

## APPENDIX L – MANUAL MATERIAL HANDLING

### L1. “CUT AND CARRY” WORKER

Table L-1. “Cut and Carry” Worker Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 – 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 – 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					<b>3.0</b>

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion	< 10%	1	0.5
= $100 \times \frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$	10% - 29%	2	1.0
= $100 \times \frac{556 \text{ (sec)}}{1162 \text{ (sec)}}$	30% - 49%	3	1.5
= 48%	50% - 79%	4	2.0
	> or = 80%	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>1.5</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute	< 4	1	0.5
= $\frac{\text{number of exertions}}{\text{total observation time (min)}}$	4 – 8	2	1.0
= $\frac{69}{19.4} = 3.6$	9 – 14	3	1.5
	15 – 19	4	2.0
	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>0.5</b>

Table L-1. “Cut and Carry” Worker Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
<b>Rating Criterion</b>	<b>Wrist Extension</b>	<b>Wrist Flexion</b>	<b>Ulnar Deviation</b>	<b>Perceived Posture</b>	<b>Rating</b>	<b>Multiplier</b>
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral (*estimated, based on RULAs done)	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>1.5</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
<b>Rating Criterion</b>	<b>Observed Pace/MTM Predicted Pace x 100%</b>	<b>Perceived Speed</b>	<b>Rating</b>	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	1.0
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet:			
Duration of Task per Day (hrs)	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
= duration of task (hrs) +	< or = 1 hr	1	0.25
duration of task (hrs) + ...	1 – 2 hrs	2	0.50
	2 – 4 hrs	3	0.75
	4 – 8 hrs	4	1.00
= (estimate ~ 2- 4 hrs)	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			<b>0.75</b>

Table L-1. “Cut and Carry” Worker Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	=	<u>SI SCORE</u>
<b>3.0 X</b>	<b>1.5 X</b>	<b>0.5 X</b>	<b>1.5 X</b>	<b>1.0 X</b>	<b>0.75</b>		<u><b>2.5</b></u>

- SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:
- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
  - SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
  - SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
  - SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table L-2. “Cut and Carry” Worker UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
Lifshitz and Armstrong (1986)

\* “No” responses are indicative of conditions associated with the risk of CTD’s

Risk Factors	No	Yes
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker’s hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N/A	N/A
3.3 Can the job be done without deviating the wrist from side to side?		Y
3.4 Can the tool be used without deviating the wrist from side to side?		Y
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without “clothes wringing” motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N/A	N/A
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	N/A	N/A
6.2 Is the span of the tool’s handle between 5 and 7 cm (2-2 3/4 inches)?	N/A	N/A
6.3 Is the handle of the tool made from material other than metal?	N/A	N/A
6.4 Is the weight of the tool below 4 kg (9lbs)?	N/A	N/A
6.5 Is the tool suspended?	N/A	N/A
<b>TOTAL</b>	<b>9 (60%)</b>	<b>6 (40%)</b>

Table L-3. “Cut and Carry” Worker OWAS

*OWAS: OVAKO Work Analysis System*  
 Louhevaara and Suurnäkki (1992)

Work Phase	Tandem carrying material to bin	Single carrying material to bin	Bin arranging	Brigade carrying material to bin	Lifting material off pile	Walking back and forth	Waiting for crane, resting
<b>TOTAL Combination Posture Score</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>
Common Posture Combinations (collapsed across work phases)							
Back	1	2	4	1			
Arms	1	1	1	1			
Legs	7	2	2	2			
Posture Repetition (% of working time)	22	7	23	18			
Back % of Working Time Score	1	1	2	1			
Arms % of Working Time Score	1	1	1	1			
Legs % of Working Time Score	1	1	1	1			
ACTION CATEGORIES: 1 = no corrective measures 2 = corrective measures in the near future 3 = corrective measures as soon as possible 4 = corrective measures immediately							

Table L-3. "Cut and Carry" Worker OWAS (continued)

<b>Work Phase</b>	Tandem carrying material to bin	Single carrying material to bin	Bin arranging	Brigade carrying material to bin	Lifting material off pile	Walking back and forth	Waiting for crane, resting
<b>Posture</b>							
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	1	1	2	1	4	1	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	7	7	2	7	2,7	7	2
<b>Load/ Use of Force</b>							
1 = weight or force needed is = or <10 kg 2 = weight or force > 10 but < 20kg 3 = weight or force > 20 kg	2	2	2	2	2,3	1	1
<b>Phase Repetition</b>							
% of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	10	2	7	5	23	5	18

Table L-4. “Cut and Carry” Worker NIOSH Manual Materials Handling Checklist

*NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling*  
Waters and Putz-Anderson (1996)

\* “YES” responses are indicative of conditions that pose a risk of developing low back pain; the larger the percentage of “YES” responses, the greater the risk.

<b>RISK FACTORS</b>	<b>YES</b>	<b>NO</b>
<b>General</b>		
1.1 Does the load handled exceed 50 lbs?		N (usually not)
1.2 Is the object difficult to bring close to the body because of it’s size, bulk, or shape?	Y	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Y	
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?	Y	
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?		N
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Y (lumbar flexion)	
1.7 Is most of the load handled by only one hand, arm, or shoulder?		N
1.8 Does the task require working in environmental hazards, such as extreme temperatures, noise, vibration, lighting, or airborne contamination?		N (cold, heat occasionally)
1.9 Does the task require working in a confined area?	Y	
<b>Specific</b>		
2.1 Does the lifting frequency exceed 5 lifts per minute (LPM)?		N (LPM = 3.4 over total cycle time)
2.2 Does the vertical lifting distance exceed 3 feet?		N
2.3 Do carries last longer than 1 minute?		N
2.4 Do tasks that require large sustained pushing or pulling forces exceed 30 seconds duration?		N (usually @ 5-10)
2.5 Do extended reach static holding tasks exceed 1 minute?		N
<b>TOTAL</b>	5 (36%)	9 (64%)

Table L-5. “Cut and Carry” Worker 3D Static Strength Prediction Program

*3D Static Strength Prediction Program*  
 University of Michigan (1997)

<b>Work Element:</b>	<b>Disc Compression (lbs) @ L5/S1</b> (Note: NIOSH Recommended Compression Limit (RCL) is 770 lbs.)
Lifting a 40 pound item out of a scrap bin, two-handed	741 lbs.
Pulling a 40 pound item out of a scrap pile, two-handed	501 lbs.
Lifting a 20 pound item off a scrap pile, one-handed	550 lbs.
Tandem lift of 40 pound item (20 pounds per person), each two-handed	312 lbs.



