (15.6% on tour 1 and 29% on tour 3). Complying with the 2-inch rule (i.e., carefully inserting the paddle between an estimated “2 inches” of mail and the stack of mail to be swept) was perceived by most employees as adding time and effort to the sweeping task.  However, the majority of these employees developed a system of lifting the blade with the right hand and allowing all of the mail to fall into the left hand - while keeping the hand at least two inches from the auger and other moving parts. Therefore, safety and engineering should consider validating this observed method as a safe alternative.

3) Further investigations of production volumes and rates per tour were conducted using the http://webEOR/ Custom Reports, ”Automation Summary by Machine by Tour” (for the Denver and Colorado Springs test sites) and “Tour Throughput”  (for Columbus).

- The reports indicate that the tour 1 rate of pieces handled per hour of run time at the Denver, Colorado Springs and Columbus test sites was approximately 17% greater than that of tour 3 (Appendix 2C).
- The higher rate of pieces handled is likely to result in larger quantities of mail grasped using 2-hand sweeps and less compliance with the “2-inch rule”.

4)  Quantity of mail swept often depends on available space in the letter tray; however, a “comfortable” quantity of mail for the subjects appeared to be between 7 and 9 inches.

5) 2-hand "scoop" sweeps of 7 to 9 inches can move 34,000 pieces of mail per hour using 159 to 204 sweeps as compared to a range of 286 to 476 sweeps using 3 to 5-inch, often 1-hand, palm down, sweeps, saving up to 317 sweeps per hour. Using 8-inch vs. 4-inch sweeps can reduce sweeping frequency from 357 to 179 or by 50%, and can greatly reduce stresses to the hands and wrists.

**E.2 Recommendations (Part 2)**

A program of training and follow-up is recommended to encourage the best practices of sweeping that were identified during the observations at the test sites. The best practices include "scooping" a comfortable quantity (7 to 9 inches) of mail using 2 hands (Fig. 4) as opposed to a one hand "pinch" with the palm down (Fig. 5). The recommended steps are as follows:

- Select a stacker with 7 to 12 inches of mail
- Identify the prospective letter tray in the 1226F tray cart and check the available space.
- Lift the stacker paddle with right hand.
- Allow 7 to 9 inches (or a comfortable amount) of mail to fall toward the left hand.
- Place the stacker-paddle behind the mail to be swept, keeping it between the right hand and the moving parts of the machine.
- "Scoop" the stack of mail to be swept with the right hand, supporting it with the left, as the fingers are kept beneath the mail.
- Lift and carry the stack of mail, using both hands, from the stacker bin and place it into the appropriate letter tray
- CAUTION: One-hand sweeps should be used only for clean up at the end of a production run and only when the machine is not running.

# Test 3: Evaluation of the Impact of Task Rotation

## Executive Summary

OSHA reported that rotation less frequent than every two hours, larger volumes of mail, and assignments to the same machines for extended periods of time increase operator exposure time to risk factors as well as the chance of fatigue and the risk of injury. To provide necessary rest and recovery time, OSHA recommended a standardized rotation, not longer than one hour, and between DBCS machines.

This evaluation focused on understanding current DBCS operator rotational practices and beliefs, and the impact on perceived rest and recovery when rotating between feeding and sweeping every hour (1-Hr) and every other hour (2-Hrs). Overall 70 DBCS operators completed some portion of the evaluation. Perceived rest and recovery ratings for the back, shoulders, and hands / wrists were summarized for 41 operators who provided three or more days of rest ratings for both test rotations.

Most participants rotate about every three hours (i.e., between passes on Tour 1) or more frequently. These operators consider rotation to be important and usually find sweeping more physically demanding than feeding. Their backs and shoulders tend to experience more rest and recovery than their hands and wrists. Although managerial support exists, active support or involvement of rotation is perceived as lacking.

Overall, participants experienced more rest and recovery following the 1-Hr rotation than the 2-Hrs rotation; although both rotations tended to provide adequate rest (‘moderate’ to ‘major’). A weak relationship between greater workload and less rest was found on Tour 1 for both test rotations. Compared to current practices, ‘about-the-same’ to ‘slightly-more’ rest and recovery was experienced on Tour 1 for both test rotations while this was only true for the 1-Hr rotation on Tour 3. Both test rotations tended to provide more perceived rest to those who normally rotate less frequently, and less perceived rest to those who normally rotate more frequently.

Based on the results of this evaluation, a standardized rotation between DBCS operators of at least every two hours (2-Hrs) should be implemented. More frequent rotation should be encouraged and permitted. Operators should continue to alternate between the first task performed (i.e., feeding or sweeping) on alternating days. Provide regular active managerial support of this rotation.

# A. Introduction

### Problem Statement

OSHA found that DBCS operators generally rotate between the two positions but that a wide discrepancy in the frequency of rotation exists. It was reported that rotation less frequent than every two hours, larger volumes of mail, and assignments to the same machines for extended periods of time increase operator exposure time to risk factors (forceful repetition combined with awkward postures) as well as the chance of fatigue and the risk of injury; and without proper rotation recuperation time may be inadequate. To provide necessary rest and recovery time, OSHA recommended a standardized rotation, not longer than one hour, and between DBCS machines.

### Objective

The objectives of the evaluation were to examine the effects of 1-hour and 2-hour rotations on operator rest and recovery; and what workplace and employee factors influence rotation frequency and compliance.

## B. Methods

### Participants

Seventy DBCS operators, 32 on Tour 1 and 38 on Tour 3, from the nine Processing & Distribution Centers participated in this evaluation after being informed of the test methods and providing their verbal consent (Table 1). This group of participants consisted of 34 males and 36 females. Participants averaged 9.9 years of DBCS experience (range 1 – 22 years). Tour 1 averaged slightly more experience (10.7 years) than Tour 3 (9.3 years).

### Baseline Rotation

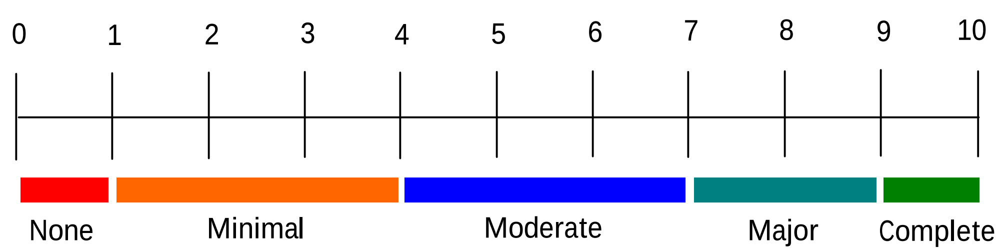
To understand current or baseline participant rotations, an introductory questionnaire consisting mainly of rating scales was completed prior to starting the test rotations. Ratings of participant beliefs of whether one task (i.e., feeding or sweeping) is considered more physically demanding; how much rest and recovery for the back, shoulders, and hands/wrists is experienced by rotating; as well as the importance of rotating were included. Frequency of active managerial support was also rated.

## Test Rotations

Two test rotations were followed - one hour (1-Hr) and two hours (2-Hrs). These rotations were based on clock time, meaning every hour or every other hour participants switched tasks. Each participant complied with each rotation for up to one week (i.e., test period) then switched to the other rotation. Most if not all participants also rotated their first task every other day (e.g., feeding Monday, Wednesday, etc.). This participant practice continued during this evaluation. Participants were asked to commit as much as possible to these rotations during the test periods especially during days when no rest and recovery ratings were taken; operational issues were encountered; participants were assigned or moved to different DBCS machines; or participants worked with a different partner.

## Perceived Rest and Recovery

Participants rated their perceived rest and recovery for their backs, shoulders, and hands/wrists (approximately at mid tour) along the following 10-pt scale.




A rating of zero (0) meant no rest and recovery was experienced for that body part whereas a rating of ten (10) meant complete rest and recovery was experienced. It should be noted that each participant provided a relative judgment of perceived rest and recovery.

At the end of each test period or week, participants rated their perceived rest and recovery per body part compared to their current or baseline rotations. Participants also rated the difficulty or ease experienced with performing the test rotation and the likelihood of complying with it in the future.

## Workload

To gauge relative workload, the number of mail Pieces Fed, Run Time, and Operation Time for each day were collected. During the test rotations, averages were 117,000 pieces fed, 3.3 hours of run time, and 5.3 hours of operation time.

These metrics are defined as:

- Pieces Fed (Pcs Fed) = number of mail pieces fed into the DBCS
- Run Time = hours DBCS is on, and actually processing or running mail
- Operation Time = hours DBCS is on including Run Time, down time and idle time

## C. Results

### Baseline Rotation

A detailed breakdown of baseline rotational practices is provided in Appendix 3B. Most (86%) participants consistently rotate; 29 participants (91%) on Tour 1 and 31 participants (82%) on Tour 3 practice a regular daily rotation. A few rotate when they want to or depending on their partners' preferences ('sometimes'), or do not rotate due to their preferences and/or self -accommodations ('no'). Tour 1 mainly (48%) rotates between passes (3-Hrs) followed by those who rotate (36%) between breaks (2-Hrs). As breaks sometimes vary, Operation Times may be about 2 - 2.5 hours long. Tour 3 participants tend to rotate more frequently as 44% rotate between breaks (2-Hrs) and 39% rotate at least every hour (< 1-Hr).

Movement between DBCS machines is a function of work assignment and rotation. Many (38%) participants work different DBCS machines on a weekly basis; Tour 3 mainly contributed with 22 participants out of 38. Following these participants, the second most common practice (26%) is not rotating to other DBCS machines (more common on Tour 1 than Tour 3). Some of these participants do however help other operators during the last 30 minutes or hour of the tour.

In regard to the frequency of being assigned to other areas or operations, more than half (59%) of the participants responded they only work the DBCS machines. Thirty percent of the participants indicated some other frequency such as, "as needed"; "maybe at the end of the tour"; or "maybe during Christmas." Other operations mentioned included manual letters, low-cost, foreign / Canada mail or expeditor.

Most (70%) participants believe that one task is more physically demanding than the other. Half (50%) of the participants consider the difference in physical demand to be moderately to highly more physical. Of the responses provided, participants (30) usually consider the sweeping task to be more demanding than feeding (8). Reasons mentioned included more bending / twisting and reaching; putting full trays on top of the tray carts; heavy full trays; and repetition. Those that find feeding more physical mentioned bending and lifting trays out of the GPMCs.

Nearly three quarters (74%) of participants believe rotation provides some level of bodily rest and recovery; about one-third (29%) reported a moderate level of rest and recovery for the body. Participants indicated that rotation provides near equal rest and recovery for the back and shoulders, but less for the hands / wrists as 23 participants (34%) indicated they believe no rest and recovery is afforded.

Eighty percent (55 participants) believe rotation is of some importance. Most (42%) participants believe rotation is very important while 28% feel it is of moderate importance. The level of importance between the two tours is similar, although more of the Tour 3 participants feel rotation is at least moderately important.

In terms of the frequency of active managerial (i.e., SDO / 204B) support including but not limited to helping to setup, discuss, encourage, or remind operators, half (52%) of the participants responded they never receive such support while the other half indicated some frequency is experienced. Overall support of rotation could be considered higher if passive support as indicated by comments (e.g., it's our choice or decision, it's left up to the operators; they know we rotate) was included.

**Perceived Rest and Recovery**

For analysis, 435 collected sample sets (back, shoulders, and hands / wrists) were reduced to 334 by eliminating any participants who did not, for any reason, comply with, have the opportunity, and/or provide rest and recovery ratings for both test rotations for a minimum of three days. All findings that follow are based on this reduced data set. Workload variables were grouped for rating comparisons. End of test period rest and recovery ratings were converted to scores to provide a numerical means of comparison, as follows: 'much-less' = -2, 'slightly-less' = -1, 'about-the-same' = 0, 'slightly-more' = 1, and 'much-more' = 2.

Inclusive of both tours, the 1-Hr test rotation was rated higher (7.5) on average than the 2-Hrs test rotation (6.8). The level of rest from the 1-Hr rotation was 'major' while the rest from the 2-Hrs rotation was 'moderate.' Tour 1 found the 2-Hrs rotation to provide 'major' (7.0) bodily rest and recovery.

For both test rotations, average bodily rest ratings were lower (7.7 & 6.6) for the highest pieces fed group (>150,000) compared to the rest ratings (7.8 & 7.0) for the next lowest group (90,000 – 150,000). A similar pattern was found for Run Time of > 4-Hrs compared to > 2-4 Hrs. However, this did not hold true for the lowest Pcs Fed or Run Time groups. Specific to Tour 1 and both rotations, a weak relationship between greater workload and less rest can be suggested (r = -0.16 to -0.21). A few participants commented that mail volume or how well the machines were running affected how they felt physically.

Compared to current practices, the 1-Hr test rotation was found to provide ‘about-the-same’ to ‘slightly-more’ (0.2) rest and recovery. The 2-Hrs rotation was rated as providing ‘about-the-same’ to ‘slightly-less’ (-0.3) rest and recovery. End of test period bodily rest ratings tended to increase (0 to 1) for participants who normally practice less frequent rotations except for those who rotate only once (4-Hrs) during the tour or not at all (8-Hrs). Rest ratings tended to decrease (-0.1 to -1) for those who normally rotate more frequently than the test rotations.

It should be noted that the number of participants and samples were small for all baseline rotation groups, especially for the < 1-Hr, 4-Hrs, and 8-Hrs groups. Personal preferences and/or self- accommodations likely influenced the perceived ratings to some degree; for example, the 1-Hr baseline group rated the 1-Hr test rotation as providing more rest (0.1) than their normal rotation; and the 4-Hrs baseline group rated the 1-Hr test rotation as providing more rest (1.0) and rated the 2-Hrs rotation as providing less rest (-1.2) even though both test rotations were more frequent. Some participants questioned the necessity to rotate every hour even if significant idle or down time occurs. Comments from those who do not normally rotate tend to suggest that they were not used to the varying physical demands of both tasks.

Most (75%) participants did not find the test rotations difficult to perform and would likely continue to rotate at least every two hours (60 - 75%); 10 – 20% of the participants were unsure.

A detailed breakdown of these data is tabulated in Appendix 3C.

## D. Conclusions

### Baseline Rotation

- Most DBCS participants rotate; few choose not to rotate. Tour 3 tends to rotate more frequently that Tour 1. Many work different DBCS machines at least monthly. No other operation other than automation (DBCS) is usually assigned.

- Most experience a difference in physical demand between feeding and sweeping - sweeping being more difficult than feeding. At least minor rest and recovery is experienced from rotating. Backs and shoulders tend to experience more rest and recovery than the hands and wrists.

- Rotating is considered important. Tour 3 feels a bit more strongly than Tour 1 about the importance of rotation, as a few more participants either felt it is very important or do not normally rotate.

- Active managerial support of rotation is perceived as lacking. Overall support by some is perceived as they feel it is their decision.

**Perceived Rest and Recovery**

- Participants experienced more rest and recovery following the 1-Hr rotation than the 2-Hrs rotation; although both rotations tend to provide adequate rest (‘moderate’ to ‘major’) and can be considered proper.
- A weak relationship between greater workload and less rest was found by comparing average rest ratings by workload group. This relationship was specific to Tour 1 rest ratings only. Even with a potential workload relationship, average bodily rest and recovery for the most demanding workload groups was considered ‘moderate’ to ‘major.’
- Compared to current practices, ‘about-the-same’ to ‘slightly-more’ rest and recovery was experienced on Tour 1 for both test rotations while this was only true for the 1-Hr rotation on Tour 3. Both test rotations tended to provide more perceived rest to those who normally rotate less frequently, and less perceived rest to those who normally rotate more frequently.

## E. Recommendations

The following recommendations are made:

1. Implement a standardized rotation between DBCS operators of at least every two hours (2-Hrs) as this rotation provided ‘moderate’ to ‘major’ bodily rest and recovery.
2. More frequent rotation, as deemed necessary or appropriate by operators, should be permitted as well as encouraged.
3. Operators should continue to alternate between the first tasks performed (i.e., feeding or sweeping) on alternating days.
4. Provide regular active managerial support of this rotation.

# Test 4: Evaluation of Maintenance and Serviceability of 1226F Tray Carts

## Executive Summary

OSHA reported in its findings on the 1226F tray cart maintenance the risk factor of repeated force associated with the development of musculoskeletal disorders

(MSDs). One possible control option OSHA cited in its findings was to provide sustained maintenance of the tray carts (including recording/tracking of such activities). Therefore, our test objectives were to establish what the current baseline of the 1226F tray cart repair is in the various plants. Second, we sought to determine if an increased risk of MSDs is created as the number of tray cart defects is increased. The third test objective was to identify best practices for maintaining the 1226F tray carts.

We observed some employees who were manually pulling out the plastic trays instead of the drawers - if they perceived that the equipment might malfunction. This may increase the potential risk factors of MSDs due both to altered work technique and equipment malfunctioning (especially the high force of drawers not opening). The number of trays with defects that we surveyed in our 10-point inspection ranged from a low of 7.7% to a high of 48.4% with an average tray defect rate of 28.5%. However, not all equipment defects increase MSD risk (simple physics dictates that drawers with missing or non-contacting cam followers open with less force). Still, operations management must make every effort to maintain the tray carts so the potential for MSDs does not increase due to lack of maintenance.

Several overlapping suggestions are offered to operations to select from in order to increase the operational efficiency and decrease the MSD risk associated with 1226F tray cart use. Common options to identify and fix racks include: labeling all racks, “tagging” defective racks, prioritizing repairs, “red dot alerts” (mark non-opening trays), logging repairs, ensuring quality parts are available and incorporate a maintenance route at a reasonable frequency. Additionally, it is recommended that a process be implemented for sites to share information on best practices in maintaining the 1226F tray carts.

## A. Introduction

### Problem Statement

OSHA reported that the functional operation of the 1226F tray racks could negatively impact the risk of MSDs (musculoskeletal disorders) among the DBCS operators.

### Objectives

The test objectives were basically three-fold:

1) To establish a representative baseline of 1226F tray cart disrepair in the various plants.

2) To determine if an increased risk of MSDs is created as the number of tray cart defects is increased.

3) To identify best practices for maintaining the 1226F tray carts.

## B. Methods

Survey of the 1226F Tray Carts Maintenance Procedures:

All DBCS employees at the test sites were to be given a supervisor lead service talk outlining the various tests including an explanation of the 1226F tray cart testing. Additionally, the ergonomist outlined the 1226F tray cart maintenance test at each plant’s initial meeting with plant management (which typically included the maintenance manager and usually at least one maintenance tour manager or supervisor). Next, the ergonomist would individually contact the tour maintenance manager (or their designee) and briefly interview them concerning their issues and ideas on how best to maintain the 1226F tray carts. Typically, the most in-depth discussion was with the individual maintenance mechanic (if the plant had one) who was primarily responsible for the majority of maintenance on the tray carts. This mechanic was also asked to show us their workstations and give us insight into the repair issues of the tray carts at their plant. Finally, the ergonomist observed employees using the tray carts (as part of test number 2 – sweeping methods) and observed their interaction, including work technique, to any defects with the 1226F tray carts.

### Test Methodology

Establishing a baseline of the current state of repair for the 1226F tray carts was accomplished by an ergonomist or ergonomics specialist manually testing every drawer in a tray cart. The speed of this testing was greatly increased by having another person record the results as they were called out. We found that pushing a drawer from the rear of the tray cart was the best method to quickly access each tray. Kinesthetically, we judged the resistance of the tray as it moved (or occasionally didn’t move). At the same time, a visual inspection of the drawers and other functional features (missing springs, malfunctioning cams, etc.) was conducted and recorded.

