Step-by-Step Guide:

NIOSH Lifting Equation (Single Task Examples)

The following examples from the NIOSH Lifting Equation Applications Manual have been adapted to show the proper use of the equation with our data collection worksheet and calculator. In addition, the examples show how this tool can be used to evaluate body mechanics recommendations and ergonomic redesign suggestions.

How to Use the Example Problems

There are several approaches for controlling the stressors related to manual lifting. One approach is to eliminate the manual requirements of the job by using hoists, cranes, manipulators, chutes, conveyors, or lift trucks, or through mechanization or automation. If the manual requirements of the job cannot be eliminated, then the demands of the job should be reduced through ergonomic design/redesign (e.g., modify the physical layout of the job or reduce the frequency or duration of lifting). As a last resort, and if redesign is not feasible, the stress on the worker should be reduced by distributing the stress between two or more workers (e.g., team lifting).

In many cases elimination of manual lifting is not feasible or practical. Thus, ergonomic design/redesign is the best available control strategy. The goal of such a strategy is to reduce the demands of the job by reducing exposure to dangerous loading conditions and stressful body movements.

Ergonomic design/redesign includes: (1) physical changes in the layout of the job, (2) reductions in the lifting frequency rate and/or the duration of the work period, and (3) modifications of the physical properties of the object lifted, such as type, size, or weight and/or improvement of hand-to-object coupling.

The lifting equation and procedures presented in this document were designed to identify ergonomic problems, and evaluate ergonomic design/redesign solutions. By examining the value of each task multiplier, the penalties associated with each job-related risk factor can be evaluated, thereby determining their relative importance in consideration of alternate workplace designs. The task factors that cause the greatest reduction in the load constant should be considered as the first priority for job redesign. Some general design/redesign suggestions outlined in the applications manual are as follows:

- If **HM** < 1.0 - Bring the load closer to the worker by removing any horizontal barriers or reducing the size of the object. Lifts near the floor should be avoided; if unavoidable, the object should fit easily between the legs.

- If **VM** < 1.0 - Raise/lower the origin/destination of the lift. Avoid lifting near the floor or above the shoulders.

- If **DM** < 1.0 - Reduce the vertical distance between the origin and the destination of the lift.

- If **AM** < 1.0 - Move the origin and destination of the lift closer together to reduce the angle of twist, or move the origin and destination further apart to force the worker to turn the feet and step, rather than twist the body.

- If **FM** < 1.0 - Reduce the lifting frequency rate, reduce the lifting duration, or provide longer recovery periods (i.e., light work period).

- If **CM** < 1.0 - Improve the hand-to-object coupling by providing optimal containers with handles or handhold cutouts, or improve the handholds for irregular objects.

- If **RWL** at the destination is less than at the origin - Eliminate the need for significant control of the object at the destination by redesigning the job or modifying the container/object characteristics.

Examples are provided to demonstrate the proper application of the lifting equation and procedures. The procedures provide a method for determining the level of physical stress associated with a specific set of lifting conditions, and assist in identifying the contribution of each job-related factor. The examples also provide guidance in developing an ergonomic redesign strategy. Specifically, for each example, a job description, job analysis, hazard assessment, redesign suggestion, illustration, and completed worksheet are provided. The ten examples were chosen to provide a representative sample of lifting jobs for which the application of this equation was suitable.

The examples are organized as follows:

Single Task, Performed a Few Times Per Shift

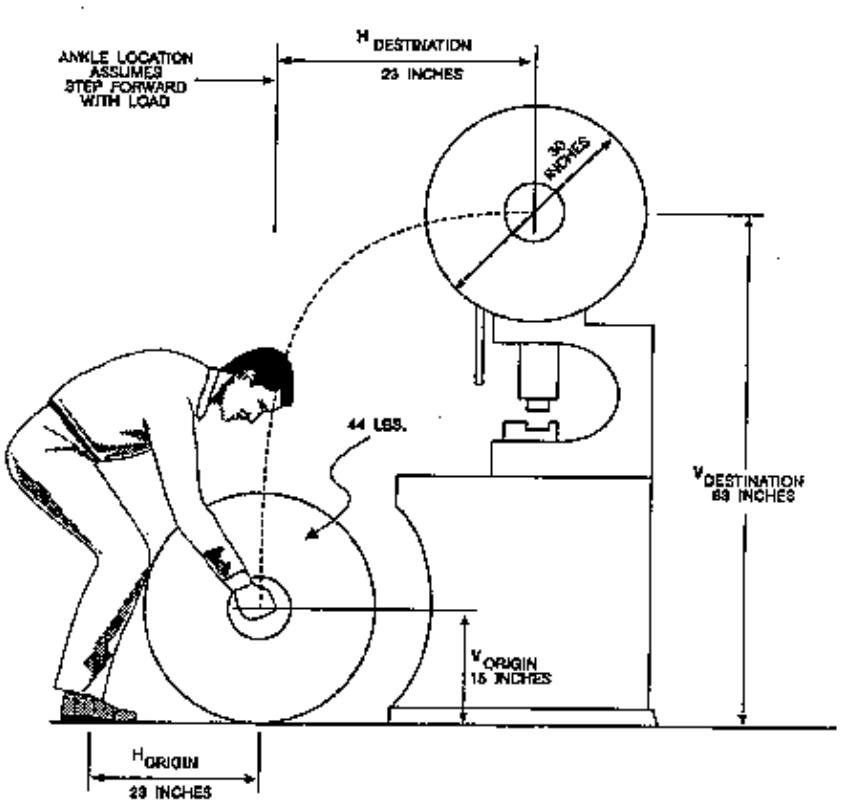
1. Loading Punch Press Stock
2. Loading Supply Rolls
3. Loading Bags Into A Hopper

Single Task, Performed Repetitively

4. Package Inspection
5. Dish-Washing Machine Unloading
6. Product Packaging I

Example 1: Loading Punch Press Stock

Job Description:
A punch press operator routinely handles small parts, feeding them into a press and removing them. A cursory view of this task may overlook the fact that once per shift the operator must load a heavy reel of supply stock (illustrated at floor height) from the floor onto the machine. The diameter of the reel is 30 inches, the width of the reel between the worker's hands is 12 inches, and the reel weighs 44 lbs. Significant control of the load is required at the destination of the lift due to the design of the machine. Also, the worker cannot get closer to the roll (i.e., between the legs) because the roll is too awkward.



Job Analysis:
The task variable data are measured and recorded on the Ergonomics Plus data collection worksheet as follows:

Data collection worksheet:

Department: *Manufacturing* Job: *Punch Press Operator*

ERGONOMICS PLUS	NIOSH Lifting Variables								
Lifting Task	**H** Horizontal Location (10-25")	**V** Vertical Location (0-70")	**D** Travel Distance (10-70")	**A** Angle of Asymmetry (0° - 135°)	**C** Coupling (1=good, 2=fair, 3=poor)	**F** Frequency (0.2 - 15 lifts/min)	**L** Ave. Load Lifted (lbs.)	**L** Max. Load Lifted (lbs.)	**Dur** Duration (1, 2, 8 hours)
Loading Supply Stock - Origin	23	15	48	0	2	0.2	44	44	1
Loading Supply Stock - Destination	23	63	48	0	2	0.2	44	44	1

Assuming the operator lifts the reel in the plane shown, rather than on the side of the machine, the vertical height (V) at the origin is 15 inches, the vertical height (V) at the destination is 63 inches, and the horizontal distance (H) is 23 inches at both the origin and the destination of the lift. The activity occurs only once per shift, so F is assumed to be < 0.2 and duration is assumed to be less than 1 hour. No asymmetric lifting is involved (i.e., A = 0), and the couplings are classified as fair because the object is irregular and the fingers can be flexed about 90 degrees. Since significant control is required at the destination, the RWL must be computed at both the origin and the destination of the lift.