Table L-6. “Cut and Carry” Worker PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

Section I: Musculoskeletal Risk Factors					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions (Preferred Method)					
2) Answer questions, score potential body regions for injury risk					
Musculoskeletal Risk Factor Questions	Body Regions				
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			Y	Y	Y
2: Is the space too limited for work movements or work materials?	Y	Y	Y	Y	Y
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			Y	Y	Y
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? e.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	N				N
c) bent sideways or mildly twisted?	Y				Y
d) severely twisted?	N				N

Table L-6. “Cut and Carry” Worker PLIBEL (continued)

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	N				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	Y				Y
b) weight of load	N				N
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	N	N			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		N			
b) forceful movements?		Y			
c) uncomfortable hand positions?		N			
d) switches or keyboards?		N			

Table L-6. "Cut and Carry" Worker PLIBEL (continued)

Musculoskeletal Risk Factors Scores					
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	16	7	4	4	14
PERCENTAGE	61.5	63.6	50	50	66.7
Section II: Environmental / Organizational Risk Factors (Modifying)					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	N				
20: Is the job performed under time demands or psychological stress	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	N				
Environmental / Organizational Risk Factors Score					
SUM	4				
PERCENTAGE	40.0				

## L2 . SORTING PAD WORKER

Table L-7. Sorting Pad Worker Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 - 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 - 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					<b>6.0</b>

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion	< 10%	1	0.5
= $100 \times \frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$	10% - 29%	2	1.0
= $100 \times \frac{993 \text{ (sec)}}{1168 \text{ (sec)}}$	30% - 49%	3	1.5
= 85%	50% - 79%	4	2.0
	> or = 80%	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>3.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute	< 4	1	0.5
= $\frac{\text{number of exertions}}{\text{total observation time (min)}}$	4 - 8	2	1.0
= $\frac{298}{19.5} = 15.3$	9 - 14	3	1.5
	15 - 19	4	2.0
	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>2.0</b>

Table L-7. Sorting Pad Worker Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
<b>Rating Criterion</b>	<b>Wrist Extension</b>	<b>Wrist Flexion</b>	<b>Ulnar Deviation</b>	<b>Perceived Posture</b>	<b>Rating</b>	<b>Multiplier</b>
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral (*estimated, based on RULAs done)	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>1.5</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
<b>Rating Criterion</b>	<b>Observed Pace/MTM Predicted Pace x 100%</b>	<b>Perceived Speed</b>	<b>Rating</b>	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	1.0
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet: Duration of Task per Day (hrs) = duration of task (hrs) + duration of task (hrs) + ... = (estimate ~ 2- 4 hrs)	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
	< or = 1 hr	1	0.25
	1 – 2 hrs	2	0.50
	2 – 4 hrs	3	0.75
	4 – 8 hrs	4	1.00
	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			<b>0.75</b>

Table L-7. Sorting Pad Worker Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	=	<u>SI SCORE</u>
<b>6.0 X</b>	<b>3.0 X</b>	<b>2.0 X</b>	<b>1.5 X</b>	<b>1.0 X</b>	<b>0.75</b>		<b><u>40.5</u></b>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
- SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table L-8. Sorting Pad Worker UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
Lifshitz and Armstrong (1986)

\* “No” responses are indicative of conditions associated with the risk of CTD’s

<b>Risk Factors</b>	<b>No</b>	<b>Yes</b>
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker’s hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N*	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N/A	N/A
3.3 Can the job be done without deviating the wrist from side to side?		Y
3.4 Can the tool be used without deviating the wrist from side to side?		Y
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without “clothes wringing” motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	N/A	N/A
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	N/A	N/A
6.2 Is the span of the tool’s handle between 5 and 7 cm (2-2 3/4 inches)?	N/A	N/A
6.3 Is the handle of the tool made from material other than metal?	N/A	N/A
6.4 Is the weight of the tool below 4 kg (9lbs)?	N/A	N/A
6.5 Is the tool suspended?	N/A	N/A
<b>TOTAL</b>	<b>9 (56%)</b>	<b>7 (44%)</b>

Table L-9. Sorting Pad Worker OWAS

*OWAS: OVAKO Work Analysis System*  
Louhevaara and Suurnäkki (1992)

Work Phase	Lifting piece from receiving bin	Carrying piece to separator bin	Throwing piece into separate bin	Walking back to receiving bin	Sweeping out receiving bin	Scraping labels off receiving bin	Cutting off zip ties
<b>TOTAL Combination Posture Score</b>	<b>3</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>4</b>	<b>1</b>
Common Posture Combinations (collapsed across work phases)							
Back	2	2	4	4	1	4	1
Arms	1	1	1	1	1	1	1
Legs	2	3	2	3	7	4	2
Posture Repetition (% of working time)	38*	38*	38*	38*	56	3	1
Back % of Working Time Score	2	2	3	3	1	1	1
Arms % of Working Time Score	1	1	1	1	1	1	1
Legs % of Working Time ScoreE	1	2	1	2	1	1	1
<b>ACTION CATEGORIES:</b> 1 = no corrective measures 2 = corrective measures in the near future 3 = corrective measures as soon as possible 4 = corrective measures immediately							



Table L-9. Sorting Pad Worker OWAS (continued)

<b>Work Phase</b>	Lifting piece from receiving bin	Carrying piece to separator bin	Throwing piece into separate bin	Walking back to receiving bin	Sweeping out receiving bin	Scraping labels off receiving bin	Cutting off zip ties
<b>Posture</b>							
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	2, 4	1	1	1	1	4	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	2,3	7	7	7	7	4	2
<b>Load/ Use of Force</b>							
1 = weight or force needed is = or <10 kg 2 = weight or force > 10 but < 20kg 3 = weight or force > 20 kg	3	3	3	1	1	1	1
<b>Phase Repetition</b>							
% of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	38	13	13	14	16	03	01

Table L-10. Sorting Pad Worker NIOSH Manual Materials Handling Checklist

*NIOSH Hazard Evaluation Checklist for Lifting, Carrying, Pushing, or Pulling*  
Waters and Putz-Anderson (1996)

\* “YES” responses are indicative of conditions that pose a risk of developing low back pain; the larger the percentage of “YES” responses, the greater the risk.