In one plant, 100% of 1226F tray carts were inspected, but a minimum of 15% of tray carts were inspected at each site. Racks that had the most serious individual defect, of a tray that would not open at all, were noted on the data collection sheet and re-inspected about a week later. If the plant had a maintenance alert tag (other than the nationally recognized red tag) then the tag was initially attached to the tray cart with a tray number detailing the issue.

## C. Results

### Data Collection and Effects on MSD Risk Factors

All data from the nine sites are summarized in a single table - Appendix 4A. The color coding of the ten test items observed indicates our assessment of the relative MSD risk category associated with each item. Test item number one: “drawer will not open” (drawer could not move at all) and test item number nine: “cam shaft locked” (all drawers in a row could not be opened) were both colored red for the highest risk category. Out of the 30,358 trays pulled in testing (a total of 1,286 racks), about one percent or 303 “drawers would not open” and less than two percent (1.96%) or 596 drawers could not open because the “cam shaft was locked”.

Less forceful defects are color coded as yellow on the appendix summary, due to the increased force that repetitively may increase MSD risk. These included: “higher force required” to open drawer for item # 2, which was the case for 1,399 drawers or about 4.6 percent of the drawers. Item # 3 was a missing tray and was observed 24 times (.08%); while item # 4 was a loose tray – seen 344 times or about 1 percent (1.1%). A “missing spring” may negatively affect the ability of the cam to reset properly and could also increase the force required to pull or push the drawer. The yellow - medium risk rating was also given due to the variability of force required when” make-shift” rubber bands were used in place of springs. The spring missing at the end of a row was noted 178 times (.6%), but it would actually affect a row of six trays (1,068 drawers or 3.5%). A “screw missing” on the cam follower was the most observed defect at 11.2% or 3,387 trays. It was also rated as a yellow - medium MSD risk because of the variability of increased force observed. Specifically, one screw missing on a cam follower with two screws could have no affect on force today, but overtime it may allow a cam follower to ride-up and snag on the cam to create a harder pull.

Three items of data collected could actually decrease the force required to pull open a drawer and were therefore given a green rating for potentially no negative MSD affect. These items were: “cam follower missing” (item # 5), which was observed 785 times (2.6%); “cam follower bent” (item # 7) – observed 1,577 times (5.2%); and “other” (most often a cam that did not touch the drawer mechanism and so added no force) occurred 250 times (.08%) of the time. It should be noted that rack mechanics reported, in their opinion, a significant “cam follower bent” was most often done purposefully by an employee. The motive for this action, if true, would be to make sure that the tray was not likely to get hung up on the cam, thereby decreasing the potential force of the tray pull.

### Results Summary

Approximately 28.5% of the trays tested or 8,654 drawers had some type of defect. Some trays in the rack had multiple defects in a single tray (926 trays or 3%). One plant, had almost half (48.4%) of all trays with some type of defect. All plants reported that staffing and budget are essential for the timely maintenance of the 1226F tray carts.

### D. Conclusions

The relative risk of an MSD injury likely varies by the type of rack defect that was observed. Specifically, “drawer will not open” (maintenance item 1) and “cam shaft locked” (maintenance item 9) require the most excessive force on the body (especially shoulder and possibly back and wrist). They were categorized as:

- “Red level”- MSD risk and should be given top maintenance priority.
- “Yellow level” or secondary MSD risk would include the following maintenance items: “higher force required´ to pull open tray (item 2); “spring missing” (item 6); “screw missing” (item 8); “missing tray” (item 3) and “loose tray” (item 4). These items need timely follow-up or prevention in order to decrease the potential for repetitive force MSDs.
- “Green level” of maintenance defect could potentially decrease MSD risk, because it often decreases the overall force required to open a drawer. These items included: “cam follower missing” (item 5); “latch bent” – if it did not touch the cam at all (item 7); and the “other category” (item 10) - if it was a disengaged cam (the most common reason).

Operations management must determine the standard level of serviceability needed for each item. For example, all red level priorities will be handled within a day, while yellow level priorities will be addressed within the week. Regardless of the actual time and money spent to maintain the 1226F tray carts at their present level, operations must determine at what level they can expect the plants to supply parts and labor to rack maintenance in the future. It appears as if some employees may stop using the pull-out drawers if as little as 5 percent of the drawers do not open. This was observed in Palatine, where just 4.3% of red category items resulted in many of the employees opting to pull out the plastic trays every time versus the metal drawers. Therefore, rack maintenance can negatively impact sweeping methods and may influence stacking methods and the need for rotation (time feeding to get away from sweeping), along with decreased productivity. The potential increase in MSD risk as a result of 1226F tray cart maintenance must be carefully considered.

**E. Recommendations**

Ensure racks are maintained so that the potential for MSDs is not elevated, due to lack of maintenance. Maintenance can reduce MSD risk factors for the sweepers by implementing methods that maintain the rack drawers' opening without excessive force. Specific recommendations to keep more of the 1226F tray racks maintained could include a number of overlapping options from which operations can put together an effective strategy at each facility.

<u>Common Options to identify and fix racks needing repair:</u>

1) Label each 1226F tray rack with a metal identifying tag so that individual racks can be found even after moving them around the floor.

2) A colored tag system placed on the racks by employees for maintenance (some plants use a tear-off tag bottom that is given to maintenance).

3) Prioritize rack maintenance issues to address the non-opening (high MSD risk) issues first.

4) Provide employees with a "red-dot alert" sticker that they can place on the front of the drawer to remind them (or alert the next tour employee) that this tray is not opening.

5) Consider maintaining a log book on rack repair at each DBCS.

6) Ensure quality parts are available and incorporate a maintenance route at a reasonable frequency.

Options to potentially reduce the future maintenance on racks:

1) Consider having maintenance run the same series of tests that the ergonomists used, as part of a comprehensive SOP, for sustained tray cart maintenance.

2) Additionally, it is recommended that a process be implemented for sites to share information on best practices in maintaining the 1226F tray carts.

These ideas, or additional ones from both management and operators, will reduce the risk of MSDs and make the racks more functional.

# Test 5: Evaluation of Feeder Station TMT and Mail Induction

**Executive Summary**

OSHA reported in its findings for the DBCS feeder station the risk factors of repeated force and extended reaches in some tasks. One possible control option OSHA sited in its findings was to provide height and tilt adjustable staging table for mail trays at the feeding stations.

Test criteria were established with two primary purposes:

1) Examine the effects of table height, table top tilt, and table placement on MSD risk factors (i.e., ergonomic impact) when feeding the DBCS jogger.

2) Recommend an acceptable table height, table top tilt, and placement of the table in conjunction with the current feeding station.

For the tests three Transfer Mail Tables or TMTs were constructed for each of the nine DBCS test sites, all at the same height with the top at varying degrees of tilt. The TMTs were tested straight inline and/or perpendicular to the jogger.

At each of the nine sites, DBCS operators from Tours 1 and 3 volunteered to participate in the TMT test. Across the 9 sites a total of 78 operators participated in the tests for a total of 303 trials, with approximately 4 trials per participant.

Primary data collected for the TMT tests consisted of participant posture severity scores for back bending, reaching, and bent wrist, and an overall rating of each TMT configuration.

Based on posture severity scores from the participants and observations by the evaluators none of the TMT configurations should impose a significant risk of MSDs for back bending, reaching, or bent wrist.

Based on the posture severity scores, overall ratings of the TMTs, participant feedback, and evaluator observations it is recommended that the basic features of the TMT include:

- 20 degree tilted top toward the operator for more wrist posture and easier removal of mail from the tray.
- Perpendicular or greater than 90 degree placement to the jogger with the ability for the operators to adjust the TMT to their needs.
- Height range for the table set at 32 to 34 inches.

Where feasible it would be desirable for the TMT to have an adjustable tilt feature from 0 – 20 degrees, a height adjustment range of at least 32 – 34 inches, and easy mobility of the TMT so the operator can place it where desired for feeding or move it out of the way, if needed.

# A. Introduction

### Problem Statement

OSHA reported in its findings for the DBCS feeder station the risk factors of repeated force and extended reaches in some tasks. According to OSHA's findings:

- Force must be exerted on either end of a bundle of mail to maintain integrity while lifting and moving mail from the jogger shelf to the jogger.
- Extended reaches increases the force exerted by the shoulder when moving mail trays to the jogger shelf and removing mail from the trays to place on jogger.
- The feeders perform extended or overhead reaches with loaded mail trays to and from the upper levels of the transport devices to the staging shelf behind the jogger.

One possible control option for the above risk factors that OSHA cited in its findings was to provide height and tilt adjustable staging table to place mail trays on for feeding mail to the DBCS jogger.

### Objective

To test the concept of a staging table for the DBCS jogging station, test criteria was established with two primary purposes:

a. Examine the effects of table height, table top tilt (angle), and table placement on MSD risk factors (i.e., ergonomic impact) when feeding the jogger.

b. Recommend an acceptable table height, table top tilt, and placement of the table in conjunction with the current feeding stations.

## B. Methods

### Transfer Mail Table

The term transfer mail table (TMT) will be used in this report to describe the staging tables tested for the DBCS feeding operation. Due to the time limits and the number of possible variables of height and table top tilt involved it was determined the tests would not include fully adjustable tables. Three TMTs were tested, all at a height of 33 inches. Each TMT had a different fixed table top tilt; 0, 20, and 40 degrees tilt toward the operator. The TMTs were tested in two primary configurations; inline and perpendicular to the jogger. Rationale for selected table features and overall dimensions are included in Appendix 5A of this report.

**Test Participants**

Participants for each of the test sites were selected among DBCS operators on a volunteer basis. After the pilot test, which included 10 participants (5 from Tour 1and 5 from Tour 3) the target for participants was to have at least 4 for each of Tours 1 and 3. Across the 9 test sites, including the pilot site, 41 operators participated from Tour 3 and 37 operators from Tour 1 for a total of 78 operators. The TMTs were tested in a total of 303 trials, with approximately 4 trials per participant.

For each participant height (stature), knuckle height, and elbow height was measured and recorded. These were determined to be the most relevant anthropometric dimensions to compare with table height and table top tilt. Measurements and anthropometric data for the participants are included in Appendix 5A of this report.

In addition to anthropometric data other information collected about the participants included number of years as a DBCS operator and current method of feeding mail: use table, place mail on the shelf behind the jogger, or other method of feeding, such as placing mail directly onto jogger.

## B. Methods

As a baseline the evaluator observed participants feeding the jogger station using current work practices as well as other feeding practices and methods pertaining to mail prep before feeding, MTE maintenance, and feeding techniques. The TMTs were then tested for each participant. Each of the three tables was tested in one or both configurations of in-line or perpendicular to jogger. For the perpendicular configuration the participant was allowed to adjust the angle to greater than 90 degrees from the jogger if desired.

The participants were first allowed to become familiar with the use of the TMT. Then they were observed for 20 to 30 minutes by the evaluator while using the TMT. The evaluator made observations concerning posture of back, shoulders, arms/elbows, hands and wrist as each operator used the TMT. Any other ergonomic or operations impact noted was also recorded by the evaluator.

At the end of each TMT test period the participants were provided a posture severity scale to rate their perception of back bending, reaching, and bent wrist while using the table. Details of the posture severity survey are included in Appendix 5.1 of this report. In addition to the posture severity scale the participants were asked to give each table an overall rating on a scale of 0 being worst to 10 being best. Any additional comments and feedback from the participants was also recorded.

Baseline: participants were initially observed feeding the jogger station following current work practices. Other feeding practices observed included:

- Frequency of removal of tray sleeves, straps, and rubber bands.
- Problems with MTE wheels, gate / webbing latches, and shelves.
- If MTE with mechanical problems was “Red Tagged.”
- If MTE gate or webbing was fully opened or left latched.
- If more than half a tray of mail was lifted to the jogger.

## C. Results

### Effects on MSD Risk Factors

To examine the potential effects of TMT height, tilt, and placement on MSD risk factors (i.e., ergonomic impact) two primary criteria was assessed; what the evaluators observed and what the operator noted. Potential for risk factors were determined by the evaluator’s observation of back bending, reaching, and bent wrist and the operator’s score from the posture severity scale. The evaluator’s observations of posture did not vary significantly from what the operator reported.

The severity scale was assigned numeric values: None = 4, Minimal =3, Moderate = 2, Severe = 1 and Worst Possible = 0, with the higher the score implying a decreasing level of risk. A score of 2.5 or greater would represent a minimal posture severity according to the scale. Posture severities rated moderate to worst possible or less than 2.5, may suggest at least a perceived increase in MSD risk. Of the six possible table configurations, none of the average posture severity scores were less than 2.5 as indicated in Table 1.

**Table 1: TMT Posture Severity Scores**

| Table Configuration | 0 > 90 | 0i | 20 > 90 | 20i | 40 > 90 | 40i | Total |
|---|---|---|---|---|---|---|---|
| Average of Bending | 3.5 | 3.3 | 3.6 | 3.4 | 3.6 | 3.4 | 3.5 |
| Average of Reaching | 3.5 | 2.7 | 3.4 | 3.1 | 3.4 | 3.3 | 3.2 |
| Average of Bent Wrist | 3.1 | 2.9 | 3.3 | 3.2 | 3.4 | 3.1 | 3.2 |

0 = flat top / 20 = 20 degree tilt / 40 = 40 degree tilt / >90 = perpendicular or > 90 degrees to jogger
i = inline to jogger

## Selection of Optimum TMT Criteria

For optimum selection of TMT criteria, the potential effects of MSD risk factors and operators' overall ratings of the TMTs were considered. The overall ratings may include factors other than comfort or ergonomic impact such as, the operator's current method of feeding mail, what type of mail is being fed, or general like or dislike of the TMT Chart 6 shows the overall ratings by category. Table 2 indicates participants' ratings for each of the TMT configurations; overall, by tour, and the total ratings by placement of the TMT.

**Table 2: TMT Rating**

| Table Configuration | 0 > 90 | 0i | 20 > 90 | 20i | 40 > 90 | 40i | Total |
|---|---|---|---|---|---|---|---|
| Average Overall Rating | **6.2** | **4.5** | **6.2** | **5.2** | **4.9** | **4.2** | **5.3** |
| Tour 1 | 5.4 | 4.2 | 5.8 | 5.2 | 4.7 | 4.9 | 5.0 |
| Tour 3 | 6.8 | 4.8 | 6.4 | 5.2 | 5.1 | 3.7 | 5.5 |
| > 90 | | | | | | | **5.7** |
| In-line | | | | | | | **4.6** |

Three of the TMT configurations; 0>90, 20>90, and 20i received the overall highest ratings. However, data analysis indicated that the difference in ratings for these TMTs was not statistically significant. Table 3 indicates both posture severity scores and overall ratings for the three TMT configurations.

**Table 3: Top TMT Posture Severity Scores and Overall Ratings**

| Table Configuration | 0 > 90 | 20 > 90 | 20i |
|---|---|---|---|
| Average of Bending | **3.5** | **3.6** | **3.4** |
| Average of Reaching | **3.5** | **3.4** | **3.1** |
| Average of Bent Wrist | **3.1** | **3.3** | **3.2** |
| Average Overall Rating | **6.2** | **6.2** | **5.2** |

The test results showed a higher rating for the >90 placement of the TMT compared to the inline placement. Data analysis indicated the difference in the rating of 5.7 for the >90 and 4.6 for the inline placement was statistically significant.

## Aspects of Feeding Operation

During baseline observations of the feeding task certain other aspects of the feeding operations and feed station were assessed. This generally had to do with aspects that may have an ergonomic impact on the feeder, such as mail prep, MTE maintenance issues, and feeder techniques or work methods. Due to the relative short duration of observations at the feed station it was difficult to accurately assess the frequency of occurrence of many of the items. A summary of the observations and collected feedback follows.

Removal of tray sleeves, straps, and rubber bands. This was commonly observed for 3rd class mail. Several participants on Tour 3 estimated 50 – 75 % of certain types of mail required some kind of prepping before feeding.

- Problems with MTE wheels, gate / webbing latches, and shelves. Frequency of observed MTE issues was very low. General feedback indicated MTE is repaired or taken from service before becoming a significant issue.

- Use of the “Red Tag” system for MTE. The red tag is generally the accepted process for marking MTE for repair. There is wide variance of feedback as to the effectiveness of the system.

- Gates or webbing on MTE fully opened. A number of observations were made of operators opening webbing at various levels, but less frequently all the way to the floor. Most operators open the webbing to the level they feel is optimum for removing trays from the lower reaches of the MTE. Feedback indicates one of the prime reasons the webbing is not lowered all the ways to the floor is because the webbing is in the way and potentially a tripping hazard. Some sites that follow a practice of false bottoms in the equipment feel that lowering the webbing to the final latch (not all the way to the floor) is optimum.

- More than ½ tray of mail at a time placed on the jogger. It was frequently observed that operators remove more than ½ tray of mail from trays, not including loading the jogger directly. Typical feedback indicates most operators will remove as much mail as they are comfortable holding.

### D. Conclusions

The results of the TMT tests indicate that none of the TMT configurations should introduce a significant MSD risk factor for back bending, reaching, or bent wrist based on the evaluators’ observations and feedback from the test participants.

Both the posture severity scores provided by the test participants and observations by the evaluators indicate working at a TMT at the feed station generally allows a neutral posture. Some feedback indicates that the TMT with a tilted table top allows a more neutral wrist posture and makes it easier to remove mail from the tray than the flat table. Since increasing the table top tilt also increases the working height (hand height of the operator) the TMT with the 40 degree tilt had a tendency to be too high for shorter operators. Shoulder shrugging was sometimes observed when lifting mail from the tray and feedback verified this TMT felt too high for some operators.

TMT with 20 degree tilt

TMT > 90 Degrees to Jogger

Two out of the three highest rated TMTs feature the 20 degree tilt. A number of participant comments expressed that the tilted top was better compared to the flat top. The 40 degree tilt received lower ratings and the comments from participants tended to be less positive than for the 20 degree tilt indicating this was the more desirable of the two. The fixed height of 33 inches generally appeared to be an acceptable height for the participants in the test group and this height allowed the trays to be handled at about the same height as the jogger.

The majority of participants preferred placement of the TMT in a perpendicular or greater than 90 degree configuration from the jogger. Participants indicated the primary reason for this preference was because it brought the mail trays closer than with the in-line TMTs. Some of the negative feedback was that the table placed in front blocked access to the tray carts and caused more turning/ twisting when feeding the jogger. Several comments indicated it would be advantageous to make the TMT easily movable.

The results support the overall concept of a TMT adjacent to the feed station as an alternative to feeding mail from trays placed on the jogger shelf behind the jogger or by unloading trays onto the jogger by direct means. The ergonomic impact of the other methods was not assessed during this test so the difference in the level of risk of MSDs cannot be compared between these and that of the TMT, based on the data collected.

Although the results were overall positive for the TMTs, participants that tried them often preferred their current method of feeding mail onto the jogger over using a TMT. This effect may be overcome by longer use of the TMT.

Participants that use direct methods of feeding mail to the jogger often cited in their comments that the TMTs added steps and slowed them down feeding the jogger, jogging the mail, and keeping the ledge full. There were also comments that the TMTs made the task more difficult because of added motions; performing two or more lifts from the mail tray rather than removing mail from the tray in one quick motion. Participants that typically preferred using the shelf behind the jogger over direct methods tended to be more favorable of the TMTs. It was frequently commented on that there was no place to stack empty trays, typically placed on the floor where the TMTs were being placed for the tests, and in some cases the TMTs added congestion to an already tight space.

### E. Recommendation

Based on the posture severity scores, overall ratings of the TMTs, participant feedback, and evaluator observations it is recommended that the basic features of the TMT includes:

1) 20 degree tilted top toward the operator for more wrist posture and easier removal of mail from the tray.