Hazard Assessment:

Analyst: Mark Middlesworth **Task:** Loading Supply Stock - Origin

Inputs:		Multipliers:	
Horizontal Location (min. 10", max. 25")	**23**	HM	**0.43**
Vertical Location (min. 0", max. 70")	**15**	VM	**0.89**
Travel Distance (min 10", max. 70")	**48**	DM	**0.86**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**2**	CM	**0.95**
Frequency (min. 0.2 lifts/min.)	**0.2**	FM	**1.00**
Avg. Load (lbs.)	**44**		
Max Load (lbs.)	**44**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds): Lifting Index:

RWL = **16.03** **LI =** **2.74**

FIRWL = **16.03** **FILI =** **2.74**

Recommendations:
Engineering or ergonomic intervention should be implemented.

Analyst: Mark Middlesworth **Task:** Loading Supply Stock - Destination

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**23**	HM	**0.43**
Vertical Location (min. 0", max. 70")	**63**	VM	**0.75**
Travel Distance (min 10", max. 70")	**48**	DM	**0.86**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**2**	CM	**1.00**
Frequency (min. 0.2 lifts/min.)	**0.2**	FM	**1.00**
Avg. Load (lbs.)	**44**		
Max Load (lbs.)	**44**		
Duration (hours)	**1**		

(enter 1, 2 or 8)

Results

Recommended Weight Limit (in pounds):		Lifting Index:	
RWL =	**14.31**	LI =	**3.08**
FIRWL =	**14.31**	FILI =	**3.08**

Recommendations:
Engineering or ergonomic intervention should be implemented.

The RWL for this activity is 16.0 lb. at the origin and 14.3 lb. at the destination. The weight to be lifted (44 lb.) is greater than the RWL at both the origin and the destination of the lift. The LI at the origin is 2.74 and the LI at the destination is 3.08. These values indicate that this lift would be hazardous for a majority of healthy industrial workers.

Redesign Suggestions:
The calculator above indicates that the smallest multipliers (i.e., the greatest penalties) are .43 for the HM, .75 for the VM at the destination, and .86 for the DM. Therefore, the following job modifications are suggested:

1. Bring the object closer to the worker at the destination to increase the HM value.
2. Lower the destination of the lift to increase the VM value.
3. Reduce the vertical travel distance between the origin and the destination of the lift to increase the DM value.
4. Modify the job so that significant control of the object at the destination is not required. This will eliminate the need to use the lower RWL value at the destination.

If the operator could load the machine from the side, rather than the from the front, the reel could be turned 90 degrees which would reduce the horizontal location of the hands at the origin (i.e., H = 10 inches) and destination of the lift (i.e., H = 12 inches). The grip, however,

would be poor because the object is bulky and hard to handle and the fingers could not be flexed near 90 degrees when picking up the reel.

Modified assessment using the improved body mechanics as suggested above:

Analyst: Mark Middlesworth **Task:** Loading Supply Stock – Modified Origin

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**10**	HM	**1.00**
Vertical Location (min. 0", max. 70")	**15**	VM	**0.89**
Travel Distance (min 10", max. 70")	**48**	DM	**0.86**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**3**	CM	**0.90**
Frequency (min. 0.2 lifts/min.)	**0.2**	FM	**1.00**
Avg. Load (lbs.)	**44**		
Max Load (lbs.)	**44**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds):		Lifting Index:	
RWL =	**34.93**	**LI =**	**1.26**
FIRWL =	**34.93**	**FILI =**	**1.26**

Recommendations:
Engineering or ergonomic intervention should be implemented.

Analyst: Mark Middlesworth **Task:** Loading Supply Stock – Modified Destination

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**12**	HM	**0.83**
Vertical Location (min. 0", max. 70")	**63**	VM	**0.75**
Travel Distance (min 10", max. 70")	**48**	DM	**0.86**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**3**	CM	**0.90**
Frequency (min. 0.2 lifts/min.)	**0.2**	FM	**1.00**

Avg. Load (lbs.)	**44**
Max Load (lbs.)	**44**
Duration (hours) (enter 1, 2 or 8)	**1**

Results

Recommended Weight Limit (in pounds):

RWL = **24.68**

FIRWL = **24.68**

Lifting Index:

LI = **1.78**

FILI = **1.78**

Recommendations:
Engineering or ergonomic intervention should be implemented.