<b>RISK FACTORS</b>	<b>YES</b>	<b>NO</b>
<b>General</b>		
1.1 Does the load handled exceed 50 lbs?	Y (sometimes)	
1.2 Is the object difficult to bring close to the body because of its size, bulk, or shape?	Y	
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Y	
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?		N
1.5 Does the task require fast movement, such as throwing, swinging, or rapid walking?	Y	
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Y (extreme lumbar flexion)	
1.7 Is most of the load handled by only one hand, arm, or shoulder?		N
1.8 Does the task require working in environmental hazards, such as extreme temperatures, noise, vibration, lighting, or airborne contamination?		N (cold, heat occasionally)
1.9 Does the task require working in a confined area?		N
<b>Specific</b>		
2.1 Does the lifting frequency exceed 5 lifts per minute (LPM)?		N (LPM = 4.5 over total cycle time, but some multiple lifts are counted singly)
2.2 Does the vertical lifting distance exceed 3 feet?	Y (sometimes)	
2.3 Do carries last longer than 1 minute?		N
2.4 Do tasks which require large sustained pushing or pulling forces exceed 30 seconds duration?		N (usually @ 5-10)
2.5 Do extended reach static holding tasks exceed 1 minute?		N
<b>TOTAL</b>	6 (43%)	8 (57%)

Table L-11. Sorting Pad Worker 3D Static Strength Prediction Program

*3D Static Strength Prediction Program*  
University of Michigan (1997)

<b>Work Phase:</b> Scrap Bin Sorting	<b>Disc Compression (lbs) @ L5/S1</b> (Note: NIOSH Recommended Compression Limit (RCL) is 770 lbs)
Two-handed lift from the bottom of the scrap bin, supported on one leg. Item (triple valve assembly) weighs 70 lbs.	<p style="text-align: center;"><b>972 lbs.</b> (beginning of lift)</p>

Table L-12. Sorting Pad Worker PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

Section I: Musculoskeletal Risk Factors					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions (Preferred Method)					
2) Answer questions, score potential body regions for injury risk					
Musculoskeletal Risk Factor Questions	Body Regions				
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			N	N	N
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	Y				Y
6: If work performed standing, is there no possibility to sit and rest?			Y	Y	Y
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? E.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	Y				Y
d) severely twisted?	Y				Y

Table L-12. Sorting Pad Worker PLIBEL (continued)

10: Is repeated or sustained work performed when the neck is:					
a) flexed forward?	Y				
b) bent sideways or mildly twisted?	Y				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Notice factors of importance as:					
a) periods of repetitive lifting	Y				Y
b) weight of load	Y				Y
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		N			
b) forceful movements?		Y			
c) uncomfortable hand positions?		N			
d) switches or keyboards?		N			

Table L-12. Sorting Pad Worker PLIBEL (continued)

Musculoskeletal Risk Factors Scores					
	Neck, Shoulder, Upper Back	Elbows, Forearms, Hands	Feet	Knees and Hips	Low Back
SUM	20	7	2	2	15
PERCENTAGE	76.9	63.6	25.0	25.0	71.4
Section II: Environmental / Organizational Risk Factors (Modifying)					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work	N				
20: Is the job performed under time demands or psychological stress	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	N				
Environmental / Organizational Risk Factors Score					
SUM	4				
PERCENTAGE	40.0				

### L3. EQUIPMENT LOADER

Table L-13. Equipment Loader RULA

*Rapid Upper Limb Assessment (RULA)*  
Matamney and Corlett (1993)

Work Phase	Lower equipment through hatch		Roll eqpt. on low profile cart		Slide equipment		Roll equipment on rollers		equipment		Waiting for new load to be delivered	
		RULA Score	Specific	RULA Score		RULA Score	Specific	RULA Score		RULA Score	Specific	RULA Score
Shoulder Extension/ Flexion	sl flex	2	sl flex	2	mod flex	3	mod flex	3	sl flex	2	neut	1
Shoulder is Raised (+1)		0		0		1		1		1		0
Upper Arm Abducted (+1)		0		0		0		1		0		0
Arm supported, leaning (-1)		0		0		0		0		0		0
Elbow Extension/ Flexion	neut	2	neut	2	ext	1	neut	2	flx	2	ext	1
Shoulder Abduction/ Adduction	neut	0	neut	0	mod abd	1	mod abd	1	mod abd	1	neut	0
Shoulder Lateral/ Medial	neut	0	neut	0	mod med	1	mod med	1	mod med	1	neut	0
Wrist Extension/ Flexion	ext	2	neut	1	ext	2	flx	2	ext	2	neut	1
Wrist Deviation	neut	0	neut	0	neut	0	neut	0	neut	0	neut	0
Wrist Bent from Midline (+1)		0		0		0		0		0		0
Wrist Twist (1) In mid range Or (2) End of range		1		1		1		1		1		1
Arm and Wrist Muscle Use Score If posture mainly static (I.e. held for longer than 10 minutes) or; If action repeatedly occurs 4 times per minute or more: (+ 1)		0		0		0		0		0		0
Arm and Wrist Force/ load Score: If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		1		2		3		3		3		0

Table L-13. Equipment Loader RULA (continued)

Work Phase	Lower equipment through hatch		Roll eqpt. on low profile cart		Slide equipment		Roll equipment on rollers		Tilt equipment		Waiting for new load to be delivered	
	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score	Specific	RULA Score
Neck Extension/ Flexion	neut	1	sl flx	2	neut	1	sl flx	2	sl flx	2	neut	1
Neck Twist (+1)		0		0		0		0		0		0
Neck Side-Bent (+1)		0		0		0		0		0		0
Trunk Extension/ Flexion	neut	1	sl flx	2	sl flx	2	sl flx	2	sl flx	2	neut	1
Trunk Twist (+1)		0		0		0		1		1		0
Trunk Side Bend (+1)		0		0		0		1		1		0
Legs: If legs and feet are supported and balanced: (+1); If not: (+2)		1		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score If posture mainly static (i.e. held for longer than 10 minutes) or; if action repeatedly occurs 4 times per minute or more: (+ 1)		0		0		0		0		0		0
Neck, Trunk, and Leg Force/ Load Score If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		1		2		3		3		3		0
<b>Total RULA Score</b>	<b>3</b>		<b>4</b>		<b>6</b>		<b>7</b>		<b>7</b>		<b>1</b>	
1 or 2 = Acceptable 3 or 4 = Investigate Further 5 or 6 = Investigate Further and Change Soon 7 = Investigate and Change Immediately												