2) Perpendicular or greater than 90 degree placement to the jogger with the ability for the operators to adjust the TMT to their needs.

3) Height range for the table set at 32 to 34 inches.

Where feasible it would be desirable for the TMT to have an adjustable tilt feature from 0 – 20 degrees, a height adjustment range of at least 32 – 34 inches, and easy mobility so the operator can place the TMT where desired for feeding or out of the way, if not needed.

# Appendices

# APPENDIX 1
# Evaluation of Methods for Limiting Tray Stacking to Two High on 1226F Surge Shelf

# Appendix 1A

## Test Plan Method for Limiting Tray Stacking to Two High
## Method 1

### Method 1:

### Tacking of Full Trays

Once a tray becomes full, it may be removed from the shelf of the 1226F tray cart and placed on top of the rack. However, ***full trays must not be stacked more than two trays high***. Once this limit has been reached, excess full trays must be offloaded into support equipment. The purpose of this limit is to minimize exposure to risk of injury from excessive reaching and lifting above shoulder height. However if a tray conveyor system is available, full trays are automatically distributed to a subsequent operation or to the dispatch unit.

When placing a full tray on top of the 1226F tray cart, grasp the handle at the front end of the tray with one hand, withdraw it halfway, and support the bottom of the tray at the middle with the other hand. Place the far end of the tray over the edge of the top of the tray cart, and then use both hands to push the tray up and onto the top shelf.

### Surge Volume Issues

The 1226-F tray cart has a total storage capacity of 36 mail trays, including 24 trays on the slide-out shelves and the additional capacity of 12 trays, which are stacked 2-high on top of the rack (**surge area –Figure 1**). When the mail volume run on the DBCS operation exceeds the capacity of the 1226-F tray cart, using the additional equipment method reduces the risk of injury.

### Stacking of DPS Mail Trays

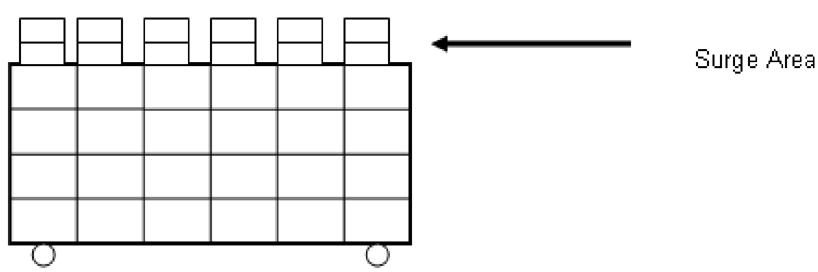



**FIGURE 1 - SURGE AREA FOR 1226-F TRAY CART**

### Additional Equipment Set Up

Once the operator performing the sweeping function becomes familiar with DPS zones and volumes, it will become evident which 1226-F tray carts generally have excess mail trays and will require support equipment. Some examples are the platform Nutting truck, flat rack and shelved General Purpose Mail Container (GPMC).

Facilities may elect to differentiate additional equipment from the standard racks. Space available and availability of equipment in a facility will dictate the type of additional equipment used and the placement of this equipment. Suggested configurations are noted below.

## Single Rack Setup

When space constraints dictate that a single 1226 cart configuration is used, it is recommended that additional equipment be placed the directly behind each corresponding 1226 rack (**single rack setup –Figure 2**).

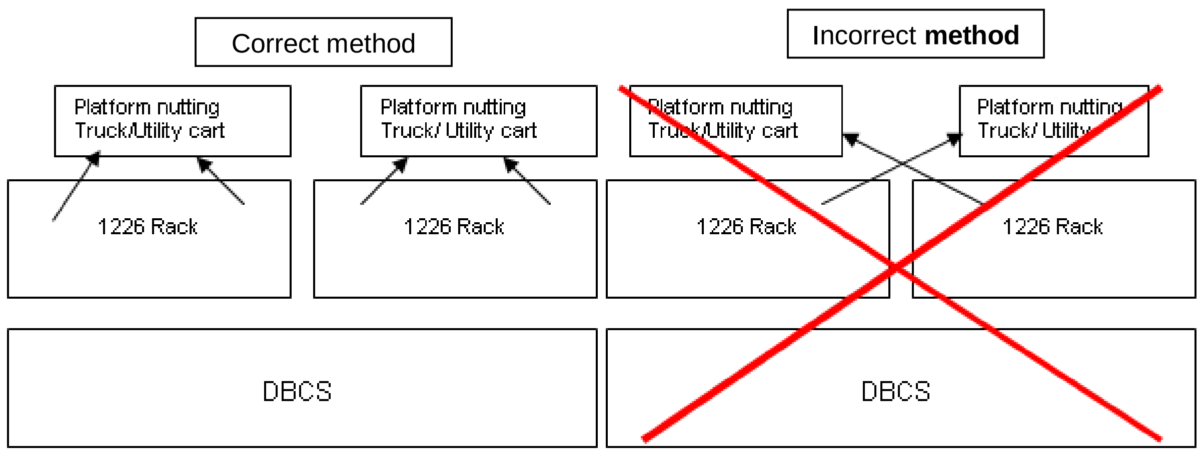



**FIGURE 2 - SINGLE RACK SETUP**

If it is not feasible to place the additional equipment behind the 1226-F tray carts, another option is to place the additional equipment at a remote location, such as near the operator at the feeder.

## Dual Rack Setup

When a dual 1226 cart configuration is used, the additional equipment is placed between the two sets of racks (dual rack setup –Figure 3).

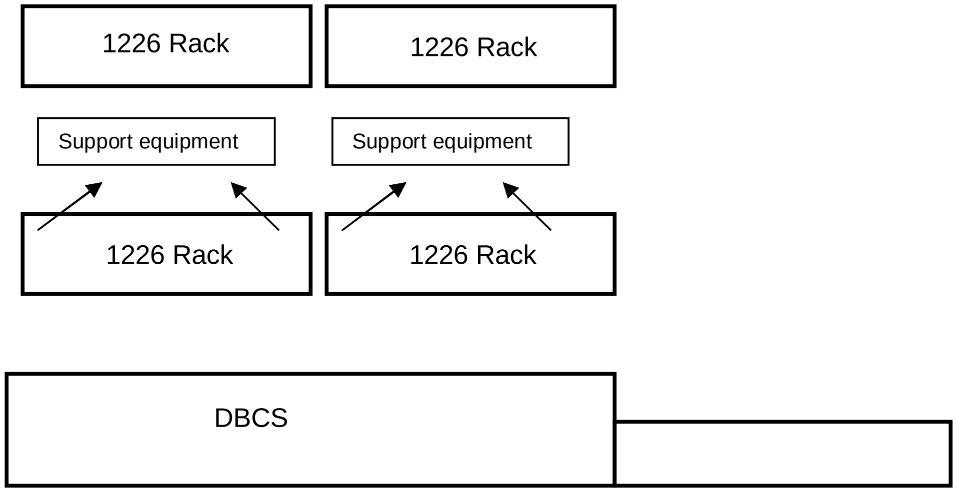



FIGURE 3 - DUAL RACK SETUP

When a particular 1226-F tray cart has trays stacked two-high, the operator walks behind the 1226-F tray cart and places any additional mail tray into the additional equipment. To reduce the risk of out of sequence mail (OOS) occurrences, this equipment should be labeled with the corresponding rack number.

## Overflow Tray Identification

When there are already two trays stacked on the surge tray, and it is necessary to stack additional trays on support equipment, it is essential that ALL trays be processed in sequence and that the trays in the overflow container are NOT forgotten.

The following tray identification process is highly recommended:

1. Place new tray into empty slot in the 1226-F tray cart column.

2. Before labeling new tray, draw a red line across the tray label with a RED marker. (This will be the ID tray – user may opt to use a red strip in the tray – as long as the tray has an identifier.

3. As the trays are being pulled and sequenced for second pass, if the sweeper sequences a tray with a ID marker (red lined tray label or red strip), then he must check the top of that tray rack column AND the overflow container for a tray to be sequenced at that point.

## Second Pass Positioning

Once a run is complete, the mail must be staged near the operator performing the feeding function. The racks are positioned in order. The additional equipment is placed after the corresponding 1226-F tray cart, never adjacent to one another (Second Pass Positioning - Figure 4). The additional equipment is always positioned between 1226-F tray carts. For example, the additional support equipment labeled #1 will be placed directly after the #1 1226-F tray cart and before the #2 1226-F tray cart. The operator at the feeder must first look in both to determine mail tray order before proceeding to the #2 1226-F tray cart and the #2 support equipment.

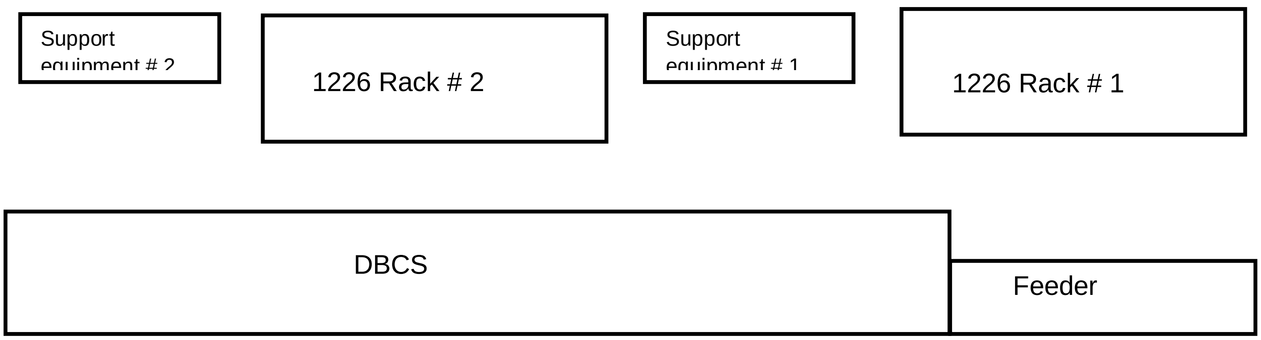



FIGURE 4 – SECOND PASS POSITIONING

### Stacking of Non-DPS Mail Trays

When the potential exists for stacking trays more than two-high on non-DPS runs, the site will take appropriate action consistent with available support equipment and staffing to ensure mail trays in excess of two-high are loaded into support equipment in order to limit stacking on 1226-F racks to no more than two high.

# Appendix 1B

## *Alternate Method for* Limiting Tray Stacking to Two-High
**Method 2**

### Method 2:

When off-loading excess full trays from the 1226F racks on first pass, it is desirable to stack the trays on top of the rack and in support equipment in the optimum order to facilitate feeding of the trays in sequence for second pass. The optimum order includes stacking full trays such that the tray needing to be fed next on second pass is always on top of a stack and can be accessed without the physical demands and reduced efficiency involved in un-stacking other trays. (Examples of such stacking patterns are illustrated in Appendix 1K).

Method 1, as described in Appendix 1A, specifies off-loading trays from the 1226F rack drawers in the order they become full (regardless of the tier from which they originate); stacking the first full trays on top of the 1226F racks until two-high; and then off-loading additional full trays into support equipment. When GPMC's with inserts are used as support equipment off-loaded trays can be positioned within the support equipment in the proper order for second pass using Method 1.

When using other types of support equipment, such as GPMCs without inserts or Nutting trucks, Method 1 does not provide the capability for positioning full trays in the proper order for heavy volume runs without significant restacking of the trays. To address this issue, sites adjusted the test method to keep excess full trays in the proper sequence for second pass feeding by off-loading all excess full trays from the 1226F racks at approximately the same time and positioning the full trays on top of the 1226F racks and in support equipment using a specific stacking pattern.

Method 2 is applicable to operations using two sets of 1226F racks per machine and support equipment such as GPMCs without inserts and Nutting trucks. The basic steps for Method 2 are the same as for Method 1 except as follows:

1) After the start of the first pass run, trays are monitored until all trays approach becoming completely full. Most trays typically approach full status at approximately the same time on first pass.

2) Before machine operations become adversely affected because of full trays, all trays in the rack are off loaded in a specific order and stacked in a pattern that facilitates second pass feeding without the need for un-stacking of trays.

3) The stacking pattern should consist of:
   a) Stacking excess full trays from each Tier 2 drawer directly above the drawer on top of the 1226F surge shelf and excess full trays from corresponding Tier 1 drawers on top of the trays removed from Tier 2.

b) Excess full trays removed from the bottom two tiers of the 1226F racks should be off-loaded to support equipment and stacked in an order to facilitate second pass feeding without having to un-stack or re-handle trays.

c) The order of tray removal from the bottom two tiers of the 1226F racks and the specific tray stacking pattern may vary depending upon the specific support equipment (i.e. Nutting truck compared to a GPMC with a middle shelf) used. A typical tray stacking pattern using only the space above the middle shelf of a GPMC for off-loaded trays is included as illustration No. 2 in Appendix 1K.

# Appendix 1C

## *Alternate Method for* Limiting Tray Stacking to Two-High
## Method 3

**Method 3:**

Sites having only one-set of 1226F racks per DBCS machine must pull down all of the full and partially full trays from the racks to the corresponding support equipment for second pass feeding. Therefore, the specification in Method 1 for accumulating and leaving two-high tray stacks on top of 1226F racks for second pass feeding is not applicable to these operations and was modified by sites to provide for off-loading full trays from the 1226F racks into support equipment at a time and frequency best-suited for the operation.

Method 3 is applicable to operations using one set of 1226F racks per machine. The basic steps for Method 3 are the same as for Method 1 except as follows:

a. After the start of the first pass run, full trays are pulled from the 1226F rack drawers and placed either directly into support equipment or on top of the 1226F racks for later placement into support equipment.

b. When GPMCs with inserts are used as support equipment, full trays can be off-loaded from the rack drawers as they become full and positioned within the GPMC in proper sequence for second pass feeding. When each stacker bin is anticipated to generate multiple full trays, empty spaces should be left adjacent to the full trays in the GPMCs for placement of additional trays from the same tray drawer. Space should also be left for the partially full trays that will be off-loaded from the 1226F racks at completion of the first pass run.

c. When types of support equipment other than GPMCs with inserts are used, tray stacking is addressed as follows:

    a. After the start of the first pass run, trays are monitored until all trays approach becoming completely full. Some trays that become full earlier than others may be pulled and placed on top of the 1226 rack if needed to extend the time prior to the off-loading of all full trays.

    b. Prior to the machine operation becoming adversely affected because of full trays, all trays in the rack are off loaded to support equipment in a specific order and stacked in a pattern that facilitates second pass feeding without the need for un-stacking of trays.

    c. Specific tray stacking patterns may vary depending upon the specific support equipment (i.e. Nutting trucks compared to a GPMCs with a middle shelf) used. Examples of tray stacking patterns are illustrated in Appendix 1J.

# Appendix 1D

## Test Methodology and Evaluation Process

The following nine facilities were selected by the USPS as sites for implementing and testing methods for limiting tray stacking to no more than two-high on 1226F racks : Denver P&DC, Colorado Springs P&DC, Providence P&DC, Tulsa P&DC, Columbus P&DC, Los Angeles P&DC, Norfolk P&DC, Palatine P&DC and Nashville P&DC.

At each location, Method 1, as documented in Appendix 1A, was reviewed with site personnel. Based upon site input, plans were developed to test the method as presented or with adjustments to address local constraints. Plans tested with adjustments made to address site constraints were consistent with either Method 2 or with Method 3, as described in Appendix !B and IC.

In each location, plans included implementing the tray stacking method to be tested during high volume runs on three of the site's DBCS machines and to observe and obtain baseline data from three machines processing similar run volumes using the site's standard tray stacking methods. Observations were made and data collected throughout the testing periods to document the effectiveness of both the test method and the site's standard tray stacking methods in limiting tray stacking on top of the 1226F racks. The presence of any other significant ergonomic issues, including issues related to aisle space for staging and moving support equipment, access points to the back of the 1226F racks, and the type of support equipment utilized were also observed.

Tests at each site were typically for durations of one or two tours with test dates selected based upon anticipated high-volume run days for DPS mail on Tour 1. Following the testing, employees participating as feeders or sweepers on the test machine and supervisors with responsibilities for DBCS operations were given the opportunity to provide input on the test method and to provide other ideas for improving tray stacking methods.

Descriptions of the specific methods tested at each site together with descriptions of each site's standard tray stacking methods are included in Appendix 1E. As noted in the Appendix, test methods were implemented in all sites with the exception of Providence P&DC where operations were impacted by inclement weather in the region.

# Appendix 1E
## Summary of Test and Standard Methods

| Site | Method Tested | Standard Method |
|---|---|---|
| **Denver** | Method tested consisted of off-loading excess full trays from Tiers 1 & 2 to the top shelf of each 1226F rack and excess trays from Tiers 3 & 4 to GPC support equipment equipped with a middle shelf. Each of two adjacent 1226F racks were served by a single GPC with full trays from Tiers 3 & 4 from the first 1226F rack unloaded to the top of the GPC and full trays from Tiers 3 & 4 of the second 1226F rack off-loaded to the bottom of the GPC. All full trays are typically off-loaded from the rack drawers at the same time so they can be stacked in a proper order for feeding on 2nd pass. A red strip of paper was added to the label holder for any new trays added to the 1226F rack to replace full trays off-loaded to the top shelf of the rack or to support equipment. . | Participants indicated standard tray stacking methods include stacking 3 trays from Tiers 1, 2, & 3 on the top shelf and the first full tray from Tier 4 on the lower shelf of 1226F racks.<br><br>Other operators indicated use of methods to consolidate mail from two stackers into one tray.<br><br>One employee indicated the method tested is similar to the method used in the site for processing during the Christmas season. |
| **Colorado Springs** | The method tested consisted of off-loading excess trays from a single set of 1226F Racks to support equipment which primarily consisted of GPCs with inserts. With a single set of 1226F racks per machine, all trays for second pass are pulled down to the support equipment. The equipment available within the facility is sufficient to typically allow use of only the upper shelves of the GPCs with inserts (the bottom two shelves are left empty). When full trays were pulled from the rack drawer, a "2" or "3" was hand written on the tray label as an indication for the second pass feeder to locate and feed either a 2nd or 3rd full tray in order to keep the mail in sequence | Supervisors and test participants indicated the test method was very similar to their standard tray stacking method with the exception that the marking of labels on new empty trays added to 1226F racks, as done during the test, is not always a part of the standard stacking methods. GPCs with inserts and Nutting trucks are the primary types of support equipment normally used in the facility. |
| **Providence** | The Test Plan Method for stacking was not implemented due to a site operations decision to allow stacking 3 high on top of 1226F Tray cart during 1st Pass run volume on Sunday for Monday of Labor Day Holiday mailing.<br><br>Test planning was impacted by inclement weather in the region that resulted from the presence of hurricane, Irene. | Most DBCS machines at the site are 3-tier using one set of 4-tier 1226F racks.<br><br>Based on observations, mail volume is swept from each machine and full trays are stacked 3-high on top of 1226F tray carts. If another tray becomes full, it is placed in sequence by lifting up the appropriate tray on top of the rack. (At the end of first pass, all full and |