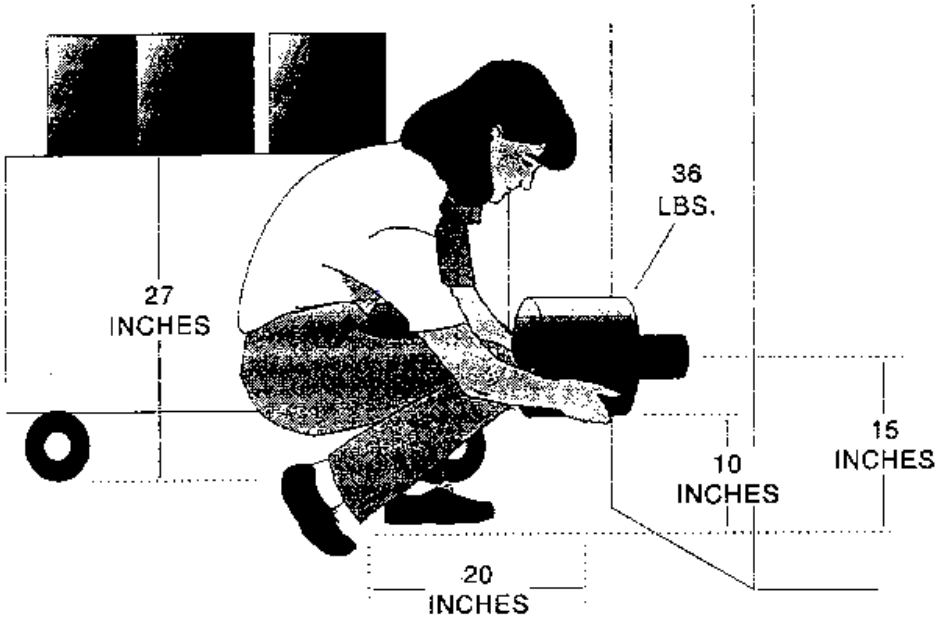
The RWL and corresponding LI values for this preferred combination of task variables (i.e., loading the machine from the side) are shown on the modified job analysis sheets above. At the origin, the RWL is 34.9 lb. and the LI is 1.26. At the destination, the RWL is 24.7 lb. and the LI is 1.78. Since the LI is still greater than 1.0, however, a more comprehensive solution may be needed. This could include: (1) lowering the vertical height of the destination, which would increase the VM and the DM at both the origin and the destination of the lift; (2) reducing the size and/or weight of the supply reel; (3) transferring the supply reel from the storage area on a mobile, mechanical lifting device or jack that could be moved near the machine to eliminate the need for manual lifting. If it is not feasible to eliminate or redesign the job, then other measures, such as assigning two or more workers, could be considered as an interim control procedure.

Comments:

Although ergonomic redesign is preferred, this example demonstrates how a change in work practices (i.e., insuring that the operator can load the reel from the side) can reduce the magnitude of physical stress associated with a manual lifting task. This approach, however, relies more on worker compliance than on physical job modifications.

Example 2: Loading Supply Rolls

Job Description:
With both hands directly in front of the body, a worker lifts the core of a 35-lb roll of paper from a cart, and then shifts the roll in the hands and holds it by the sides to position it on a machine, as shown below. Significant control of the roll is required at the destination of the lift. Also, the worker must crouch at the destination of the lift to support the roll in front of the body, but does not have to twist.



Job Analysis:
The task variable data are measured and recorded on the Ergonomics Plus data collection worksheet as follows:

Data collection worksheet:

Department: *Shipping* Job: *Packager*

Lifting Task	NIOSH Lifting Variables								
	H Horizontal Location (10-25")	**V** Vertical Location (0-70")	**D** Travel Distance (10-70")	**A** Angle of Asymmetry (0° - 135°)	**C** Coupling (1=good, 2=fair, 3=poor)	**F** Frequency (0.2 - 15 lifts/min)	**L** Ave. Load Lifted (lbs.)	**L** Max. Load Lifted (lbs.)	**Dur** Duration (1, 2, 8 hours)
Load paper supply rolls - Origin	*15*	*27*	*17*	*0*	*3*	*0.2*	*35*	*35*	*1*
Load paper supply rolls - Destination	*20*	*10*	*17*	*0*	*3*	*0.2*	*35*	*35*	*1*