Table L-14. Equipment Loader Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 - 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 - 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					<b>6.0</b>

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion	< 10%	1	0.5
= $100 \times \frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$	10% - 29%	2	1.0
= $100 \times \frac{1495 \text{ (sec)}}{2910 \text{ (sec)}}$	30% - 49%	3	1.5
= 51%	50% - 79%	4	2.0
	> or = 80%	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>2.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute	< 4	1	0.5
= $\frac{\text{number of exertions}}{\text{total observation time (min)}}$	4 - 8	2	1.0
= $\frac{108}{48} = 2.2$	9 - 14	3	1.5
	15 - 19	4	2.0
	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>0.5</b>

Table L-14. Equipment Loader Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
<b>Rating Criterion</b>	<b>Wrist Extension</b>	<b>Wrist Flexion</b>	<b>Ulnar Deviation</b>	<b>Perceived Posture</b>	<b>Rating</b>	<b>Multiplier</b>
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral (*estimated, based on RULAs done)	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>1.0</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
<b>Rating Criterion</b>	<b>Observed Pace/MTM Predicted Pace x 100%</b>	<b>Perceived Speed</b>	<b>Rating</b>	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	1.0
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet:			
Duration of Task per Day (hrs)	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
= duration of task (hrs) +	< or = 1 hr	1	0.25
duration of task (hrs) + ...	1 – 2 hrs	2	0.50
	2 – 4 hrs	3	0.75
	4 – 8 hrs	4	1.00
= (estimate ~ 2- 4 hrs)	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			<b>0.75</b>

Table L-14. Equipment Loader Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	=	<u>SI SCORE</u>
6.0 X	2.0 X	0.5 X	1.0 X	1.0 X	0.75	=	<u>4.5</u>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
- SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table L-15. Equipment Loader UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
Lifshitz and Armstrong (1986)

\* "No" responses are indicative of conditions associated with the risk of CTD's

Risk Factors	No	Yes
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges		Y
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker's hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?		Y
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	N	
3.3 Can the job be done without deviating the wrist from side to side?		Y
3.4 Can the tool be used without deviating the wrist from side to side?		Y
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without "clothes wringing" motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	n/a	n/a
4.2 Can the height of the work surface be adjusted?	n/a	n/a
4.3 Can the location of the tool be adjusted?	n/a	n/a
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?		Y
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	n/a	n/a
6.2 Is the span of the tool's handle between 5 and 7 cm (2-2 3/4 inches)?	n/a	n/a
6.3 Is the handle of the tool made from material other than metal?	n/a	n/a
6.4 Is the weight of the tool below 4 kg (9lbs)?	n/a	n/a
6.5 Is the tool suspended?	n/a	n/a
<b>TOTAL</b>	<b>8 (50%)</b>	<b>8 (50%)</b>

Table L-16. Equipment Loader OWAS

*OWAS: OVAKO Work Analysis System*  
Louhevaara and Suurnäkki (1992)


<b>Work Phase</b>	Lower equipment through hatch	Roll eqpt. on low profile cart	Slide equipment	Roll equipment on rollers	Tilt eqpt.	Waiting for new load to be delivered
<b>TOTAL Combination Posture Score</b>	<b>1</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>1</b>
<b>Common Posture Combinations (collapsed across work phases)</b>						
Back	1	2	2			
Arms	1	1	1			
Legs	2	7	6			
Posture Repetition (% of working time)	58	18	11			
Back % of Working Time Score	1	1	1	1		
Arms % of Working Time Score	1	1	1	1		
Legs % of Working Time Score	1	1	1	1		
<b>ACTION CATEGORIES:</b> 1 = no corrective measures 2 = corrective measures in the near future 3 = corrective measures as soon as possible 4 = corrective measures immediately						

Table L-16. Equipment Loader OWAS (continued)

<b>Work Phase</b>	Lower equipment through hatch	Roll eqpt. on low profile cart	Slide equipment	Roll equipment on rollers	Tilt equipment	Waiting for new load to be delivered
<b>Posture</b>						
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	1	2	2	2	2	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	2	7	7	7	6	2
<b>Load/ Use of Force</b>						
1 = weight or force needed is = or <10 kg (<22lbs) 2 = weight or force > 10 but < 20kg (>22lbs < 44 lbs) 3 = weight or force > 20 kg (>44 lbs)	1	2	3	3	3	1
<b>Phase Repetition</b>						
% of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	12	4	7	7	11	46

Table L-17. Equipment Loader 3D Static Strength Prediction Program

*3D Static Strength Prediction Program*  
University of Michigan (1997)

<p>Work Phase: Equipment Loader Tilting Equipment</p>	<p>Disc Compression (lbs) @ L5/S1 (Note: NIOSH Recommended Compression Limit (RCL) is 770 lbs)</p>
<p>Equipment Loader tilts equipment: approximate hand loads of 100 pounds</p> 	<p style="text-align: center;"><b>789 pounds</b></p>