| | | |
|---|---|---|
| | | partially full trays are on top of the tray cart with empty trays in tray cart drawers).<br><br>Some operators use different methods such as using the bottom shelf of 1226F Tray carts for full trays. Others use shelved support equipment for 1226F tray cart pull down. |
| **Tulsa** | The method tested consisted of off-loading excess trays from 1226F Racks to support equipment which primarily consists of Nutting Trucks and GPCs without inserts. The facility does not have a second set of 1226F racks so all trays for second pass are pulled down to the support equipment. When full trays were pulled from the rack drawer, a "2" or "3" was hand written on the tray label as an indication for the second pass feeder to locate and feed either a 2nd or 3rd full tray to keep the mail in sequence. | Participants indicated the test method was very similar to their standard tray stacking method except they normally don't assign a separate piece of support equipment for each 1226F racks in order to consolidate the trays into fewer pieces of equipment. |
| **Columbus** | The method tested consisted of off-loading excess trays from 1226F tray carts to APCs with inserts.<br><br>Two machines were tested with: (a) Use of a single APC for each 1226F rack, (b) the top 2 rows of # 1 trays (surge trays) moved to top surge shelf of 1226F tray cart, (c) Bottom 2 rows of # 1 trays (surge trays) moved to an APC, and (d) a tray identification method that consisted of bin numbers on #1 tray labels, use of tray locations in 1226F tray carts to identify # 2 trays together with operators knowing only two trays per bin are generated; and labeling trays if three or more trays are generated.<br><br>One additional, machine was tested with: (a) one APC serving 2, 1226F racks, (b) the top 2 rows of # 1 trays (surge trays) moved to an APC, (c) Bottom 2 rows of # 1 trays (surge trays) moved to the top surge shelf of 1226F tray cart, and (d) a tray identification method that consisted of labeling # 1 and # 2 trays; use of tray locations in 1226F tray carts and APCs; together with operators knowing that only two trays per bin are generated | The site used APCs to limit stacking of trays on the surge shelf of 1226F tray carts in the past. It is a current practice by a few operators and was the practice of most operators prior to 2005.<br><br>A Tour 1 204B supervising a test machine mentioned that DBCS operators moved away from using APCs back in 2005 since they were responsible for getting their own APCs, and over time, found it easier or less time consuming to put excess full trays on top of the surge shelves. |
| **Los** | The method tested consisted of off-loading excess trays from 1226F tray carts to APCs; 1 machine used 2 APCs with inserts | Based on participant feedback, stacking all excess trays (3-4 high) on top of the rack is |

| | | |
|---|---|---|
| **Angeles** | for each 1226F rack with excess trays numbered to coincide with all like trays. Two additional machines used a single shelved APC for each rack with excess trays numbered (i.e. 2, 3) to coincide with each tray. | the standard method used in the past. |
| **Norfolk** | The Test Plan Method for stacking was not observed on the Sunday for Monday as planned because operations ran most of the first pass volume on Saturday for Sunday when no evaluators were scheduled to observe. | The site runs their largest volume 1st Pass Sort programs on Saturday for Sunday and pulls down all trays into MTE support equipment (ERMCs, APCs and GMPCs). MTEs loaded are numbered sequentially. Trays are labeled by bin numbers and kept in sequence.<br><br>On Sunday for Monday, machines are available for running of Prime or other Sort programs on Tour 3.<br><br>1st Pass mail processed Sunday for Monday (Tour 1) is lower volume than on Saturday for Sunday and stacking on top of the 1226F is limited to no more than 1 or 2 high. |
| **Palatine** | **Test Plan Method: (Tested on 2 Machines)** The method tested consisted of off-loading excess trays from 1226F racks to support equipment which primarily consisted of Nutting Trucks (or some GPCs) in numerical sequence. One Nutting truck for two 1226F tray racks. When full trays were pulled from the rack drawer, a “2” or “3” was hand written on the tray label as an indication for the second pass feeder to locate and feed either a 2nd or 3rd full tray in order to keep the mail in sequence. | Test participants indicated that they have used a single GPC top shelf per 1226F rack, in the past and have marked the plastic trays with a rack number, but not the label.<br><br>Some past use of consolidation methods was also indicated. |
| | **1 plus ½ Tray Method Test: (Tested on One Machine)** Once all trays become full, Tiers 2 & 4 are removed from the shelves of the 1226F tray cart and placed on top of that 1226F tray rack.<br><br>When placing full trays on top of the 1226F tray cart, trays from the bottom (4th) row are pulled first and placed directly above the same column. Trays from the 2nd row are then placed on top of trays from the 4th row on top of the 1226F tray cart. | Test participants indicated that they have used a single GPC top shelf per 1226F rack, in the past and have marked the plastic trays with a rack number, but not the label.<br><br>Some past use of consolidation methods was |

| | | |
|---|---|---|
| | Empty full trays are then placed into the open tray drawers in the 2nd & 4th rows, inside the 1226F tray cart and a single half tray is placed inside the new full size empty tray being placed in the Tier 2 and Tier 4 drawers to create two separate sort locations on the 2nd and 4th row. Full trays on the 1st row and the 3rd row of trays are allowed to remain inside the 1226F tray cart.<br><br>With the modified tray cart setup, additional mail is swept from the 1st tier (top) and placed into the half tray in the 2nd row of the 1226F tray cart. Second tier mail is placed into full size tray, in the 2nd row behind the half tray with mail facing away from the machine.<br><br>Mail from the 3rd tier is placed into the half tray in the bottom (4th) row in the 1226F tray cart and mail swept from the fourth tier is placed into the full size tray in the bottom (4th) row behind the half tray with mail facing away from the machine. | also indicated. |
| **Nashville** | The method tested consisted of off-loading excess trays from 1226F tray carts to shelved-GPMCs, if available, or into APCs.<br><br>Two test machines used 2 shelved GPMCs per 1226F rack with the top two tiers of the 1226F rack moved to the top surge shelf of the rack and the bottom two tiers moved to a shelved GPMC. A third test machine used a single APC for each 1226F rack with the top two tiers of the 1226F moved to the top surge shelf of the rack and the bottom two tiers moved to a shelved GPMC<br><br>The tray identification method consisted of writing bin numbers on #1 tray labels and use of tray locations in 1226F tray carts to identify # 2 trays. Operators labeled new trays only if a 3rd trays was generated | Standard method is same as test method. |

# Appendix 1F

## Summary of Results for Methods 1, 2 & 3

## Table 1

## Summary of Method 1 Test Results

### (Two Sets 1226F Racks per Machine and GPMCs with Inserts)

| Site | Number of Machines Evaluated | | Tray Stacks More Than Two-High | | Causes of Excess Tray Stacking on Test Machines |
|---|---|---|---|---|---|
| | Standard Site Methods (Baseline) | Tested with Method 1 | Baseline Machines | Test Machines | |
| Columbus P&DC | 3 | 3 | 52 stacks up to 4 high on one machine (DBCS #7)<br><br>No stacks on other two machines.<br><br>Range of Run Volumes: 86,320 – 152,337 | No stacking more than two-high occurred on any of the three test machines.<br><br>Range of Run Volumes: 97,970 – 134,642 | No stacking more than two-high occurred |
| Los Angeles P&DC | 3 | 1 | Maximum of 38 stacks up to 4-high (DBCS #1)<br><br>Minimum of 11 stacks up to 4-high (DBCS #11)<br><br>Range of Run Volumes: 95,969 – 173,458 | 4 Stacks on test machine (DBCS #7) up to 3-high.<br><br>Test Machine Run Volume: 135,997 | Relief help utilized during final pull down was untrained on the test method (DBCS #7) |

## Table 2

## Summary of Method 2 Test Results

## (Two Sets 1226F Racks per Machine and Equipment Other than GMPCs with Inserts)

| Site | Number of Machines Evaluated | | Tray Stacks More than Two-High | | Causes of Excess Tray Stacking on Test Machines |
|---|---|---|---|---|---|
| | Standard Site Methods (Baseline) | Tested with Method 2 | Baseline Machines | Test Machines | |
| Denver P&DC | 3 | 2 | Maximum of 11 stacks up to 4-high (DBCS #36)<br><br>Minimum of 1 stack 3-high (DBCS #35)<br><br>Range of Run Volumes: 140,618 – 158,664 | No stacking more than two-high occurred on either of the two test machines.<br><br>Range of Run Volumes: 147,755 – 155,807 | No stacking more than two-high occurred |
| Los Angeles P&DC | 3 | 2 | Maximum of 38 stacks up to 4-high (DBCS #1)<br><br>Minimum of 11 stacks up to 4-high (DBCS #11)<br><br>Range of Run Volumes: 95,969 – 173,458 | 12 stacks up to 4-high on DBCS #33.<br><br>8 stacks up to 4-high on DBCS #40<br><br>Range of Run Volumes: 146,506 – 156,024 | Not enough support equipment for three 1226F racks (DBCS #33)<br><br>Not enough support equipment for two 1226F racks (DBCS #40) |
| Palatine P&DC | 3 | 2 | Nine stacks up to 3-high (DBCS #3)<br><br>Four stacks up to 3-high (DBCS #38)<br><br>No stacks exceeding two-high on DBCS #24<br><br>Range of Run Volumes: 153,643 – 194,325 | No stacking more than two-high occurred on either of the two test machines.<br><br>Range of Run Volumes: 129,397 -  133,079 | No stacking more than two-high occurred. |

| | | | | | |
|---|---|---|---|---|---|
| Nashville P&DC | 3 | 2 | No tray stacks exceeding two-high on any of baseline machines.<br><br>Range of Run Volumes: 90,594 – 104,921 | No stacking more than two-high on the two test machines.<br><br>Range of Run Volumes: 134,245 – 187,284 | No stacking more than two-high occurred. |

## Table 3

## Summary of Method 3 Test Results

## (One Set of 1226F Racks per Machine and Use of Support Equipment)

| Site | Number of Machines Evaluated | | Tray Stacks More than Two-High | | Causes of Excess Tray Stacking on Test Machines |
|---|---|---|---|---|---|
| | Standard Site Methods (Baseline) | Tested with Method 3 | Baseline Machines | Test Machines | |
| Colorado Springs P&DC | 3 | 3 | No tray stacks exceeding two-high on any baseline machines.<br><br>Range of Run Volumes: 90,407 – 116,940 | 3 stacks, 3-high on DBCS #13<br><br>No stacking more than two-high occurred on the two other test machines<br><br>Range of Run Volumes: 59,608 – 103,082 | Three, 3-high stacks developed on DBCS #13 when one operator left machine area to locate additional mail for feeding |
| Tulsa P&DC | 3 | 3 | No tray stacks exceeding two-high on any baseline machines.<br><br>Range of Run Volumes: 61,620 – 78,287 | One tray stack, 3-high occurred on DBCS #91.<br><br>Range of Run Volumes: 54,288 – 72,254 | DBCS #91 developed one stack of 3-high trays due to machine being operated with only one operator during the run. |
| Nashville P&DC | 3 | 1 | No tray stacks exceeding two-high on any of baseline machines.<br><br>Range of Run Volumes: 90,594 – 104,921 | Three stacks, 3 trays high occurred on test machine DBCS #21<br><br>Range of Run Volumes: 134,245 - 187,284 | DBCS #21 exceeded two-high stacking due to not having enough support equipment during last hour of run. |

(Notes: Results for Providence P&DC and Norfolk P&DC are not included in the above tables. Test 1 evaluation did not occur at Providence due to operational concerns related to inclement weather in the region, and the test method at Norfolk was implemented by site personnel on a Saturday for Sunday night when no evaluators were scheduled to observe the operations).

# Appendix 1G

## Low Back Compression Force Evaluations for Support Equipment

### Evaluation Method:

The University of Michigan 3D Static Strength Prediction Program (3DSSPP), Version 6.0.5 has been utilized to calculate low back compression forces for selected postures assumed when loading and unloading full trays from various types of support equipment.

Based upon observations at various sites, actual postures and lifting techniques utilized by USPS employees vary significantly and are impacted by site conditions such as the amount of clearance available to access support equipment for loading and unloading trays. Rather than a more extensive evaluation to establish the full ranges of low back compression forces experienced by employees of varying stature and body weights using various lifting postures, the scope of this evaluation is limited to establishing the relative differences in low back compression forces experienced when lowering and lifting full trays to and from the same elevations where trays are positioned when using various types of support equipment.

The calculations have been developed using the University of Michigan 3DSSPP and the following methods and conditions:

a) The 3DSSPP's Posture Prediction function is utilized to predict an employee's posture when lifting or lowering trays to and from the same elevations where trays are positioned when using various types of support equipment.
b) Weight of full trays is assumed to be 25 pounds.
c) Horizontal distance to each hand is assumed to be 10 inches.
d) Lateral distance between each hand is assumed to be 24 inches.
e) Vertical distance is varied for each case analyzed based upon the specific support equipment and the vertical positioning of the full tray.
f) Each case has been analyzed for the 50$^{th}$ percentile male.

**Results of Evaluations for 50th Percentile Males:**

| Type of Support Equipment | Tray Placement Elevations Evaluated | Low Back Compression Forces (lbs.) | Percent Difference from NIOSH Action Level of 770 lbs. (1) |
|---|---|---|---|
| GPMC with Inserts | Tier 1 (Top Shelf) | 210 | -72.7% |
| | Tier 2 | 224 | -70.9% |
| | Tier 3 | 340 | -55.8% |
| | Tier 4 (Mid Shelf) | 362 | -52.9% |
| | Tier 5 | 417 | -45.8% |
| | Tier 6 | 538 | -30.1% |
| | Tier 7 | 635 | -17.5% |
| | Tier 8 (Bottom Shelf) | 866 | +12.5% |
| GPMC / ERMCs with Mid Shelf | Top Level (65.5") | 210 | -72.7% |
| | Mid-Shelf Level | 362 | -52.9% |
| | Bottom Shelf Level (Lifting) | 866 | +12.5% |
| | Bottom Shelf Level – (Lowering by dropping tray from elevation of 28")(2) | 517 | -32.9% |
| Nutting Truck | Platform Level | 790 | + 2.6% |
| | Mid-Level (27") | 534 | -30.6% |
| | Top Level (stacked 54" to handle level ) | 329 | -57.3% |

Notes: (1) 770 lbs. is the NIOSH Action Limit documented in the Work Practices Guide for Manual Lifting (NIOSH, 1981). (2) When using GPMCs/ERMCs without inserts employees typically place trays into the lower levels of the equipment by dropping trays from slightly below waist level.

**Forces for Selected Support Equipment and Tray Locations (Listed from Lowest to Highest Force Levels**):[3]

1) Mid-Shelf of GPMC (43-inches): 362 pounds (47.1% of NIOSH Action Level)
2) Third Tier from Bottom in GPMC with inserts (26.5-inches): 538 pounds (69.9% of NIOSH Action Level)
3) Second Tier from Bottom in GPMC with inserts (18.5"): 635 pounds (82.5% of Action Level
4) Platform level of Nutting Truck (17-inches): 790 lbs. (102.6% of NIOSH Action Level).
5) Lowest shelf of GPMC with or without inserts: (11-inches): 866 pounds (112.5% of NIOSH Action Level).

Note: (3) Calculations for selected support equipment are based on lifting trays from elevations encountered when lifting to or from the shelves or platforms of the specified equipment.

**Factors with Potential for Increasing Back Compression Forces Shown in Table:**

1) Lifting/lowering full trays further from body than 10" assumed in calculations.
2) Lifting/lowering trays weighing more than the 25 lbs. assumed in calculations.
3) Twisting when lifting/lowering trays.
4) Lifting/lowering by individuals taller in stature and heavier than the $50^{th}$ percentile male.

**Lifting and Lowering Comparisons:**

Calculations made assume back compression forces are the same for lifting and lowering with the exception of loading full trays into the bottom of GPMCs without inserts. When using this equipment, the bottom level of trays must be lifted by reaching to a level of 11-inches to access trays. However, when off-loading trays into a GPMC without inserts it has been observed that it is common practice to lower full trays to an elevation, typically slightly below waist level, and then drop them into place in the bottom of the GPMC.

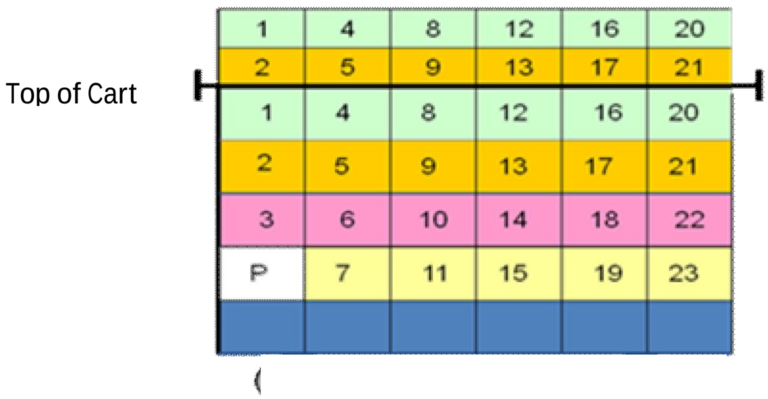
Calculations indicate a low back compression force of 517 pounds (67.1% of NIOSH Action Level) when a full tray is lowered to an elevation of 28-inches and then dropped, compared to 866 pounds (112.5% of NIOSH Action Level) when lowering a full tray to an elevation of 11-inches, consistent with the lowest tier on a GPMC with inserts. (During on-site testing some employees expressed a preference for the use of GPMCs without inserts because of the bending required to off-load full trays into the lowest tiers of GPMC with inserts compared to the dropping of trays into the bottom of a GPMC without inserts).

# Appendix 1H

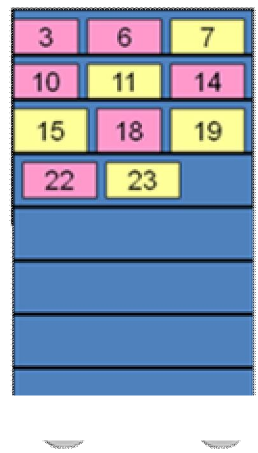
## Tray Stacking Pattern Illustrations

### Illustration #1 – Use of GPMCs with Inserts for Operation with Two Sets of 1226F Racks

(Illustrations Not to Scale)




**Back of 1226F Tray Cart #1**




**Front View of GMPC with Inserts**

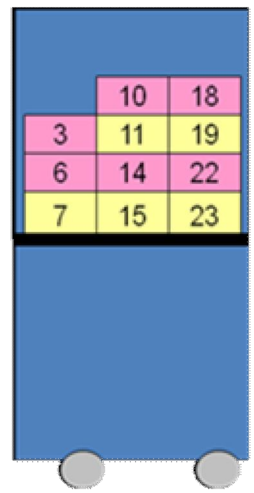
**Illustration No. 1** illustrates a method for maintaining full trays in the proper sequence for 2nd Pass feeding when off-loading to the top of the 1226F tray cart and to a GPMC equipped with inserts. The method illustrated requires two-sets of 1226F tray carts and a sufficient number of GPMCs with inserts. Excess full trays from the top two rows of the 1226F Cart are placed on top of the 1226 tray cart with the optimum pattern for second pass consisting of trays from the second row (i.e. tray #2) placed directly on top of the surge shelf and full trays from the first row (i.e. tray #1) placed on top of the second row trays.

As trays become full on the bottom two rows of the 1226F tray carts they are off-loaded to a GPMC with inserts and placed in proper order for 2nd pass feeding. An example of an effective pattern for stacking trays within the GPMC is as follows:

- Full trays off-loaded from the bottom two rows of the 1226F racks should be positioned in a consistent, sequential order in the GPMC. For example, placement of the #3 tray in the upper left hand corner of the GPMC and positioning other trays from the bottom two rows of the tray cart, as shown in the illustration, provides a correct sequence for feeding the trays using a left to right and high to low tray selection process.
- For some high volume runs, operators may know from experience that more than one excess tray will be generated by each stacker bin. In these cases, operators should leave spaces open when placing the first full trays in the GPMCs with inserts so that the next full tray with the same bin number can be positioned adjacent to the previously off-loaded tray. This will allow, for example, all full trays from stacker Bin #3 to be placed next to one another in the GPMC. When more than one full tray is generated in the top two rows of the 1226F tray carts the excess trays will also need to be off-loaded to support equipment to avoid stacking more than two-high on top of the tray cart. For example, these trays may be placed in the lower, unused levels of the illustrated GPMC or in a separate piece of support equipment. In all cases, an effective labeling system must be in place to ensure all trays are located as needed to maintain proper sequence for second pass feeding.
- Additional GPMCs with inserts should be placed into service as needed to support the first pass run without the need for stacking more than two-high on top or the 1226F tray cart.