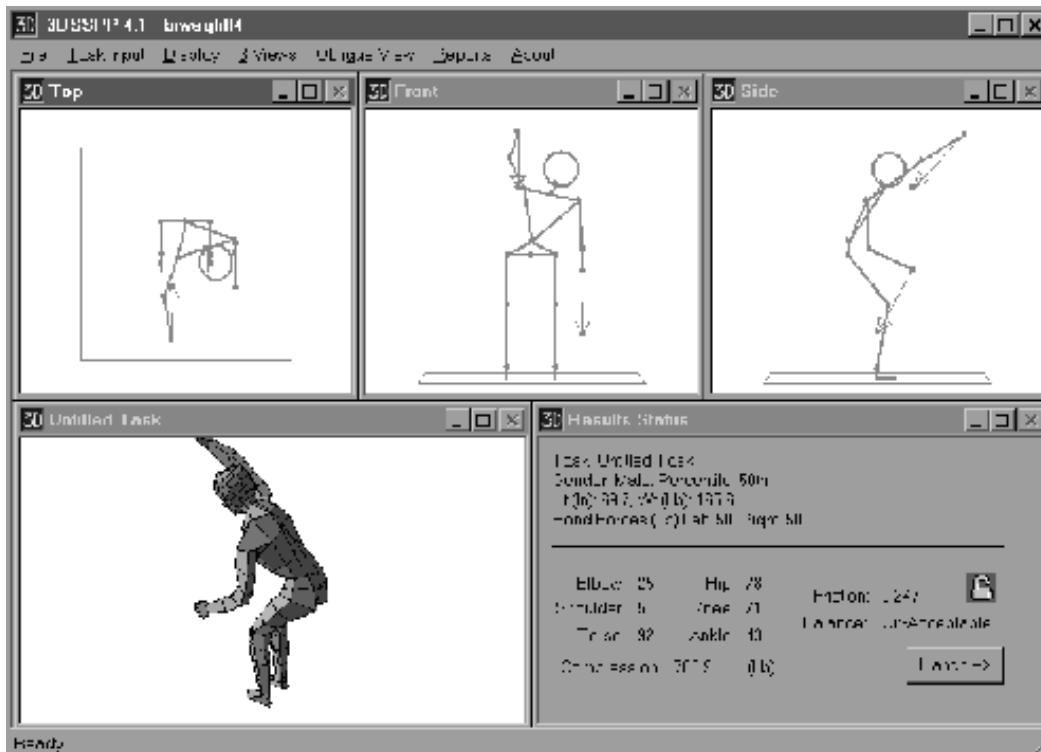


Table L-18. Equipment Loader PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

<b>Section I: Musculoskeletal Risk Factors</b>					
Methods of Application: 1) Find the injured body region, answer yes or no to corresponding questions 2) Answer questions, score potential body regions for injury risk					
Musculoskeletal Risk Factor Questions	Body Regions				
	Neck, Shoulder, and Upper Back	Elbows, Forearms, and Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			Y	Y	Y
2: Is the space too limited for work movements or work materials?	Y	Y	Y	Y	Y
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	n/a				n/a
6: If work performed standing, is there no possibility to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? e.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when the back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	N				N
c) bent sideways or mildly twisted?	N				N
d) severely twisted?	N				N



Table L-18. Equipment Loader PLIBEL (continued)

10: Is repeated/sustained work performed with neck:					
a) flexed forward?	N				
b) bent sideways or mildly twisted?	N				
c) severely twisted?	N				
d) extended backwards?	N				
11: Are loads lifted manually? Note important factors:					
a) periods of repetitive lifting	Y				Y
b) weight of load	Y				Y
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	N	N			
b) similar work movements beyond comfortable reaching distance?	N	N			
15: Is repeated or sustained manual work performed? Notice factors of importance as:					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		N			
b) forceful movements?		Y			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table L-18. Equipment Loaders PLIBEL (continued)

<b>Musculoskeletal Risk Factors Scores</b>					
	Neck, Shoulder, and Upper Back	Elbows, Forearms, and Hands	Feet	Knees and Hips	Low Back
SUM	13	7	3	3	12
PERCENTAGE	50	63.6	37.5	37.5	57.1
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work?	N				
20: Is the job performed under time demands or psychological stress?	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	N				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	4				
PERCENTAGE	40.0				

## L4. BIN UNLOADING

Table L-19. Bin Unloader RULA

*Rapid Upper Limb Assessment (RULA)*  
Matamney and Corlett (1993)

Work Phase	Walk back to bins		Lift piece from bin		Carry piece		Rack arranging		Rest	
	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score	Spec	RULA Score
Shoulder Extension/ Flexion	neut	1	mod flex	3	neut	1	sl flex	2	neut	1
Shoulder is Raised (+1)		0		0		0		0		0
Upper Arm Abducted (+1)		0		0		0		0		0
Arm supported, leaning (-1)		0		0		0		0		0
Elbow Extension/ Flexion	ext	1	ext	1	neut	2	ext	1	ext	1
Shoulder Abduction/ Adduction	neut	0	add	1	neut	0	neut	0	neut	0
Shoulder Lateral/ Medial	neut	0	neut	0	neut	0	neut	0	neut	0
Wrist Extension/ Flexion	neut	1	ext	2	ext	2	ext	2	neut	1
Wrist Deviation	neut	0	ulnar	1	neut	0	neut	0	neut	0
Wrist Bent from Midline (+1)		0		0		0		0		0
Wrist Twist (1) In mid range or (2) End of range		1		1		1		1		1
Arm and Wrist Muscle Use Score: If posture mainly static (i.e. held for longer than 10 minutes) or; if action repeatedly occurs 4 times per minute or more: (+ 1)		0		1		1		0		0
Arm and Wrist Force/ Load Score: If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		0		2		1		1		0

Table L-19. Bin Unloader RULA (continued)

Work Phase	Walk back to bins		Lift piece from bin		Carry piece		Rack arranging		Rest	
	<i>Spec</i>	<i>RULA Score</i>	<i>Spec</i>	<i>RULA Score</i>	<i>Spec</i>	<i>RULA Score</i>	<i>Spec</i>	<i>RULA Score</i>	<i>Spec</i>	<i>RULA Score</i>
Neck Extension/ Flexion	sl flx	2	ext	4	sl flx	2	mod flx	3	neut	1
Neck Twist (+1)		0		0		0		0		0
Neck Side-Bent (+1)		0		0		0		0		0
Trunk Extension/ Flexion	neut	1	hyp flx	4	neut	1	mod flx	3	neut	1
Trunk Twist (+1)		0		1		0		0		0
Trunk Side Bend (+1)		0		0		0		0		0
Legs: If legs and feet are supported and balanced: ( +1); If not: (+2)		1		1		1		1		1
Neck, Trunk, and Leg Muscle Use Score: If posture mainly static (i.e. held for longer than 10 minutes) or; if action repeatedly occurs 4 times per minute or more: (+ 1)		1		1		1		0		0
Neck, Trunk, and Leg Force/ Load Score: If load less than 2 kg (intermittent): (+0) If 2kg to 10 kg (intermittent): (+1) If 2kg to 10 kg (static or repeated): (+2) If more than 10 kg load or repeated or shocks: (+3)		1		2		1		1		1
<b>Total RULA Score</b>	<b>3</b>		<b>7</b>		<b>4</b>		<b>3</b>		<b>2</b>	
1 or 2 = Acceptable 3 or 4 = Investigate Further 5 or 6 = Investigate Further and Change Soon 7 = Investigate and Change Immediately										