**Illustration #2 – Use of GPMCs with Middle Shelf for Operation with Two Sets of 1226F Racks**


**Back of 1226F Tray Cart #1**




**Front View of GMPC with Mid-Shelf**

**Illustration No. 2** illustrates a method for maintaining full trays in the proper sequence for 2nd Pass feeding when off-loading to the top of the 1226F tray cart and to a GPMC equipped with a middle shelf. The method requires two-sets of 1226F tray carts and off-loading of full trays at the same time to maintain optimum stacking for 2nd Pass feeding.

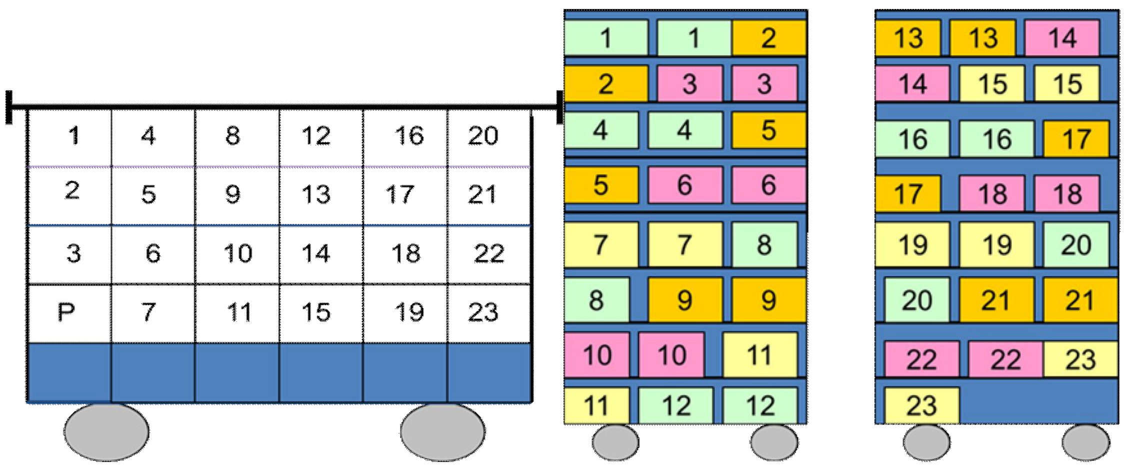
With this method, excess full trays from the top two rows of the 1226F Cart are placed on top of the 1226 tray cart with trays from the second row (i.e. tray #2) placed directly on top of the surge shelf and full trays from the first row (i.e. tray #1) placed on top of the second row trays.

The bottom two rows are then off-loaded to support equipment, such as a GPMC with a middle shelf, in the proper order for 2nd pass feeding trays as follows:

- The last tray in the bottom row (4th row) of the tray cart (#23 in the above illustration) is off-loaded first and placed, as shown, in the right hand corner of the GPMC.
- Off-loading the bottom row of full trays from the tray cart to the bottom row of the GPMC is then completed by skipping over the next tray on the bottom tray cart level (#19) to off-load tray #15 and then proceeding to off-load tray #7.
- Selected trays from the 3rd row of the tray cart are then off-loaded to the next level in the GPMC by starting with off-loading the last full tray from the 3rd row (#22 in the above illustration) to the next row in the GPMC as shown.
- Off-loading selected trays from the 3rd row of the tray cart to the next level of the GPMC is completed by skipping over the next tray on the 3rd row of the tray cart level (#18) to off-load tray #14 and then proceeding to off-load tray #6.
- Remaining trays on the 4th row of the 1226F tray cart are then off-loaded and placed in the next row of the GPMC as illustrated. (Note: the illustration is of a 1226F cart positioned to support the first set of DBCS stacker bins and therefore has only five trays on the bottom row of the tray cart due to the printer located in the position designated with a "P").
- Remaining full trays from the 3rd row of the 1226F tray cart are then off-loaded and placed in the next row of the GPMC.

Off-loading excess full tray by this method results in the each tray being accessible for feeding in the proper sequence without the need for un-stacking of trays. For example, after tray #1 from the top row of the 1226F cart is fed, the 2nd tray #1 is directly accessible from the surge area of the 1226F rack and thereafter, the proper excess full tray for feeding (#2 - #23 in the above illustration) is always on top of a stack when it needs to be fed for maintaining proper sequence.

## Illustration #3 – Use of GPMCs with Inserts for Operation with One Set of 1226F Racks




**Back of 1226F Tray Cart #1 After Off-Loading of All Trays**

**Front View of Two GPMCs with Inserts Containing Two Full Trays from Each Drawer of Tray Cart #1**

**Illustration No. 3** illustrates a method for maintaining full trays in the proper sequence for 2nd Pass feeding when off-loading all of the trays from a single set of 1226F tray carts to GPMC s equipped with inserts.  The illustration is for a case where 2 trays have been off-loaded from the 1226F tray cart in a proper sequence for the 2nd pass run.
As trays become full on first pass, they are pulled from the 1226F tray cart and placed in the proper position in the GPMC with inserts. When generation of additional trays from the same stacker bin is anticipated, a space is left open adjacent to the first tray placed into the GPMC to allow proper positioning of additional trays.  Operations with only one set of racks must pull down all trays at end of the first pass and position within the support equipment for the second pass run.

Trays off-loaded from the 1226F racks should be positioned in a consistent, sequential order in the GPMC. For example, positioning trays as, shown in the illustration, provides the correct sequence for feeding the trays using a left to right and high to low tray selection process.  In all cases, an effective tray identification system must be in place to ensure all trays are located as needed to maintain proper sequence for second pass feeding.
When the availability of equipment and floor space allows, the placement of full trays should be limited to only the upper tiers of GPCs with inserts in order to minimize the level of MSD risk factors, particularly from bending to place full trays into the lowest levels of the GPMCs.  For example, whenever feasible it is desirable to avoid the need for placement of full trays into the bottom two levels of the GPMCs, in order to reduce MSD risk factors. The number of GPMCs utilized must also be sufficient to limit stacking on top of the 1226F tray carts to no more than two-high for the full duration of the run.

# APPENDICES 2
# Test 2: Evaluation of Sweeping Operations from the DBCS Stacker to the 1226F Tray Carts

# Appendix 2A

## Interactive Excel Spreadsheet Macro to Convert the EOR Viewer Bin Count Table to a Bin Diagram

1. Type in "Web EOR" into the browser, click "Enter".
2. Click "Enter Application".
3. Click "Click Here to View Other Sites".
4. Select Parent Site.
5. Click "View".
6. Select "EOR Viewer" under File (first column).
7. Select "Site".
8. Select "Machine Type" (DBCS or DIOSS), and any other criterion desired, i.e., “Machine #”, “Operation No”, “Tour”, “Sort Program” or “MODS Date”.
9. Click "Refresh Data".
11. Click on the Pencil Icon (first column) for the Machine, Operation number, and Sort Program (columns 4, 5, & 6) wanted. <u>Make note of Machine, Operation number, Sort Program, and Date.</u>
12. Scroll down on report to "Bin Counts" section.
13. Select or highlight all columns and rows (see example of “EOR Viewer” Bin Counts table below).

| Bin Counts | | | | | | | | | | | | | | | | | | | back to Top |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 7 | 24 | 573 | 47 | 144 | 70 | 229 | 93 | 196 | 116 | 142 | 139 | 42 | 162 | 43 | 185 | 66 | 208 | 0 |
| 2 | 0 | 25 | 852 | 48 | 55 | 71 | 98 | 94 | 154 | 117 | 94 | 140 | 152 | 163 | 26 | 186 | 38 | 209 | 0 |
| 3 | 0 | 26 | 0 | 49 | 295 | 72 | 53 | 95 | 116 | 118 | 43 | 141 | 73 | 164 | 137 | 187 | 7 | 210 | 0 |
| 4 | 0 | 27 | 244 | 50 | 239 | 73 | 263 | 96 | 34 | 119 | 35 | 142 | 48 | 165 | 54 | 188 | 55 | 211 | 0 |
| 5 | 833 | 28 | 197 | 51 | 106 | 74 | 178 | 97 | 186 | 120 | 156 | 143 | 26 | 166 | 61 | 189 | 65 | 212 | 0 |
| 6 | 5 | 29 | 297 | 52 | 104 | 75 | 113 | 98 | 146 | 121 | 80 | 144 | 157 | 167 | 58 | 190 | 51 | 213 | 0 |
| 7 | 3 | 30 | 262 | 53 | 353 | 76 | 36 | 99 | 135 | 122 | 61 | 145 | 66 | 168 | 89 | 191 | 10 | 214 | 0 |
| 8 | 156 | 31 | 200 | 54 | 164 | 77 | 235 | 100 | 40 | 123 | 34 | 146 | 49 | 169 | 63 | 192 | 108 | 215 | 0 |
| 9 | 18 | 32 | 103 | 55 | 128 | 78 | 207 | 101 | 287 | 124 | 132 | 147 | 38 | 170 | 62 | 193 | 69 | 216 | 0 |
| 10 | 12 | 33 | 719 | 56 | 84 | 79 | 97 | 102 | 117 | 125 | 81 | 148 | 133 | 171 | 27 | 194 | 43 | 217 | 0 |
| 11 | 2 | 34 | 180 | 57 | 399 | 80 | 41 | 103 | 86 | 126 | 40 | 149 | 81 | 172 | 88 | 195 | 4 | 218 | 0 |
| 12 | 0 | 35 | 116 | 58 | 164 | 81 | 210 | 104 | 6 | 127 | 45 | 150 | 63 | 173 | 55 | 196 | 87 | 219 | 0 |
| 13 | 0 | 36 | 84 | 59 | 140 | 82 | 98 | 105 | 191 | 128 | 137 | 151 | 32 | 174 | 58 | 197 | 59 | 220 | 0 |
| 14 | 428 | 37 | 282 | 60 | 39 | 83 | 88 | 106 | 139 | 129 | 66 | 152 | 111 | 175 | 34 | 198 | 44 | 221 | 0 |
| 15 | 0 | 38 | 181 | 61 | 927 | 84 | 33 | 107 | 106 | 130 | 52 | 153 | 77 | 176 | 31 | 199 | 20 | 222 | 45 |
| 16 | 90 | 39 | 124 | 62 | 154 | 85 | 198 | 108 | 26 | 131 | 32 | 154 | 65 | 177 | 43 | 200 | 190 | | |
| 17 | 34 | 40 | 55 | 63 | 101 | 86 | 109 | 109 | 853 | 132 | 817 | 155 | 19 | 178 | 63 | 201 | 0 | | |
| 18 | 118 | 41 | 477 | 64 | 27 | 87 | 142 | 110 | 86 | 133 | 74 | 156 | 86 | 179 | 12 | 202 | 0 | | |
| 19 | 4 | 42 | 201 | 65 | 261 | 88 | 44 | 111 | 39 | 134 | 43 | 157 | 62 | 180 | 86 | 203 | 0 | | |
| 20 | 3 | 43 | 155 | 66 | 110 | 89 | 214 | 112 | 50 | 135 | 27 | 158 | 56 | 181 | 96 | 204 | 0 | | |
| 21 | 1026 | 44 | 92 | 67 | 115 | 90 | 134 | 113 | 289 | 136 | 138 | 159 | 26 | 182 | 44 | 205 | 0 | | |
| 22 | 547 | 45 | 279 | 68 | 52 | 91 | 98 | 114 | 80 | 137 | 73 | 160 | 91 | 183 | 10 | 206 | 0 | | |
| 23 | 432 | 46 | 191 | 69 | 247 | 92 | 42 | 115 | 25 | 138 | 56 | 161 | 60 | 184 | 116 | 207 | 0 | | |

14. Copy.
15. Go to the "Bin Counts Data" tab in the spreadsheet file.
16. Select or Click cell A2.
17. Right Click, Select "Paste Special" and "Unicode Text" or Select the Edit Menu, "Paste Special", and "Unicode Text".
18. Click OK.
19. If data appear in column A only, go to Data Menu, "Text to Columns", “Delimited", "Next", select "Space", "finish".
20. If data appear in all columns go to step 21.
21. Click "OK" to the question "Do you want to replace the contents of the destination cells?"
22. Click the "Run Macro" button.
23. Go to the "Tier Data" tab in the spreadsheet file for results.

See example of spreadsheet “Bin Diagram” summary below and detailed Bin Diagram on the next page for the Denver P&DC, Machine #18, Sort Program 271FILNG, MODS Date 07/27/2011; 26,860 pieces processed:

<table>
<tr><td>Tier 1</td><td>2760</td><td colspan="2">10.3%</td></tr>
<tr><td>Tier 2</td><td>13705</td><td>51.0%</td><td rowspan="2">73.9%</td></tr>
<tr><td>Tier 3</td><td>6135</td><td>22.8%</td></tr>
<tr><td>Tier 4</td><td>4260</td><td colspan="2">15.9%</td></tr>
</table>

USPS DBCS Ergonomic Issues Evaluation November 28 2011 (Revised July 13, 2012)

**Bins** 225

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tier 1 | 1 | 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | 48 | 52 | 56 | 60 | 64 | 68 | 72 | 76 | 80 | 84 | 88 | 92 | 96 | 100 | 104 | 108 |
| **Pcs** | **7** | **0** | **156** | **0** | **90** | **3** | **573** | **197** | **103** | **84** | **55** | **92** | **55** | **104** | **84** | **39** | **27** | **52** | **53** | **36** | **41** | **33** | **44** | **42** | **34** | **40** | **6** | **26** |
| Tier 2 | 2 | 5 | 9 | 13 | 17 | 21 | 25 | 29 | 33 | 37 | 41 | 45 | 49 | 53 | 57 | 61 | 65 | 69 | 73 | 77 | 81 | 85 | 89 | 93 | 97 | 101 | 105 | 109 |
| **Pcs** | **0** | **833** | **18** | **0** | **34** | **1026** | **852** | **297** | **719** | **282** | **477** | **279** | **295** | **353** | **399** | **927** | **261** | **247** | **263** | **235** | **210** | **198** | **214** | **196** | **186** | **287** | **191** | **853** |
| Tier 3 | 3 | 6 | 10 | 14 | 18 | 22 | 26 | 30 | 34 | 38 | 42 | 46 | 50 | 54 | 58 | 62 | 66 | 70 | 74 | 78 | 82 | 86 | 90 | 94 | 98 | 102 | 106 | 110 |
| **Pcs** | **0** | **5** | **12** | **428** | **118** | **547** | **0** | **262** | **180** | **181** | **201** | **191** | **239** | **164** | **164** | **154** | **110** | **229** | **178** | **207** | **98** | **109** | **134** | **154** | **146** | **117** | **139** | **86** |
| Tier 4 | p | 7 | 11 | 15 | 19 | 23 | 27 | 31 | 35 | 39 | 43 | 47 | 51 | 55 | 59 | 63 | 67 | 71 | 75 | 79 | 83 | 87 | 91 | 95 | 99 | 103 | 107 | 111 |
| **Pcs** | **p** | **3** | **2** | **0** | **4** | **432** | **244** | **200** | **116** | **124** | **155** | **144** | **106** | **128** | **140** | **101** | **115** | **98** | **113** | **97** | **88** | **142** | **98** | **116** | **135** | **86** | **106** | **39** |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Tier 1 | 112 | 115 | 119 | 123 | 127 | 131 | 135 | 139 | 143 | 147 | 151 | 155 | 159 | 163 | 167 | 171 | 175 | 179 | 183 | 187 | 191 | 195 | 199 | 203 | 207 | 211 | 215 | 219 |
| **Pcs** | **50** | **25** | **35** | **34** | **45** | **32** | **27** | **42** | **26** | **38** | **32** | **19** | **26** | **26** | **58** | **27** | **34** | **12** | **10** | **7** | **10** | **4** | **20** | **0** | **0** | **0** | **0** | **0** |
| Tier 2 | 113 | 116 | 120 | 124 | 128 | 132 | 136 | 140 | 144 | 148 | 152 | 156 | 160 | 164 | 168 | 172 | 176 | 180 | 184 | 188 | 192 | 196 | 200 | 204 | 208 | 212 | 216 | 220 |
| **Pcs** | **289** | **142** | **156** | **132** | **137** | **817** | **138** | **152** | **157** | **133** | **111** | **86** | **91** | **137** | **89** | **88** | **31** | **86** | **116** | **55** | **108** | **87** | **190** | **0** | **0** | **0** | **0** | **0** |
| Tier 3 | 114 | 117 | 121 | 125 | 129 | 133 | 137 | 141 | 145 | 149 | 153 | 157 | 161 | 165 | 169 | 173 | 177 | 181 | 185 | 189 | 193 | 197 | 201 | 205 | 209 | 213 | 217 | 221 |
| **Pcs** | **80** | **94** | **80** | **81** | **66** | **74** | **73** | **73** | **66** | **81** | **77** | **62** | **60** | **54** | **63** | **55** | **43** | **96** | **66** | **65** | **69** | **59** | **0** | **0** | **0** | **0** | **0** | **0** |
| Tier 4 | p | 118 | 122 | 126 | 130 | 134 | 138 | 142 | 146 | 150 | 154 | 158 | 162 | 166 | 170 | 174 | 178 | 182 | 186 | 190 | 194 | 198 | 202 | 206 | 210 | 214 | 218 | 222 |
| **Pcs** | **p** | **43** | **61** | **40** | **52** | **43** | **56** | **48** | **49** | **63** | **65** | **56** | **43** | **61** | **62** | **58** | **63** | **44** | **38** | **51** | **43** | **44** | **0** | **0** | **0** | **0** | **0** | **45** |

| Tier 1 | 223 | 227 | 231 | 235 | 239 | 243 | 247 | 251 | 255 | 259 | 263 | 267 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pcs** | **45** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| Tier 2 | 224 | 228 | 232 | 236 | 240 | 244 | 248 | 252 | 256 | 260 | 264 | 268 |
| **Pcs** | **45** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| Tier 3 | 225 | 229 | 233 | 237 | 241 | 245 | 249 | 253 | 257 | 261 | 265 | 269 |
| **Pcs** | **45** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |
| Tier 4 | 226 | 230 | 234 | 238 | 242 | 246 | 250 | 254 | 258 | 262 | 266 | 270 |
| **Pcs** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **0** |

| | **Total Pcs** | **%** | |
|---|---|---|---|
| **Tier 1** | 2760 | 10.3% | |
| **Tier 2** | 13705 | 51.0% | **73.9%** |
| **Tier 3** | 6135 | 22.8% | |
| **Tier 4** | 4260 | 15.9% | |

# Appendix 2B

### Calculation of the Targeted Optimal Percentage (TOP) for DBCS middle tiers 2 and 3

Full-time regular DBCS clerks typically work 8.5-hour days with a 0.5-hour break for lunch and two 15-minute breaks during the day leaving approximately 7.5 hours for productive work. The Ergonomics Task Analysis form developed by the USPS contract ergonomists, the WISHA Checklist, the NIOSH Revised Lifting Guide, and other generally accepted ergonomic assessment tools place low exposure to reaching and lifting tasks at less than 2 hours. Therefore, an ergonomically “optimal” sort program would require at least 5.5 of the 7.5 hours, or 73.3%, sweeping from tiers 2 and 3 (between shoulder and standing knuckle height) of the DBCS machine. If a 0.5-hour tolerance is set for productive time then the TOP range should from 5/7 to 6/8 or 71.4 to 75.0%.

# Appendix 2C

## Comparative Rates of Pieces of Mail Handled (Tour 1 vs. Tour 3)

| Test Site | Tour 1 | | | Tour 3 | | |
|---|---|---|---|---|---|---|
| | Date | Pcs Handled | Run Time (hrs.) | Date | Pcs Handled | Run Time (hrs.) |
| Denver P&DC* | Sun. 7/31/11 | 7,670,495 | 208.29 | Mon. 8/1/11 | 2,852,208 | 94.31 |
| Colorado Springs P&DC* | Sun. 8/28/11 | 2,693,465 | 72.84 | Mon. 8/29/11 | 2,491,412 | 79.24 |
| Columbus P&DC* | Sun. 10/2/11 | 5,128,767 | 143.54 | Mon. 10/3/11 | 2,867,761 | 89.90 |
| *WebEOR Custom Reports: Denver and Colorado Springs, *Automation Summary by Machine by Tour.* Columbus, *Tour Throughput* | Totals: | 15,492,727 | 424.67 | Totals: | 8,211,381 | 263.45 |
| | Tour 1 Rate | 36,482 pcs per hr. | | Tour 3 Rate | 31,169 pcs per hr. | |
| | 36,482/31,169 = 1.170 | | | | | |
| | Tour 1 Rate was approximately 17% greater than Tour 3 | | | | | |

Table indicates a 17% higher rate of pieces of mail handled on tour 1 compared to tour 3 at the Denver, Colorado Springs and Columbus test sites. A higher rate is likely to result in larger quantities of mail handled with each sweep.

# Appendix 2D
## DBCS/DIOSS
## EOR (End of Run) and Bin Density Reports Guide

**SPO/FUIS Operation Numbers**

271000* (DBCS-OSS/Output System) = Local (Overnight) and Outgoing (2&3 day) OSS
481000 (DIOSS) = 891000 (DBCS) = Outgoing Primary
482000 (DIOSS) = 892000 (DBCS) = Outgoing Secondary

**Operation Numbers that might be locally modified**

893000 = MMP/Managed Mail Processing

**DPS Operation Numbers (Sequential/Non-modifiable)**

918000 (First Pass)
919000 (Second Pass)

* 000 is added to the operation numbers for input purposes only.

**Three (3) EOR (End of Run) Reports**

- **Automation Detail:** Show all Operation Numbers, Sort programs, Machine #s, Machine Outputs, and Run Times for a selected MODS date (day of the week).

- **Machine Chart – Run:** A 24-hour timeline color coded by Machine Sort Program showing Number of Pieces run, Operation Number, run time in hours, & pieces per hour on a selected day for a specific type of machine, e.g., DBCS, DIOSS, etc.

- **EOR Viewer:** Shows actual bin counts and bin descriptions (at the bottom of the reports) for a specific Machine Sort Program & Operation Number on a specific Machine Type, e.g., DBCS, DIOSS, and Machine no. on a particular MODS (Machine Operations Data) Date. It also shows Run Start & End Times, Run Time, Idle Time etc.

The **DPS Sequence Bin Tool** shows how the bins are numbered and distributed across the four levels (tiers) of the DBCS/CIOSS/DIOSS machines. (Notice that the bins below #3 and below #114 are label printer locations.) The DPS sequence numbers printed in blue font can be ignored.

- **Bin Density Report:** Shows actual bin counts (density) & totals (& percentages) per each level (tier) for selected sort programs that were run on a particular MODS date. Unfortunately, these bin counts cannot be reported by machine number. This report probably gives the best overall example of the resulting bin densities of the various sort programs.

# APPENDIX 3
# Evaluation of the Impact of Task Rotation

# Appendix 3A

## Participants

| | Tours 1 & 3 | | Tour 1 | | Tour 3 | |
|---|---|---|---|---|---|---|
| **Site** | **Participants** | **DBCS Yrs. Ave (Range)** | **Participants** | **DBCS Yrs. Ave (Range)** | **Participants** | **DBCS Yrs. Ave (Range)** |
| CO Springs | 7 | 10.6 (1.5 – 18) | 3 | 13.8 (8.5 -17) | 4 | 8 3 (1.5 – 18) |
| Columbus | 8 | 10.4 (2 – 16) | 4 | 8.8 (2 – 15) | 4 | 12.1 (5.5 – 16) |
| Denver | 8 | 14.5 (8 – 18) | 4 | 15.0 (11 – 18) | 4 | 14.0 (8 – 16) |
| LA+ | 8 | 6.2 (1 – 9) | 4 | 4.3 (1 – 9) | 4 | 6.8 (6 – 9) |
| Nashville | 8 | 9.8 (1 – 16) | 4 | 7.5 (6 – 9) | 4 | 12.0 (1 – 16) |
| Norfolk | 8 | 7.8 (1 – 22) | 2 | 13.0 (12 – 14) | 6 | 6.0 (1 – 22) |
| Palatine | 8 | 9.9 (1 – 22) | 4 | 7.8 (1 – 18) | 4 | 12.0 (3 – 22) |
| Providence | 7 | 10.1 (1 – 20) | 3 | 15.7 (10 – 20) | 4 | 6.0 (1 – 16) |
| Tulsa | 8 | 9.4 (1 – 19) | 4 | 10.3 (3.5 – 19) | 4 | 8.5 (1.5 – 15) |
| **Total** | **70** | **9.9 (1 – 22)** | **32** | **10.7 (1 – 20)** | **38** | **9.3 (1 – 22)** |

+ All introductory (i.e., baseline) rotation data not obtained from one participant

# Appendix 3B

## Baseline Rotation

### Baseline Rotation: Practice

| | Tours 1 & 3 | | | Tour 1 | | | Tour 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Site** | Yes | Some-times | No | Yes | Some-times | No | Yes | Some-times | No |
| CO Springs | 6 | 1 | 0 | 2 | 1 | 0 | 4 | 0 | 0 |
| Columbus | 2 | 0 | 6 | 2 | 0 | 2 | 0 | 0 | 4 |
| Denver | 8 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 0 |
| LA | 8 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 0 |
| Nashville | 8 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 0 |
| Norfolk | 6 | 2 | 0 | 2 | 0 | 0 | 4 | 2 | 0 |
| Palatine | 8 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 0 |
| Providence | 6 | 1 | 0 | 3 | 0 | 0 | 3 | 1 | 0 |
| Tulsa | 8 | 0 | 0 | 4 | 0 | 0 | 4 | 0 | 0 |
| **Total (Percent)** | **60 (86%)** | **4 (6%)** | **6 (8%)** | **29 (91%)** | **1 (3%)** | **2 (6%)** | **31 (82%)** | **3 (8%)** | **4 (10%)** |

### Baseline Rotation: Frequency (Length of Time)

| | Tour 1 | | Tour 3 | |
|---|---|---|---|---|
| **Baseline Rotation** | **Participants (%)** | **Description** | **Participants (%)** | **Description** |
| < 1-Hr | 1 (3%) | Every other GPMC or about 40 minutes | 4 (11%) | Pcs fed = 10,000 or about every 30 minutes<br>Every GPMC or about 30 minutes |
| 1-Hr | | | 10 (28%) | Hourly (alternate days start feeding)<br>Every GPMC or about 1-Hr |
| 2-Hrs | 12 (36%) | Every 2-Hrs (alternate days start feeding)<br>Not to exceed 2-Hrs (alternate days start feeding)<br>Between passes or breaks<br>Every 2-Hrs or between breaks (2-Hrs to 2.5 Hrs.) | 16 (44%) | Every 2-Hrs (doesn't matter who starts feeding first)<br>Between breaks<br>Every 2-Hrs or every 2 GPMCs<br>Every 2-Hrs or between breaks (2-Hrs to 2.5 Hrs.) |
| 3-Hrs | 16 (48%) | Between 1st & 2nd pass<br>Between 1st & 2nd pass (alternate days running 1st pass) | | |
| 4-Hrs | | | 4 (11%) | Switch after lunch |
| 8-Hrs | 4 (12%) | Do not rotate | 2 (6%) | Do not rotate |
| **Total (Percent)** | **33 (100%)** | | **36 (100%)** | |

## Baseline Rotation: Frequency to Other DBCS Machines and Operations Participants (%)

| | Tours 1 & 3 | | Tour 1 | | Tour 3 | |
|---|---|---|---|---|---|---|
| | To Other DBCSs | To Other Operations | To Other DBCSs | To Other Operations | To Other DBCSs | To Other Operations |
| **Never** | 18 (26%) | 41 (59%) | 13 | 23 | 5 | 18 |
| **Daily** | 9 (13%) | 1 (2%) | 4 | 0 | 5 | 1 |
| **Weekly** | 26 (38%) | 2 (3%) | 4 | 0 | 22 | 2 |
| **Monthly** | 7 (10%) | 3 (4%) | 6 | 1 | 1 | 2 |
| **Quarterly** | 0 (0%) | 1 (2%) | 0 | 1 | 0 | 0 |
| **Other** | 9 (13%) | 21 (30%) | 4 | 6 | 5 | 15 |
| **Total (Percent)** | **69 (100%)** | | **31 (100%)** | | **38 (100%)** | |

## Baseline Rotation: Level of Physical Demand Between Tasks Participants (%)

| | Tours 1 & 3 | Tour 1 | Tour 3 |
|---|---|---|---|
| **No** | 21 (30%) | 11 (35%) | 10 (26%) |
| **Slightly More Physical** | 10 (14%) | 6 (19%) | 4 (11%) |
| **Moderately More Physical** | 21 (30%) | 7 (23%) | 14 (37%) |
| **Highly More Physical** | 14 (20%) | 5 (16%) | 9 (24%) |
| **Extremely More Physical** | 3 (4%) | 2 (6%) | 1 (3%) |
| **Total (Percent)** | **69 (100%)** | **31 (100%)** | **38 (100%)** |

## Baseline Rotation: Level of Rest and Recovery Provided by Rotation (Tours 1 & 3) Participants (%)

| | Bodily^ | Back | Shoulders | Hands/Wrists |
|---|---|---|---|---|
| **None** | 54 (26%) | 15 (22%) | 16 (24%) | 23 (34%) |
| **Minor** | 44 (22%) | 15 (22%) | 16 (24%) | 13 (19%) |
| **Moderate** | 60 (29%) | 23 (33%) | 21 (31%) | 16 (24%) |
| **Major** | 32 (16%) | 12 (12%) | 10 (15%) | 10 (15%) |
| **Complete** | 14 (7%) | 4 (6%) | 4 (6%) | 6 (9%) |
| **Total (Percent)** | **204 (100%)** | **69 (100%)** | **67 (100%)** | **68 (100%)** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Baseline Rotation: Importance of Rotation Participants (%)

| | Tours 1 & 3 | Tour 1 | Tour 3 |
|---|---|---|---|
| **Not at All** | 14 (20%) | 6 (19%) | 8 (21%) |
| **Slightly Important** | 5 (7%) | 4 (13%) | 1 (3%) |
| **Neutral** | 2 (3%) | 1 (3%) | 1 (3%) |
| **Moderately Important** | 19 (28%) | 8 (26%) | 11 (29%) |
| **Very Important** | 29 (42%) | 12 (39%) | 17 (45%) |
| **Total (Percent)** | **69 (100%)** | **31 (100%)** | **38 (100%)** |

## Baseline Rotation: Frequency of Active Managerial Support of Rotation Participants (%)

| | Tours 1 & 3 | Tour 1 | Tour 3 |
|---|---|---|---|
| **Never** | 36 (52%) | 16 (52%) | 20 (53%) |
| **Rarely** | 5 (7%) | 3 (10%) | 2 (5%) |
| **Occasionally** | 12 (17%) | 5 (16%) | 7 (18%) |
| **Frequently** | 7 (10%) | 5 (16%) | 2 (5%) |
| **Constantly** | 9 (13%) | 2 (6%) | 7 (18%) |
| **Total (Percent)** | **69 (100%)** | **31 (100%)** | **38 (100%)** |

# Appendix 3C

## Perceived Rest and Recovery

### Rest and Recovery: Total Average Ratings by Tour

| | | Bodily^ | | Back | | Shoulders | | Hands / Wrists | |
|---|---|---|---|---|---|---|---|---|---|
| **Tour** | **Participants (Samples)** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| **1 & 3** | **41 (334)** | 7.5 | 6.8 | 7.4 | 6.7 | 7.4 | 7.0 | 7.6 | 6.8 |
| **1** | **16 (126)** | 7.8 | 7.0 | 7.5 | 7.0 | 7.9 | 7.2 | 7.9 | 6.9 |
| **3** | **25 (208)** | 7.3 | 6.7 | 7.4 | 6.6 | 7.1 | 6.8 | 7.4 | 6.7 |

^ Bodily = Back + Shoulders + Hands/Wrists

### Rest and Recovery: Site Average Ratings for Tours 1 and 3

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 9.2 | 8.5 | 7.6 | 8.4 | 8.9 | 7.9 | 8.6 | 8.2 |
| Columbus | 7.6 | 6.9 | 9.0 | 8.7 | 8.4 | 7.1 | 8.3 | 7.6 |
| Denver | 8.2 | 8.9 | 8.3 | 8.7 | 8.5 | 8.5 | 8.4 | 8.7 |
| LA | 6.4 | 5.0 | 6.1 | 4.8 | 6.9 | 5.6 | 6.5 | 5.1 |
| Nashville | 4.0 | 4.0 | 2.0 | 3.0 | 2.0 | 3.0 | 2.7 | 3.3 |
| Palatine | 6.8 | 6.8 | 6.9 | 6.9 | 6.5 | 6.8 | 6.8 | 6.8 |
| Providence | 5.4 | 3.9 | 6.6 | 4.8 | 6.7 | 5.5 | 6.2 | 4.8 |
| Tulsa | 8.8 | 5.8 | 8.8 | 5.8 | 8.8 | 5.8 | 8.8 | 5.8 |
| **Total** | **7.4** | **6.7** | **7.4** | **7.0** | **7.6** | **6.8** | **7.5** | **6.8** |

^ Bodily = Back + Shoulders + Hands/Wrists

### Rest and Recovery: Site Average Ratings for Tour 1

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| Columbus | 8.9 | 8.4 | 8.9 | 8.1 | 9.3 | 7.2 | 9.0 | 7.9 |
| Denver | 8.0 | 7.9 | 8.3 | 7.9 | 7.7 | 7.3 | 8.0 | 7.7 |
| LA | 5.9 | 4.4 | 7.1 | 5.4 | 7.6 | 5.2 | 6.9 | 5.0 |
| Palatine | 6.4 | 6.5 | 6.5 | 6.9 | 6.5 | 6.9 | 6.5 | 6.8 |
| **Total** | **7.5** | **7.0** | **7.9** | **7.2** | **7.9** | **6.9** | **7.8** | **7.0** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Site Average Ratings for Tour 3

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| Colorado Springs | 9.0 | 8.1 | 7.1 | 8.0 | 8.6 | 7.3 | 8.3 | 7.8 |
| Columbus | 6.0 | 5.3 | 9.1 | 9.3 | 7.3 | 7.0 | 7.5 | 7.2 |
| Denver P&DC | 8.5 | 9.9 | 8.4 | 9.7 | 9.5 | 9.8 | 8.8 | 9.8 |
| LA | 6.8 | 5.5 | 5.4 | 4.4 | 6.3 | 5.8 | 6.2 | 5.2 |
| Nashville | 4.0 | 4.0 | 2.0 | 3.0 | 2.0 | 3.0 | 2.7 | 3.3 |
| Palatine | 7.1 | 7.0 | 7.1 | 7.0 | 6.5 | 6.7 | 6.9 | 6.9 |
| Providence | 5.4 | 3.9 | 6.6 | 4.8 | 6.7 | 5.5 | 6.2 | 4.8 |
| Tulsa | 8.8 | 5.8 | 8.8 | 5.8 | 8.8 | 5.8 | 8.8 | 5.8 |
| **Total** | **7.4** | **6.6** | **7.1** | **6.8** | **7.4** | **6.7** | **7.3** | **6.7** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Total Average Ratings by Pcs Fed Group (Tours 1 and 3)

| | | Bodily^ | | Back | | Shoulders | | Hands/ Wrists | |
|---|---|---|---|---|---|---|---|---|---|
| **Pcs Fed+** | **Participants (Samples)** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| **< 90,000** | **26 (62)** | 6.9 | 6.1 | 6.8 | 6.5 | 6.6 | 6.1 | 7.2 | 5.8 |
| **90,000 – 150,000** | **21 (229)** | 7.8 | 7.0 | 7.7 | 6.8 | 7.8 | 7.3 | 7.8 | 7.0 |
| **> 150,000** | **42 (43)** | 7.1 | 6.6 | 6.8 | 6.8 | 7.1 | 6.4 | 7.3 | 6.6 |

^ Bodily = Back + Shoulders + Hands/Wrists
+ Average pcs fed = 117,000 (14,000 – 196,000)

## Rest and Recovery: Site Average Ratings for < 90,000 Pcs Fed (Tours 1 and 3)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 10.0 | 8.5 | 8.3 | 8.3 | 10.0 | 6.6 | 9.4 | 7.8 |
| Columbus | 5.7 | 5.0 | 9.3 | 10.0 | 7.0 | 6.0 | 7.3 | 7.0 |
| Denver | 8.2 | 9.3 | 7.8 | 8.8 | 9.2 | 8.3 | 8.4 | 8.8 |
| LA | 6.6 | 4.5 | 4.9 | 2.8 | 6.5 | 4.5 | 6.0 | 3.9 |
| Nashville | 4.0 | | 2.0 | | 2.0 | | 2.7 | |
| Palatine | 5.8 | 4.0 | 5.3 | 4.3 | 5.3 | 2.7 | 5.4 | 3.7 |
| Providence | 5.4 | 4.0 | 6.6 | 4.5 | 6.7 | 5.0 | 6.2 | 4.5 |
| Tulsa | 8.5 | 7.5 | 8.5 | 7.5 | 8.5 | 7.5 | 8.5 | 7.5 |
| **Total** | **6.8** | **6.5** | **6.6** | **6.1** | **7.2** | **5.8** | **6.9** | **6.1** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Site Average Ratings for 90,000-150,000 Pcs Fed (Tours 1and 3)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 9.0 | 9.1 | 7.5 | 9.1 | 8.6 | 9.4 | 8.4 | 9.2 |
| Columbus | 7.7 | 7.0 | 8.9 | 8.6 | 8.4 | 7.2 | 8.3 | 7.6 |
| Denver | 8.4 | 8.8 | 8.6 | 8.8 | 8.5 | 8.5 | 8.5 | 8.7 |
| LA | 6.7 | 5.2 | 6.3 | 5.7 | 6.8 | 6.0 | 6.6 | 5.6 |
| Palatine | 6.5 | 6.7 | 6.8 | 6.9 | 6.1 | 6.8 | 6.5 | 6.8 |
| Providence | | 3.9 | | 5.0 | | 5.8 | | 4.9 |
| Tulsa | 8.8 | 5.6 | 8.8 | 5.6 | 8.8 | 5.6 | 8.8 | 5.6 |
| **Total** | **7.7** | **6.8** | **7.8** | **7.3** | **7.8** | **7.0** | **7.8** | **7.0** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Site Average Ratings for > 150,000 Pcs Fed (Tours 1 and 3)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | | 7.0 | | 7.3 | | 7.3 | | 7.2 |
| Columbus | 8.8 | | 9.0 | | 9.5 | | 9.1 | |
| Denver | 7.0 | 8.8 | 7.0 | 8.5 | 6.5 | 8.5 | 6.8 | 8.6 |
| LA | 5.0 | 4.5 | 7.3 | 3.0 | 7.7 | 4.5 | 6.7 | 4.0 |
| Nashville | 4.0 | 4.0 | 2.0 | 3.0 | 2.0 | 3.0 | 2.7 | 3.3 |
| Palatine | 8.5 | 9.3 | 8.3 | 9.3 | 8.7 | 9.8 | 8.5 | 9.4 |
| Tulsa | 9.0 | | 9.0 | | 9.0 | | 9.0 | |
| **Total** | **6.8** | **6.8** | **7.1** | **6.4** | **7.3** | **6.6** | **7.1** | **6.6** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Total Average Ratings by Run Time Group (Tours 1 and 3)

| | | Bodily^ | | Back | | Shoulders | | Hands/ Wrists | |
|---|---|---|---|---|---|---|---|---|---|
| **Run Time+** | **(Samples)** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| **≤ 2-Hrs** | **(31)** | 6.8 | 5.3 | 6.9 | 5.7 | 6.4 | 5.2 | 7.1 | 5.1 |
| **> 2-4 Hrs.** | **(255)** | 7.8 | 7.1 | 7.7 | 6.9 | 7.7 | 7.3 | 7.8 | 7.0 |
| **> 4-Hrs** | **(48)** | 6.6 | 6.3 | 6.5 | 6.5 | 6.6 | 6.2 | 6.8 | 6.1 |

^ Bodily = Back + Shoulders + Hands/Wrists
+ Average run time = 3.3 Hrs. (0.4 – 6.4 Hrs.)