Table L-20. Bin Unloader Strain Index

*Strain Index: Distal Upper Extremity Disorders Risk Assessment*  
Moore and Garg (1995)

<b>1. Intensity of Exertion:</b> An estimate of the strength required to perform the task one time. Mark the rating after using the guidelines below; then fill in the corresponding multiplier in the far right box.					
Rating Criterion	% Maximal Strength	Borg Scale	Perceived Effort	Rating	Multiplier
Light	< 10%	< or = 2	barely noticeable or relaxed effort	1	1.0
Somewhat Hard	10% - 29%	3	noticeable or definite effort	2	3.0
Hard	30% - 49%	4 - 5	obvious effort; unchanged facial expression	3	6.0
Very Hard	50% - 79%	6 - 7	substantial effort; changes to facial expression	4	9.0
Near Maximal	> or = 80%	> 7	uses shoulder or trunk to generate force	5	13.0
<b>Intensity of Exertion Multiplier</b>					<b>3.0</b>

<b>2. Duration of Exertion (% of cycle):</b> Calculated by measuring the duration of all exertions during an observation period, and then dividing the measured duration of exertion by the total observation time and multiplying by 100. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
% Duration of Exertion	< 10%	1	0.5
= $100 \times \frac{\text{duration of all exertions (sec)}}{\text{Total observation time (sec)}}$	10% - 29%	2	1.0
= $100 \times \frac{204 \text{ (sec)}}{268 \text{ (sec)}}$	30% - 49%	3	1.5
= 76%	50% - 79%	4	2.0
	> or = 80%	5	3.0
<b>Duration of Exertion Multiplier</b>			<b>1.0</b>

<b>3. Efforts per Minute:</b> Measured by counting the number of exertions that occur during an observation period, and then dividing the number of exertions by the duration of the observation period, measured in minutes. NOTE: If duration of exertion is 100% (as with some static tasks), then efforts/minute multiplier should be set to 3.0			
Worksheet:	Rating Criterion	Rating	Multiplier
Efforts per Minute	< 4	1	0.5
= $\frac{\text{number of exertions}}{\text{total observation time (min)}}$	4 - 8	2	1.0
= $\frac{69}{4.5} = 11.2$	9 - 14	3	1.5
	15 - 19	4	2.0
	> or = 20	5	3.0
<b>Efforts per Minute Multiplier</b>			<b>1.5</b>

Table L-20. Bin Unloader Strain Index (continued)

<b>4. Hand/Wrist Posture:</b> An estimate of the position of the hand or wrist relative to neutral position.						
<b>Rating Criterion</b>	<b>Wrist Extension</b>	<b>Wrist Flexion</b>	<b>Ulnar Deviation</b>	<b>Perceived Posture</b>	<b>Rating</b>	<b>Multiplier</b>
Very Good	0 – 10 degrees	0 – 5 degrees	0 – 10 degrees	perfectly neutral	1	1.0
Good	11 – 25 degrees	6 – 15 degrees	11 – 15 degrees	near neutral	2	1.0
Fair	26 – 40 degrees	16 – 30 degrees	16 – 20 degrees	non-neutral (*estimated, based on RULAs done)	3	1.5
Bad	41 – 55 degrees	31 – 50 degrees	21 – 25 degrees	marked deviation	4	2.0
Very Bad	> 60 degrees	> 50 degrees	> 25 degrees	near extreme	5	3.0
<b>Hand/Wrist Posture Multiplier</b>						<b>2.0</b>

<b>5. Speed of Work:</b> An estimate of how fast the worker is working.				
<b>Rating Criterion</b>	<b>Observed Pace/MTM Predicted Pace x 100%</b>	<b>Perceived Speed</b>	<b>Rating</b>	<b>Multiplier</b>
Very Slow	< or = 80%	extremely relaxed pace	1	1.0
Slow	81% – 90%	“taking one’s own time”	2	1.0
Fair	91% - 100%	“normal” speed of motion	3	1.0
Fast	101% - 115%	rushed, but able to keep up	4	1.5
Very Fast	> 115%	rushed, barely or unable to keep up	5	2.0
<b>Speed of Work Multiplier</b>				<b>1.0</b>

<b>6. Duration of Task per Day:</b> Either measured or obtained from plant personnel			
Worksheet: Duration of Task per Day (hrs) = duration of task (hrs) + duration of task (hrs) + ...  = (estimate ~ 2 - 4 hrs)	<b>Rating Criterion</b>	<b>Rating</b>	<b>Multiplier</b>
	< or = 1 hr	1	0.25
	1 – 2 hrs	2	0.50
	2 – 4 hrs	3	0.75
	4 – 8 hrs	4	1.00
	> or = 8 hrs	5	1.50
<b>Duration of Task per Day Multiplier</b>			<b>0.75</b>

Table L-20. Bin Unloader Strain Index (continued)

7. Calculate the Strain Index (SI) Score: Insert the multiplier values for each of the six task variables into the spaces below, then multiply them all together.							
Intensity of Exertion	Duration of Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration of Task	=	<u>SI SCORE</u>
<b>3.0 X</b>	<b>2.0 X</b>	<b>1.5 X</b>	<b>1.5 X</b>	<b>1.0 X</b>	<b>0.75</b>		<b><u>10.1</u></b>

SI Scores are used to predict Incidence Rates of Distal Upper Extremity injuries per 100 FTE:

- SI Score < 5 is correlated to an Incidence Rate of about 2 DUE injuries per 100 FTE;
- SI Score of between 5 – 30 is correlated to an Incidence Rate of about 77 DUE injuries per 100 FTE;
- SI Score of between 31 – 60 is correlated to an Incidence Rate of about 106 DUE injuries per 100 FTE; and
- SI Score of > 60 is correlated to an Incidence Rate of about 130 DUE injuries per 100 FTE.