## Rest and Recovery: Site Average Ratings for ≤ 2-Hrs Run Time (Tours 1 and 3)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | | 10.0 | | 9.5 | | 6.5 | | 8.7 |
| Columbus | 6.5 | 5.0 | 9.0 | 10.0 | 8.0 | 6.0 | 7.8 | 7.0 |
| Denver | 8.3 | | 8.7 | | 10.0 | | 9.0 | |
| LA | 6.6 | 4.3 | 4.9 | 2.8 | 6.5 | 4.3 | 6.0 | 3.8 |
| Palatine | 4.0 | 4.0 | 4.0 | 3.5 | 2.0 | 3.0 | 3.3 | 3.5 |
| Providence | 7.5 | | 8.0 | | 8.0 | | 7.8 | |
| Tulsa | 8.5 | 7.5 | 8.5 | 7.5 | 8.5 | 7.5 | 8.5 | 7.5 |
| **Total** | **6.9** | **5.7** | **6.4** | **5.2** | **7.1** | **5.1** | **6.8** | **5.3** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Site Average Ratings for > 2-4 Hrs. Run Time (Tours 1 and 3)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 9.5 | 8.6 | 8.1 | 8.6 | 9.3 | 8.2 | 8.9 | 8.5 |
| Columbus | 7.6 | 6.8 | 8.9 | 8.7 | 8.3 | 7.1 | 8.3 | 7.5 |
| Denver | 8.3 | 8.7 | 8.4 | 8.7 | 8.5 | 8.3 | 8.4 | 8.6 |
| LA | 6.7 | 5.2 | 6.3 | 5.3 | 6.8 | 6.0 | 6.6 | 5.5 |
| Palatine | 6.9 | 7.0 | 7.0 | 7.2 | 6.7 | 7.1 | 6.8 | 7.1 |
| Providence | 5.0 | 3.9 | 6.3 | 4.8 | 6.5 | 5.5 | 5.9 | 4.8 |
| Tulsa | 8.8 | 5.5 | 8.8 | 5.5 | 8.8 | 5.5 | 8.8 | 5.5 |
| **Total** | **7.7** | **6.9** | **7.7** | **7.3** | **7.8** | **7.0** | **7.8** | **7.1** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Site Average Ratings for > 4 Hrs. Run Time (Tours 1 and 3)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 7.0 | 7.0 | 4.5 | 7.3 | 6.0 | 7.3 | 5.8 | 7.2 |
| Columbus | 8.0 | 8.3 | 9.2 | 8.3 | 9.0 | 7.5 | 8.7 | 8.0 |
| Denver | 7.0 | 10.0 | 7.0 | 9.3 | 6.5 | 10.0 | 6.8 | 9.8 |
| LA | 5.0 | 4.9 | 7.3 | 4.9 | 7.7 | 4.5 | 6.7 | 4.8 |
| Nashville | 4.0 | 4.0 | 2.0 | 3.0 | 2.0 | 3.0 | 2.7 | 3.3 |
| Palatine | 8.0 | | 7.8 | | 8.0 | | 7.9 | |
| Tulsa | 9.0 | 6.0 | 9.0 | 6.0 | 9.0 | 6.0 | 9.0 | 6.0 |
| **Total** | **6.5** | **6.5** | **6.6** | **6.2** | **6.8** | **6.1** | **6.6** | **6.3** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Total Average Ratings by Operation Time Group (Tours 1 and 3)

| | | Bodily^ | | Back | | Shoulders | | Hands/ Wrists | |
|---|---|---|---|---|---|---|---|---|---|
| **Operation Time+** | **Participants (Samples)** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| **≤ 2-Hrs** | **2 (4)** | 5.4 | | 6.3 | | 3.8 | | 6.3 | |
| **> 2-4 Hrs.** | **26 (63)** | 6.9 | 5.8 | 6.9 | 5.9 | 7.0 | 5.7 | 6.9 | 5.7 |
| **> 4-Hrs** | **42 (267)** | 7.7 | 7.0 | 7.6 | 6.9 | 7.6 | 7.2 | 7.8 | 7.0 |

^ Bodily = Back + Shoulders + Hands/Wrists
+ Average operation time = 5.3 Hrs. (1.2 – 10.2 Hrs.)

## Rest and Recovery: Site Average Ratings for ≤ 2 Hrs. Operation Time (Tours 1 and 3)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| LA | 6.3 | | 3.8 | | 6.3 | | 5.4 | |
| **Total** | **6.3** | | **3.8** | | **6.3** | | **5.4** | |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Site Average Ratings for > 2-4 Hrs. Operation Time (Tours 1 and 3)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 10.0 | 10.0 | 10.0 | 9.5 | 10.0 | 6.5 | 10.0 | 8.7 |
| Columbus | 7.0 | 5.0 | 9.2 | 10.0 | 7.8 | 6.0 | 8.0 | 7.0 |
| LA | 7.0 | 5.0 | 5.5 | 3.8 | 6.9 | 5.2 | 6.5 | 4.7 |
| Palatine | 5.6 | 6.4 | 6.0 | 6.6 | 5.1 | 6.0 | 5.6 | 6.3 |
| Providence | 6.5 | | 7.0 | | 7.0 | | 6.8 | |
| Tulsa | 8.5 | 5.6 | 8.5 | 5.6 | 8.5 | 5.6 | 8.5 | 5.6 |
| **Total** | **6.9** | **5.9** | **7.0** | **5.7** | **6.9** | **5.7** | **6.9** | **5.8** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: Site Average Ratings for > 4 Hrs. Operation Time (Tours 1 and 3)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 9.1 | 8.3 | 7.5 | 8.3 | 8.8 | 8.0 | 8.5 | 8.2 |
| Columbus | 7.8 | 7.0 | 9.0 | 8.6 | 8.6 | 7.2 | 8.4 | 7.6 |
| Denver | 8.2 | 8.9 | 8.3 | 8.7 | 8.5 | 8.5 | 8.4 | 8.7 |
| LA | 6.3 | 5.0 | 6.8 | 5.3 | 7.0 | 5.7 | 6.7 | 5.3 |
| Nashville | 4.0 | 4.0 | 2.0 | 3.0 | 2.0 | 3.0 | 2.7 | 3.3 |
| Palatine | 7.5 | 6.9 | 7.4 | 7.1 | 7.3 | 7.1 | 7.4 | 7.0 |
| Providence | 4.5 | 3.9 | 6.3 | 4.8 | 6.5 | 5.5 | 5.8 | 4.8 |
| Tulsa | 8.9 | 6.0 | 8.9 | 6.0 | 8.9 | 6.0 | 8.9 | 6.0 |
| Total | **7.6** | **6.9** | **7.6** | **7.2** | **7.8** | **7.0** | **7.7** | **7.0** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Total Average Ratings by Tour

| | | Bodily^ | | Back | | Shoulders | | Hands / Wrists | |
|---|---|---|---|---|---|---|---|---|---|
| **Tour** | **Participants (Samples)** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| **1 & 3** | **40 (76)** | 0.2 | -0.3 | 0.3 | -0.4 | 0.2 | -0.3 | 0.1 | -0.3 |
| **1** | **16 (29)** | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 | 0.3 | 0.4 | 0.5 |
| **3** | **24 (47)** | 0.2 | -0.7 | 0.3 | -0.8 | 0.2 | -0.6 | 0.0 | -0.7 |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Site Average Ratings for Tours 1 and 3

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | -0.4 | -0.4 | -0.4 | -0.6 | -0.4 | -1.2 | -0.4 | -0.7 |
| Columbus | -0.1 | -1.5 | -0.1 | -0.3 | 0.0 | -1.0 | -0.1 | -0.9 |
| Denver | 0.1 | 0.3 | -0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| LA | 1.1 | -0.5 | 1.3 | 0.1 | 0.6 | 0.4 | 1.0 | 0.0 |
| Nashville | 1.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.0 |
| Palatine | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Providence | 1.0 | -1.0 | 0.5 | -1.0 | 0.0 | 0.0 | 0.5 | -0.7 |
| Tulsa | 0.3 | -1.3 | 0.3 | -1.7 | 0.3 | -1.3 | 0.3 | -1.4 |
| **Total** | **0.3** | **-0.4** | **0.2** | **-0.3** | **0.1** | **-0.3** | **0.2** | **-0.3** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Site Average Ratings for Tour 1

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Columbus | 0.5 | -1.0 | 0.0 | -0.5 | 0.5 | -1.0 | 0.3 | -0.8 |
| Denver | 0.5 | 0.5 | 0.0 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| LA | 0.5 | 0.8 | 1.3 | 1.0 | 1.3 | 1.8 | 1.0 | 1.2 |
| Palatine | -0.7 | 0.0 | -0.7 | 0.0 | -0.7 | 0.0 | -0.7 | 0.0 |
| **Total** | **0.3** | **0.2** | **0.2** | **0.3** | **0.4** | **0.5** | **0.3** | **0.3** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Site Average Ratings for Tour 3

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | -0.5 | -0.5 | -0.5 | -0.8 | -0.5 | -1.5 | -0.5 | -0.9 |
| Columbus | -1.0 | -2.0 | -0.3 | 0.0 | -0.7 | -1.0 | -0.7 | -1.0 |
| Denver | -0.3 | 0.0 | -0.7 | -0.3 | -0.3 | -0.3 | -0.4 | -0.2 |
| LA | 1.8 | -1.8 | 1.3 | -0.8 | 0.0 | -1.0 | 1.0 | -1.2 |
| Nashville | 1.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.0 |
| Palatine | 0.5 | 0.0 | 0.5 | 0.0 | 0.5 | 0.0 | 0.5 | 0.0 |
| Providence | 1.0 | -1.0 | 0.5 | -1.0 | 0.0 | 0.0 | 0.5 | -0.7 |
| Tulsa | 0.3 | -1.3 | 0.3 | -1.7 | 0.3 | -1.3 | 0.3 | -1.4 |
| **Total** | **0.3** | **-0.8** | **0.2** | **-0.6** | **0.0** | **-0.7** | **0.2** | **-0.7** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Total Average Ratings by Baseline Rotation

| | | Bodily^ | | Back | | Shoulders | | Hands/ Wrists | |
|---|---|---|---|---|---|---|---|---|---|
| **Baseline Rotation** | **Participants (Samples)** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| **< 1-Hr** | **3 (6)** | -0.1 | -0.8 | 0.0 | 0.0 | -0.3 | -0.7 | 0.0 | -1.7 |
| **1-Hr** | **7 (14)** | 0.1 | -1.0 | 0.1 | -1.0 | 0.1 | -1.0 | 0.1 | -1.0 |
| **2-Hrs** | **11 (20)** | 0.1 | 0.0 | 0.3 | 0.0 | 0.0 | -0.2 | 0.0 | 0.1 |
| **3-Hrs** | **10 (19)** | 0.3 | 0.5 | 0.1 | 0.3 | 0.4 | 0.4 | 0.4 | 0.8 |
| **4-Hrs** | **4 (8)** | 1.0 | -1.2 | 1.8 | -1.8 | 1.3 | -0.8 | 0.0 | -1.0 |
| **8-Hrs** | **5 (9)** | -0.1 | -0.9 | -0.2 | -1.5 | -0.2 | -0.3 | 0.0 | -1.0 |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Site Average Ratings Baseline Rotation < 1-Hr (30 – 40 minutes)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | -1.0 | 0.0 | -1.0 | -0.5 | -1.0 | -2-Hrs | -1.0 | -0.8 |
| Denver | 2.0 | 0.0 | 1.0 | -1.0 | 2.0 | -1.0 | 1.7 | -0.7 |
| **Total** | **0.0** | **0.0** | **-0.3** | **-0.7** | **0.0** | **-1.7** | **-0.1** | **-0.8** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Site Average Ratings
## Baseline Rotation 1-Hr

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 0.0 | -1.0 | 0.0 | -1.0 | 0.0 | -1.0 | 0.0 | -1.0 |
| Palatine | 0.0 | -0.5 | 0.0 | -0.5 | 0.0 | -0.5 | 0.0 | -0.5 |
| Tulsa | 0.3 | -1.5 | 0.3 | -1.5 | 0.3 | -1.5 | 0.3 | -1.5 |
| **Total** | **0.1** | **-1.0** | **0.1** | **-1.0** | **0.1** | **-1.0** | **0.1** | **-1.0** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Site Average Ratings
## Baseline Rotation 2-Hrs

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| Columbus | 0.0 | | 0.0 | | 0.0 | | 0.0 | |
| Denver | -0.5 | 0.5 | -1.0 | 0.3 | -0.8 | 0.3 | -0.8 | 0.3 |
| Nashville | 1.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.0 |
| Palatine | 1.0 | 0.5 | 1.0 | 0.5 | 1.0 | 0.5 | 1.0 | 0.5 |
| Providence | 1.0 | -1.0 | 0.5 | -1.0 | 0.0 | 0.0 | 0.5 | -0.7 |
| Tulsa | | -1.0 | | -2.0 | | -1.0 | | -1.3 |
| **Total** | **0.3** | **0.0** | **0.0** | **-0.2** | **0.0** | **0.1** | **0.1** | **0.0** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Site Average Ratings
## Baseline Rotation 3-Hrs (Between passes on Tour 1)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| CO Springs | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Denver | 0.5 | 0.0 | 0.5 | 0.0 | 0.5 | 0.0 | 0.5 | 0.0 |
| LA | 0.5 | 0.8 | 1.3 | 1.0 | 1.3 | 1.8 | 1.0 | 1.2 |
| Palatine | -0.7 | 0.0 | -0.7 | 0.0 | -0.7 | 0.0 | -0.7 | 0.0 |
| **Total** | **0.1** | **0.3** | **0.4** | **0.4** | **0.4** | **0.8** | **0.3** | **0.5** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Site Average Ratings Baseline Rotation 4-Hrs (At Lunch)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| LA | 1.8 | -1.8 | 1.3 | -0.8 | 0.0 | -1.0 | 1.0 | -1.2 |
| **Total** | **1.8** | **-1.8** | **1.3** | **-0.8** | **0.0** | **-1.0** | **1.0** | **-1.2** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Site Average Ratings Baseline Rotation 8-Hrs (No Rotation)

| | Back | | Shoulders | | Hands/ Wrists | | Bodily^ | |
|---|---|---|---|---|---|---|---|---|
| **Site** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** | **1-Hr** | **2-Hrs** |
| Columbus | -0.2 | -1.5 | -0.2 | -0.3 | 0.0 | -1.0 | -0.1 | -0.9 |
| **Total** | **-0.2** | **-1.5** | **-0.2** | **-0.3** | **0.0** | **-1.0** | **-0.1** | **-0.9** |

^ Bodily = Back + Shoulders + Hands/Wrists

## Rest and Recovery: End of Test Period Level of Difficulty or Ease Experienced Performing 1-Hr Test Rotation

| Participants (%) | Tours 1 & 3 | Tour 1 | Tour 3 |
|---|---|---|---|
| **Very Difficult** | 2 (5%) | 1 | 1 |
| **Difficult** | 8 (20%) | 6 | 2 |
| **Undecided** | 1 (2%) | 1 | 0 |
| **Easy** | 15 (38%) | 6 | 9 |
| **Very Easy** | 14 (35%) | 2 | 12 |
| **Total (Percent)** | **40 (100%)** | **16 (100%)** | **24 (100%)** |

## Rest and Recovery: End of Test Period Level of Difficulty or Ease Experienced Performing 2-Hrs Test Rotation Participants (%)

| | Tours 1 & 3 | Tour 1 | Tour 3 |
|---|---|---|---|
| **Very Difficult** | 0 (0%) | 0 | 0 |
| **Difficult** | 9 (25%) | 2 | 7 |
| **Undecided** | 1 (3%) | 0 | 1 |
| **Easy** | 18 (50%) | 7 | 11 |
| **Very Easy** | 8 (22%) | 4 | 4 |
| **Total (Percent)** | **36 (100%)** | **13 (100%)** | **23 (100%)** |

**Rest and Recovery: End of Test Period**
**Likelihood of Complying with the 1-Hr Test Rotation**
**Participants (%)**

| | Tours 1 & 3 | Tour 1 | Tour 3 |
|---|---|---|---|
| **Extremely Unlikely** | 1 (3%) | 0 | 1 |
| **Unlikely** | 1 (3%) | 0 | 1 |
| **Not Sure** | 8 (20%) | 6 | 2 |
| **Likely** | 18 (46%) | 7 | 11 |
| **Extremely Likely** | 11 (28%) | 2 | 9 |
| **Total (Percent)** | **39 (100%)** | **15 (100%)** | **24 (100%)** |

**Rest and Recovery: End of Test Period**
**Likelihood of Complying with the 2-Hrs Test Rotation**
**Participants (%)**

| | Tours 1 & 3 | Tour 1 | Tour 3 |
|---|---|---|---|
| **Extremely Unlikely** | 3 (9%) | 0 | 3 |
| **Unlikely** | 7 (20%) | 0 | 7 |
| **Not Sure** | 4 (11%) | 1 | 3 |
| **Likely** | 15 (43%) | 8 | 7 |
| **Extremely Likely** | 6 (17%) | 4 | 2 |
| **Total (Percent)** | **35 (100%)** | **13 (100%)** | **22 (100%)** |