Table L-21. Bin Unloader UE CTD Checklist

*Michigan Checklist for Upper Extremity Cumulative Trauma Disorders*  
Lifshitz and Armstrong (1986)

\* "No" responses are indicative of conditions associated with the risk of CTD's

Risk Factors	No	Yes
<b>1. Physical Stress</b>		
1.1 Can the job be done without hand/ wrist contact with sharp edges	N	
1.2 Is the tool operating without vibration?		Y
1.3 Are the worker's hands exposed to temperature >21degrees C (70 degrees F)?	N	Y
1.4 Can the job be done without using gloves?	N	
<b>2. Force</b>		
2.1 Does the job require exerting less than 4.5 kg (10lbs) of force?	N	
2.2 Can the job be done without using finger pinch grip?	N	
<b>3. Posture</b>		
3.1 Can the job be done without flexion or extension of the wrist?	N	
3.2 Can the tool be used without flexion or extension of the wrist?	n/a	n/a
3.3 Can the job be done without deviating the wrist from side to side?	N	
3.4 Can the tool be used without deviating the wrist from side to side?	n/a	n/a
3.5 Can the worker be seated while performing the job?	N	
3.6 Can the job be done without "clothes wringing" motion?		Y
<b>4. Workstation Hardware</b>		
4.1 Can the orientation of the work surface be adjusted?	N	
4.2 Can the height of the work surface be adjusted?	N	
4.3 Can the location of the tool be adjusted?	n/a	n/a
<b>5. Repetitiveness</b>		
5.1 Is the cycle time longer than 30 seconds?	N	
<b>6. Tool Design</b>		
6.1 Are the thumb and finger slightly overlapped in a closed grip?	n/a	n/a
6.2 Is the span of the tool's handle between 5 and 7 cm (2-2 3/4 inches)?	n/a	n/a
6.3 Is the handle of the tool made from material other than metal?	n/a	n/a
6.4 Is the weight of the tool below 4 kg (9lbs)?	n/a	n/a
6.5 Is the tool suspended?	n/a	n/a
<b>TOTAL</b>	11 (79%)	3 (21%)



Table L-22. Bin Unloader OWAS

*OWAS: OVAKO Work Analysis System*  
(Louhevaara and Suurnäkki, 1992)

Work Phase	Walk back to bins	Lift piece from bin	Carry piece	Rack arranging	Rest
TOTAL Combination Posture Score	1	2	1	2	1
Common Posture Combinations (collapsed across work phases)					
Back	1	4	1	2	1
Arms	1	1	1	1	1
Legs	7	2	7	2	2
Posture Repetition (% of working time)	42	48	26	2	8
Back % of Working Time Score	1	3	1	1	1
Arms % of Working Time Score	1	1	1	1	1
Legs % of Working Time Score	1	1	1	1	1
<b>ACTION CATEGORIES:</b> 1 = no corrective measures 2 = corrective measures in the near future 3 = corrective measures as soon as possible 4 = corrective measures immediately					

Table L-22. Bin Unloader OWAS (continued)

Work Phase	Walk back to bins	Lift piece from bin	Carry piece	Rack arranging	Rest
<b>Posture</b>					
<b>Back</b> 1 = straight 2 = bent forward, backward 3 = twisted or bent sideways 4 = bent and twisted or bent forward and sideways	1	4	1	2	1
<b>Arms</b> 1 = both arms are below shoulder level 2 = one arm is at or above shoulder level 3 = both arms are at or above shoulder level	1	1	1	1	1
<b>Legs</b> 1 = sitting 2 = standing with both legs straight 3 = standing with the weight on one straight leg 4 = standing or squatting with both knees bent 5 = standing or squatting with one knee bent 6 = kneeling on one or both knees 7 = walking or moving	7	2	7	2	2
<b>Load/ Use of Force</b>					
1 = weight or force needed is = or <10 kg (<22lbs) 2 = weight or force > 10 but < 20kg (>22lbs < 44 lbs) 3 = weight or force > 20 kg (>44 lbs)	1	2	2	1	1
<b>Phase Repetition</b>					
% of working time (0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100)	16	48	26	2	8

Table L-23. Bin Unloader NIOSH Lifting Equation Analysis

*NIOSH Lifting Equation*  
Waters, Putz-Anderson, Garg, and Fine (1993)

<b>RESULTS</b>	<b>ORIGIN</b>	<b>DESTINATION</b>
Recommended Weight Limit (RWL)	3.8 pounds	9.3 pounds
Lifting Index, LI (RWL/Load)	2.63	
Population Capable	Male = 46 % Capable Female = 4 % Capable	
<b>ORIGIN VARIABLE</b>	<b>ORIGIN VALUE</b>	<b>ORIGIN MULTIPLIER</b>
Horizontal Location, H	24 inches	0.42
Vertical Location, V	5 inches	0.81
Travel Distance, D	31 inches	0.88
Asymmetric Angle, A	0 degrees	1.00
Frequency, F	10 lifts/minute	0.26
Hand to Object Coupling, C	Fair	1.00
<b>DESTINATION VARIABLE</b>	<b>DESTINATION VALUE</b>	<b>DESTINATION MULTIPLIER</b>
Horizontal Location, H	12 inches	0.83
Vertical Location, V	36 inches	0.96
Travel Distance, D	31 inches	0.88
Asymmetric Angle, A	0 degrees	1.00
Frequency, F	10 lifts/minute	0.26
Hand to Object Coupling, C	Fair	1.00
<b>Duration: 2 hours</b>	<b>Average Object Weight: 10 pounds</b>	<b>Maximum Object Weight: 40 pounds</b>

Table L-24. Bin Unloader 3D Static Strength Prediction Program

*3D Static Strength Prediction Program*  
University of Michigan (1997)

Work Phase: Bin Unloading in Panel Line Area	Disc Compression (lbs) @ L5/S1 (Note: NIOSH Recommended Compression Limit (RCL) is 770 lbs)
Bin unloader picks up material from bottom of bin, approximate weight 40 pounds	<b>898 pounds</b>

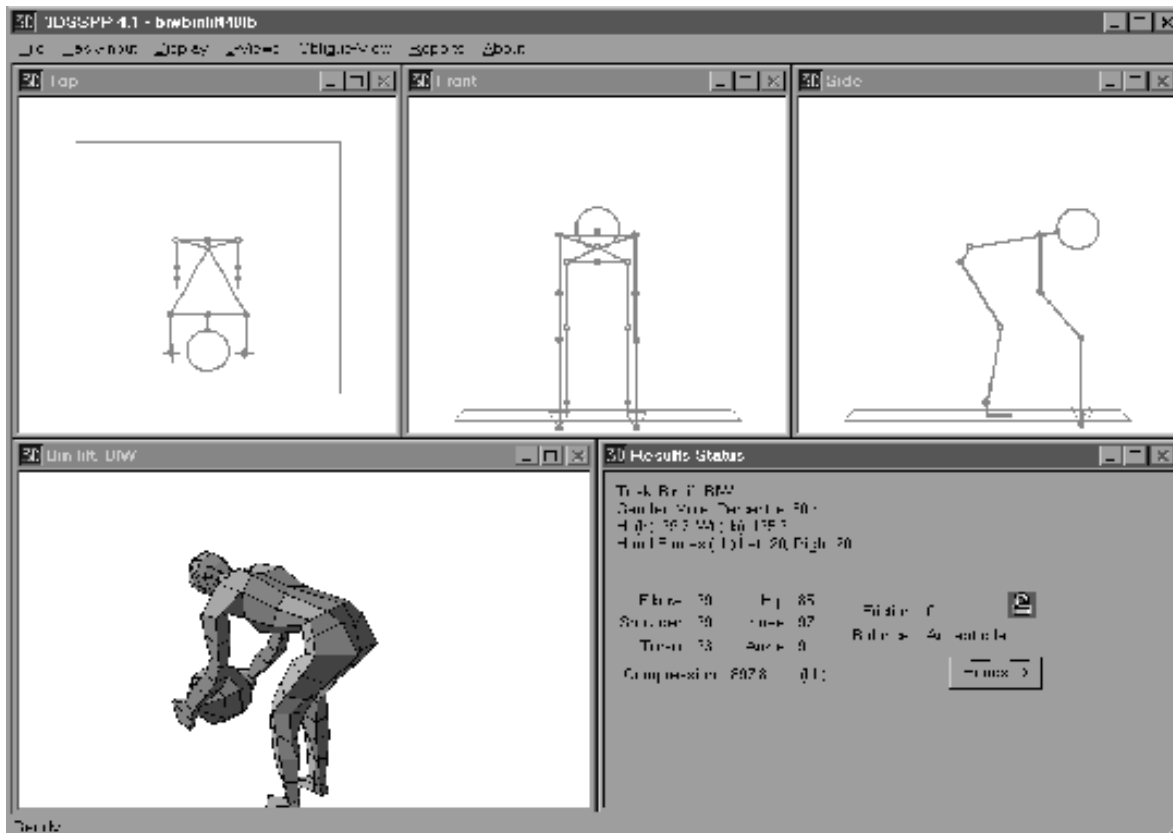


Table L-25. Bin Unloader PLIBEL

*PLIBEL Checklist*  
Kemmlert (1995)

<b>Section I: Musculoskeletal Risk Factors</b>					
Methods of Application:					
1) Find the injured body region, answer yes or no to corresponding questions					
2) Answer questions, score potential body regions for injury risk					
<b>Musculoskeletal Risk Factor Questions</b>	<b>Body Regions</b>				
	Neck, Shoulder, Upper Back	Elbows, Forearm, and Hands	Feet	Knees and Hips	Low Back
1: Is the walking surface uneven, sloping, slippery or nonresilient?			N	N	N
2: Is the space too limited for work movements or work materials?	N	N	N	N	N
3: Are tools and equipment unsuitably designed for the worker or the task?	Y	Y	Y	Y	Y
4: Is the working height incorrectly adjusted?	Y				Y
5: Is the working chair poorly designed or incorrectly adjusted?	n/a				n/a
6: If work performed standing, is there no chance to sit and rest?			N	N	N
7: Is fatiguing foot pedal work performed?			N	N	
8: Is fatiguing leg work performed? e.g. ...					
a) repeated stepping up on stool, step etc..			N	N	N
b) repeated jumps, prolonged squatting or kneeling?			N	N	N
c) one leg being used more often in supporting the body?			N	N	N
9: Is repeated or sustained work performed when back is:					
a) mildly flexed forward?	Y				Y
b) severely flexed forward?	Y				Y
c) bent sideways or mildly twisted?	Y				Y
d) severely twisted?	N				N

Table L-25. Bin Unloader PLIBEL (continued)

10: Is repeated/sustained work performed with neck:					
a) flexed forward?	N				
b) bent sideways or mildly twisted?	N				
c) severely twisted?	N				
d) extended backwards?	Y				
11: Are loads lifted manually? Note important factors:					
a) periods of repetitive lifting	Y				Y
b) weight of load	Y				Y
c) awkward grasping of load	Y				Y
d) awkward location of load at onset or end of lifting	Y				Y
e) handling beyond forearm length	Y				Y
f) handling below knee length	Y				Y
g) handling above shoulder height	N				N
12: Is repeated, sustained or uncomfortable carrying, pushing or pulling of loads performed?	Y	Y			Y
13: Is sustained work performed when one arm reaches forward or to the side without support?	N				
14: Is there a repetition of:					
a) similar work movements?	Y	Y			
b) similar work movements beyond comfortable reaching distance?	Y	Y			
15: Is repeated or sustained manual work performed?					
a) weight of working materials or tools	Y	Y			
b) awkward grasping of working materials or tools	Y	Y			
16: Are there high demands on visual capacity?	N				
17: Is repeated work, with forearm and hand, performed with:					
a) twisting movements?		N			
b) forceful movements?		N			
c) uncomfortable hand positions?		Y			
d) switches or keyboards?		N			

Table L-25. Bin Unloader PLIBEL (continued)

<b>Musculoskeletal Risk Factors Scores</b>					
	Neck, Shoulder, Upper Back	Elbows, Forearms, and Hands	Feet	Knees and Hips	Low Back
SUM	16	6	1	1	12
PERCENTAGE	61.5	54.5	12.5	12.5	57.1
<b>Section II: Environmental / Organizational Risk Factors (Modifying)</b>					
18: Is there no possibility to take breaks and pauses?	N				
19: Is there no possibility to choose order and type of work tasks or pace of work?	N				
20: Is the job performed under time demands or psychological stress?	N				
21: Can the work have unusual or expected situations?	N				
22: Are the following present?					
a) cold	Y				
b) heat	Y				
c) draft	Y				
d) noise	Y				
e) troublesome visual conditions	N				
f) jerks, shakes, or vibration	N				
<b>Environmental / Organizational Risk Factors Score</b>					
SUM	4				
PERCENTAGE	40.0				