# APPENDIX 4
# Evaluation of Maintenance and Serviceability of 1226F Tray Cart

# Appendix 4A
# Nine Plants Summary of Rack Defects

| Location | Racks Inspected | Types of Defects Identified | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 Will Not Open | 2 Higher Force Required | 3 Missing Tray | 4 Loose Tray | 5 Cam follower Missing | 6 Spring Missing | 7 Cam follower Bent | 8 Screw Missing | 9 Cam Shaft Locked | 10 Other | Trays with Multiple Defects | Total Trays With Defects | Total Trays in Rack |
| Denver | 219 | 31 | 112 | 6 | 34 | 486 | 9 | 229 | 664 | 53 | 46 | 169 | 1410 | 4992 |
| % of Totals | 16.85% | 0.62% | 2.24% | 0.12% | 0.68% | 9.74% | 0.18% | 4.59% | 13.30% | 1.06% | 0.92% | 3.39% | 28.25% | |
| Providence | 204 | 8 | 110 | 0 | 10 | 2 | 8 | 8 | 178 | 64 | 3 | 34 | 372 | 4828 |
| % of Totals | 33.17% | 0.17% | 2.28% | 0.00% | 0.21% | 0.04% | 0.16% | 0.16% | 3.68% | 1.33% | 0.06% | 0.70% | 7.71% | |
| CO Springs | 175 | 5 | 114 | 0 | 0 | 85 | 19 | 86 | 533 | 0 | 28 | 40 | 830 | 4200 |
| % of Totals | 100% | 0.12% | 2.71% | 0.00% | 0.00% | 2.02% | 0.45% | 2.05% | 12.69% | 0.00% | 0.67% | 0.95% | 19.76% | |
| Palatine | 115 | 94 | 130 | 2 | 16 | 30 | 75 | 1 | 382 | 24 | 54 | 66 | 667 | 2760 |
| % of Totals | 19% | 3.41% | 4.71% | 0.07% | 0.58% | 1.09% | 2.72% | 0.04% | 13.84% | 0.87% | 1.96% | 2.39% | 24.17% | |
| L.A. | 175 | 58 | 221 | 8 | 73 | 33 | 42 | 212 | 22 | 35 | 33 | 81 | 614 | 4200 |
| % of Totals | 15% | 1.38% | 5.26% | 0.19% | 1.74% | 0.79% | 1.00% | 5.05% | 0.52% | 0.83% | 0.79% | 1.93% | 14.62% | |
| Tulsa | 34 | 31 | 4 | 0 | 2 | 53 | 16 | 378 | 68 | 0 | 12 | 73 | 491 | 816 |
| % of Totals | 16% | 3.80% | 0.49% | 0.00% | 0.25% | 6.50% | 1.96% | 46.32% | 8.33% | 0.00% | 1.47% | 8.95% | 60.17% | |
| Nashville | 58 | 5 | 44 | 0 | 17 | 20 | 4 | 26 | 282 | 16 | 15 | 40 | 437 | 1254 |
| % of Totals | 17% | 0.40% | 3.51% | 0.00% | 1.36% | 1.59% | 0.32% | 2.07% | 22.49% | 1.28% | 1.20% | 3.19% | 34.85% | |
| Columbus | 174 | 32 | 479 | 8 | 157 | 20 | 5 | 129 | 1254 | 330 | 6 | 404 | 1990 | 4116 |
| % of Totals | 29% | 0.78% | 11.64% | 0.19% | 3.81% | 0.49% | 0.12% | 3.13% | 30.47% | 8.02% | 0.15% | 9.82% | 48.35% | |
| Norfolk | 132 | 39 | 185 | 0 | 35 | 56 | 0 | 508 | 4 | 74 | 53 | 19 | 935 | 3192 |
| % of Totals | 29% | 1.22% | 5.80% | 0.00% | 1.10% | 1.75% | 0.00% | 15.91% | 0.13% | 2.32% | 1.66% | 0.60% | 29.29% | |
| Grand Totals | 1286 | 303 | 1399 | 24 | 344 | 785 | 1086* | 1577 | 3387 | 596 | 250 | 926 | 8654 | 30358 |
| Grand % | | 1.00% | 4.61% | 0.80% | 1.13% | 2.59% | 3.52% | 5.19% | 11.16% | 1.96% | 0.82% | 3.05% | 28.50% | 100% |

* Spring missing was seen 178 times and would affect all 6 trays in a row (1086 trays)

# APPENDIX 5
# Evaluation of Feeder Station TMT and Mail Induction

# Appendix 5A

# Transfer Mail Table

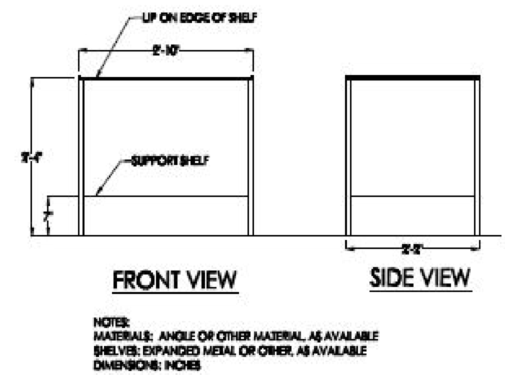
**1. Transfer Mail Table Requirements:**

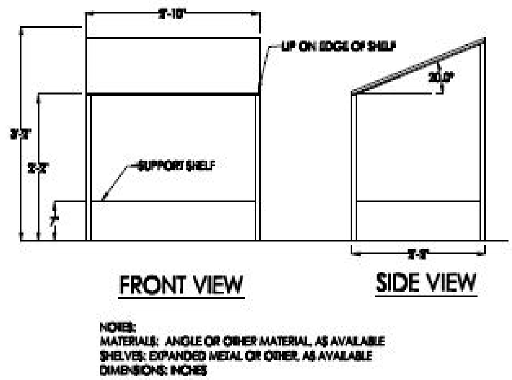
a. Height: all TMTs were set at a height of 33 inches from floor to leading edge of the table top. This was based on a previous recommended table height for DBCS feeding of 32 to 34 inches to provide to accommodate the shorter clerk's elbow height while maintaining none to minimal bending for taller clerks. The average height of the range was selected for the TMTs.

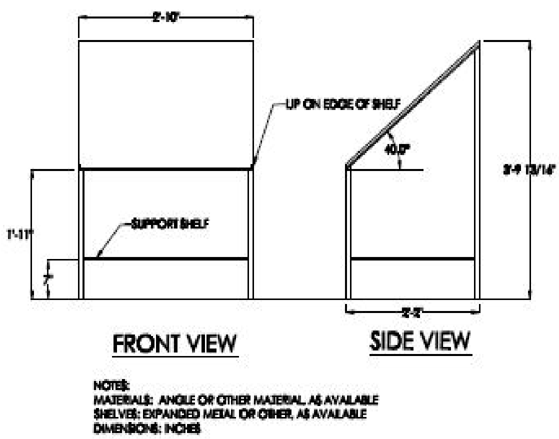
b. Length and Width: The dimension for top of the TMT was 24 X 24 inches. This was to accommodate the full length of a mail tray with room to place 2 trays side by side if necessary.

c. Tilt: three different tables top tilts were selected for the TMTs; 0, 20, and 40 degrees from horizontal tilted toward the operator.

d. Configuration: The TMTs were tested in two general configurations. One with the TMT placed straight inline to the jogger and the other turned toward the operator at 90 degree angle (perpendicular) or greater to the jogger.




**TMT Specifications**

## 2. TMT Configurations

There were 6 possible TMT configurations tested including:

a. flat top perpendicular or greater than 90 degrees to the jogger (0>90)
b. flat top in-line to the jogger (0i)
c. 20 degree tilt perpendicular or greater than 90 degrees to the jogger (20>90)
d. 20 degree tilt in-line to the jogger (20i)
e. 40 degree tilt perpendicular or greater to the jogger (40>90).
f. 40 degree tilt in-line to the jogger (40i).

**0 > 90**

**0i**

**20  > 90**

**20i**

**40 > 90**

**40i**

**TMT Test Configurations**

# Appendix 5B

# Test Participants

## 1. Number of Participants

Across the 9 test sites 41 operators participated from Tour 3 and 37 operators from Tour 1 for a total of 78 operators. The TMTs were tested in a total of 303 trails, approximately 4 trails per participant. Following summarizes participation per test site.

| Phase | Test Site | Tour 3 | Tour 1 | Total |
|---|---|---|---|---|
| 1 (pilot) | Denver P&DC | 5 | 5 | 10 |
| 2 | Providence P&DC | 6 | 4 | 10 |
| 2 | Colorado Springs P&DC | 4 | 4 | 8 |
| 3 | Columbus P&DC | 4 | 4 | 8 |
| 3 | Los Angeles P&DC | 4 | 4 | 8 |
| 3 | Nashville P&DC | 4 | 4 | 8 |
| 3 | Norfolk P&DC | 6 | 6 | 12 |
| 3 | Palatine P&DC | 4 | 4 | 8 |
| 3 | Tulsa P&DC | 4 | 2 | 6 |
| **All** | **Total** | **41** | **37** | **78** |

## 2. Anthropometric Measurements

For each participant height (stature), knuckle height, and elbow height was measured and recorded. These were determined to be the most relevant anthropometric dimensions to compare with table height and table top tilt. Following are the ranges of dimensions for the participants' anthropometric measurements:

- Stature: 58 to 77 inches
- Knuckle Height: 27 to 36.5 inches
- Elbow Height: 37 to 48.5 inches

The following 5 ranges of participant anthropometric data were established to compare to TMT configurations tested.

| (inches) | 5th Range | 25th Range | 50th Range | 75th Range | 95th Range |
|---|---|---|---|---|---|
| Stature | 0.00 - 63.25 | 63.26 – 65.75 | 65.76 - 68.50 | 68.51 – 71.50 | > 71.5 |
| Knuckle) | 0.00 - 27.75 | 27.76 – 29.25 | 29.26 – 30.50 | 30.51 – 32.00 | > 32 |
| Elbow | 0.00 - 40.00 | 40.01- 42.00 | 42.01 – 43.75 | 43.76 – 45.75 | > 45.75 |

For the final analysis it was determined that elbow height would be the most significant measure to assess anthropometric relationship of the operator compared to TMT.

# Appendix 5C
# MSD Risk Factors

## 1. Effects on MSD Risk Factors

To examine the potential effects of TMT height, tilt, and placement on MSD risk factors (i.e., ergonomic impact) two primary criteria was assessed; what the evaluators observed and what the participants noted. The posture severity scale shown in Figure 1 was used to collect feedback from the participant after each TMT trail.

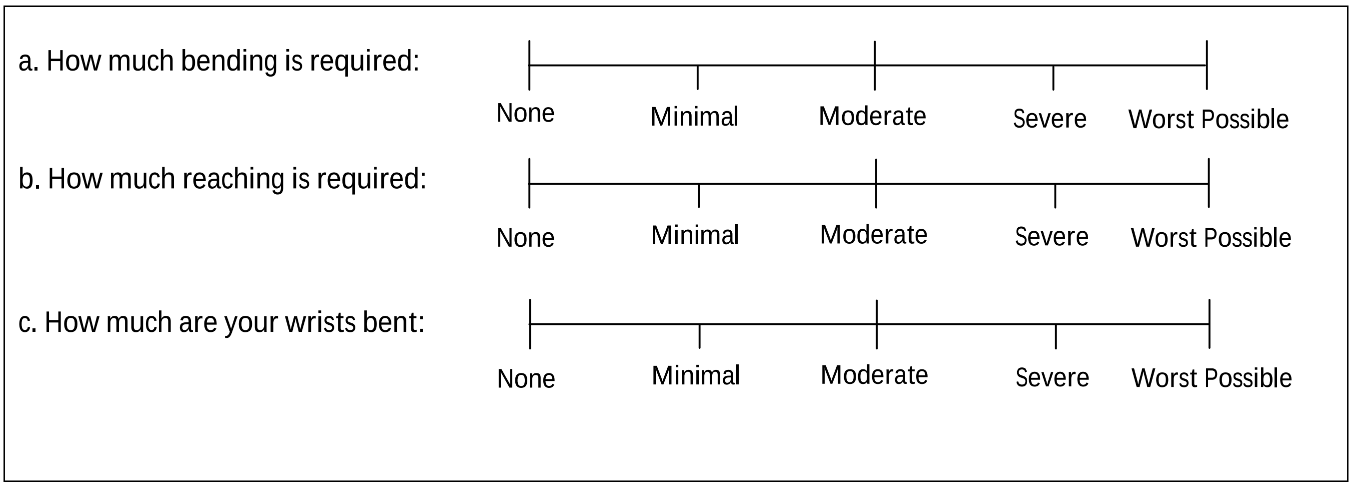



**Figure 1: Posture Severity Scale**

The posture severity scale was assigned numeric values: None = 4, Minimal =3, Moderate = 2, Severe = 1 and Worst Possible = 0, with the higher the score implying a decreasing level of risk. A score of 2.5 or greater would represent a minimal posture severity according to the scale. Posture severities rated moderate to worst possible or less than 2.5, may suggest at least a perceived increase in risks factors.

Tables 1 - 5 below summarize the average posture severity scores indicated by the operators. Table 1 includes the overall posture severity average scores. Tables 2 and 3 show the posture severity average scores by tour. Table 4 is posture severity average scores for elbow height of the operator. Table 4 shows posture severity average scores for placement of the TMT.

**Table 1: TMT Posture Severity Scores - Overall**

| TMT Configuration | 0 > 90 | 0i | 20 > 90 | 20i | 40 > 90 | 40i | Total |
|---|---|---|---|---|---|---|---|
| Average of Bending | 3.5 | 3.3 | 3.6 | 3.4 | 3.6 | 3.4 | 3.5 |
| Average of Reaching | 3.5 | 2.7 | 3.4 | 3.1 | 3.4 | 3.3 | 3.2 |
| Average of Bent Wrist | 3.1 | 2.9 | 3.3 | 3.2 | 3.4 | 3.1 | 3.2 |

**Table 2: TMT Posture Severity Scores - Tour 1**

| TMT Configuration | 0 > 90 | 0i | 20 > 90 | 20i | 40 > 90 | 40i | Total |
|---|---|---|---|---|---|---|---|
| Average of Bending | 3.4 | 3.3 | 3.6 | 3.6 | 3.6 | 3.5 | 3.5 |
| Average of Reaching | 3.4 | 2.7 | 3.3 | 3.3 | 3.4 | 3.5 | 3.2 |
| Average of Bent Wrist | 2.8 | 2.7 | 3.1 | 3.1 | 3.3 | 3.2 | 3.0 |

**Table 3: TMT Posture Severity Scores - Tour 3**

| TMT Configuration | 0 > 90 | 0i | 20 > 90 | 20i | 40 > 90 | 40i | Total |
|---|---|---|---|---|---|---|---|
| Average of Bending | 3.6 | 3.4 | 3.5 | 3.2 | 3.5 | 3.4 | 3.4 |
| Average of Reaching | 3.5 | 2.7 | 3.5 | 2.8 | 3.4 | 3.3 | 3.2 |
| Average of Bent Wrist | 3.4 | 3.2 | 3.5 | 3.2 | 3.4 | 3.1 | 3.3 |

**Table 4: TMT Posture Severity Scores - Elbow Height**

| **5th Range** | 0 > 90 | 0i | 20 > 90 | 20i | 40 > 90 | 40i | Total |
|---|---|---|---|---|---|---|---|
| Average of Bending | 3.6 | 3.4 | 3.8 | 3.4 | 3.7 | 3.5 | 3.6 |
| Average of Reaching | 3.5 | 3.2 | 3.4 | 3.4 | 3.4 | 3.8 | 3.4 |
| Average of Bent Wrist | 2.5 | 2.3 | 2.7 | 2.8 | 3.0 | 2.8 | 2.6 |
| **25th Range** | | | | | | | |
| Average of Bending | 3.6 | 3.5 | 3.6 | 3.6 | 3.7 | 3.6 | 3.6 |
| Average of Reaching | 3.8 | 2.8 | 3.6 | 3.1 | 3.5 | 3.3 | 3.3 |
| Average of Bent Wrist | 3.5 | 3.4 | 3.5 | 3.4 | 3.6 | 3.2 | 3.4 |
| **50th Range** | | | | | | | |
| Average of Bending | 3.6 | 3.7 | 3.6 | 4.0 | 3.4 | 3.5 | 3.6 |
| Average of Reaching | 3.5 | 2.3 | 3.4 | 4.0 | 3.3 | 3.5 | 3.2 |
| Average of Bent Wrist | 3.0 | 2.8 | 3.5 | 3.5 | 3.2 | 3.0 | 3.1 |
| **75th Range** | | | | | | | |
| Average of Bending | 3.4 | 2.9 | 3.5 | 2.4 | 3.4 | 3.0 | 3.2 |
| Average of Reaching | 3.2 | 2.6 | 3.3 | 2.6 | 3.4 | 3.3 | 3.1 |
| Average of Bent Wrist | 2.9 | 2.9 | 3.3 | 2.8 | 3.2 | 3.3 | 3.1 |
| **95th Range** | | | | | | | |
| Average of Bending | 3.2 | 3.2 | 3.2 | 3.2 | 3.5 | 3.0 | 3.2 |
| Average of Reaching | 3.3 | 2.6 | 3.3 | 2.6 | 3.4 | 3.0 | 3.1 |
| Average of Bent Wrist | 3.6 | 3.2 | 3.6 | 3.0 | 3.6 | 3.3 | 3.4 |

**Table 5: TMT Posture Severity Scores - Placement**

| > 90 | Total |
|---|---|
| Average of Bending | 3.4 |
| Average of Reaching | 2.9 |
| Average of Bent Wrist | 3.0 |
| In-line | |
| Average of Bending | 3.5 |
| Average of Reaching | 3.4 |
| Average of Bent Wrist | 3.3 |

Most of the severity rating averages were at or above 2.5. As indicated in Table 4, the 5$^{th}$ percentile group showed the highest severity for the posture of "Bent Wrist" for all the TMT configurations with one score at 2.3. This would seem to correlate with the group having the lower elbow height, which might tend toward a more deviated or bent posture of the wrist than other ranges at the current TMT height.

The comparison of posture severity scores by placement of the table as indicated in Chart 5 does not raise risk factor concerns for one or the other. However, the in-line indicates a slightly more positive score than the perpendicular / > 90 degrees.

# Appendix 5D

## Participant Overall TMT Ratings

Participant overall ratings of the TMTs are shown in Table 6. The overall ratings by the operator may be affected by reasons other than comfort or ergonomic impact, such as the operator's current method of feeding mail, what type of mail is being fed, and general like or dislike of the TMT.

**Table 6: TMT Overall Rating**

| | 0 > 90 | 0i | 20 > 90 | 20i | 40 > 90 | 40i | Total |
|---|---|---|---|---|---|---|---|
| Average Overall Rating | **6.2** | **4.5** | **6.2** | **5.2** | **4.9** | **4.2** | **5.3** |
| Tour 1 | 5.4 | 4.2 | 5.8 | 5.2 | 4.7 | 4.9 | 5.0 |
| Tour 3 | 6.8 | 4.8 | 6.4 | 5.2 | 5.1 | 3.7 | 5.5 |
| Elbow 5th Range | 5.7 | 5.0 | 6.0 | 3.4 | 5.9 | 4.0 | 5.3 |
| Elbow 25th Range | 6.7 | 4.3 | 5.8 | 5.2 | 4.6 | 4.5 | 5.2 |
| Elbow 50th Range | 6.0 | 4.8 | 6.7 | 8.0 | 4.3 | 4.5 | 5.6 |
| Elbow 75th Range | 6.4 | 5.1 | 6.7 | 6.2 | 5.7 | 3.7 | 5.9 |
| Elbow 95th Range | 5.3 | 3.3 | 5.6 | 4.8 | 3.5 | 3.8 | 4.4 |
| > 90 | | | | | | | **5.7** |
| In-line | | | | | | | **4.6** |

Two TMT configurations received an equal overall rating of 6.2. This included the in-line no tilt perpendicular / > 90 degrees and the 20 degrees tilt perpendicular / > 90 degrees. These two TMT configurations consistently scored highest in all categories, except for one, the participant elbow height range. To determine statistical significance of the different ratings a simple unpaired t-test was performed to compare the ratings.

The 20 degrees tilt in-line TMT was rated third overall at 5.2. The difference in rating for this table was not statistically significant from the top two highest rated TMT configurations.

All the other configurations; 40 degree in-line with a 4.2 rating, flat in-line with a 4.5 rating, and the 40 degree perpendicular / > 90 degrees at a 4.9 rating, the difference in overall rating was found to be statistically significant from the top two TMT overall ratings.

A general comparison of the two configurations of the in-line and the perpendicular / > 90 degrees, the latter had an overall higher rating at 5.7 compared to 4.6 of the other. An unpaired t-test of the data indicated the difference in the two ratings was statistically significant.