The vertical location of the hands is 27 inches at the origin and 10 inches at the destination. The horizontal location of the hands is 15 inches at the origin and 20 inches at the destination. The asymmetric angle is 0 degrees at both the origin and the destination, and the frequency is 4 lifts/shift (i.e., less than .2 lifts/min for less than 1 hour). The coupling is classified as poor because the worker must reposition the hands at the destination of the lift and they can't flex the fingers to the desired 90 degrees angle (e.g., hook grip). No asymmetric lifting is involved (i.e., A = 0), and significant control of the object is required at the destination of the lift. Thus, the RWL should be computed at both the origin and the destination of the lift.

Hazard Assessment:

Analyst: Mark Middlesworth **Task:** Loading Paper Supply Rolls - Origin

Inputs:		Multipliers:	
Horizontal Location (min. 10", max. 25")	**15**	HM	**0.67**
Vertical Location (min. 0", max. 70")	**27**	VM	**0.98**
Travel Distance (min 10", max. 70")	**17**	DM	**0.93**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**3**	CM	**0.90**
Frequency (min. 0.2 lifts/min.)	**0.2**	FM	**1.00**
Avg. Load (lbs.)	**35**		
Max Load (lbs.)	**35**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds): Lifting Index:

RWL = **27.69** **LI =** **1.26**

FIRWL = **27.69** **FILI =** **1.26**

Recommendations:
Engineering or ergonomic intervention should be implemented.

Analyst: Mark Middlesworth **Task:** Loading Paper Supply Rolls - Destination

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**20**	HM	**0.50**
Vertical Location (min. 0", max. 70")	**10**	VM	**0.85**
Travel Distance (min 10", max. 70")	**17**	DM	**0.93**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**3**	CM	**0.90**
Frequency (min. 0.2 lifts/min.)	**0.2**	FM	**1.00**
Avg. Load (lbs.)	**35**		
Max Load (lbs.)	**35**		

Duration (hours) (enter 1, 2 or 8)	**1**

Results

Recommended Weight Limit (in pounds):		Lifting Index:	
RWL =	**18.06**	**LI =**	**1.94**
FIRWL =	**18.06**	**FILI =**	**1.94**

Recommendations:
Engineering or ergonomic intervention should be implemented.

The weight to be lifted (35 lb.) is greater than the RWL at both the origin and destination of the lift (27.7 lb. and 18.1 lb. respectively). The LI at the origin is 1.26, and the LI at the destination is 1.94. These values indicate that this job is only slightly stressful at the origin, but moderately stressful at the destination of the lift.

Redesign Suggestions:
The first choice for reducing the risk of injury for workers performing this task would be to adapt the cart so that the paper rolls could be easily pushed into position on the machine, without manually lifting them.

If the cart cannot be modified, then the results of the equation may be used to suggest task modifications. The calculator worksheet above indicates that the multipliers with the smallest magnitude (i.e., those providing the greatest penalties) are .50 for the HM at the destination, .67 for the HM at the origin, .85 for the VM at the destination, and .90 for the CM value. The following job modifications are suggested:

1. Bring the load closer to the worker by making the roll smaller so that the roll can be lifted from between the worker's legs. This will decrease the H value, which in turn will increase the HM value.
2. Raise the height of the destination to increase the VM.
3. Improve the coupling to increase the CM.

If the size of the roll can't be reduced, then the vertical height (V) of the destination should be increased. Using the calculator modified assessment as shown below, you can see what happens to the RWL and LI for this lifting task if V is increased to 30 inches at the destination:

Analyst: Mark Middlesworth **Task:** Loading Paper Supply Rolls - Destination

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**15**	HM	**0.67**
Vertical Location (min. 0", max. 70")	**30**	VM	**1.00**
Travel Distance (min 10", max. 70")	**5**	DM	**1.00**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**3**	CM	**0.90**
Frequency (min. 0.2 lifts/min.)	**0.2**	FM	**1.00**
Avg. Load (lbs.)	**35**		
Max Load (lbs.)	**35**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds):		Lifting Index:	
RWL =	**30.60**	**LI =**	**1.14**
FIRWL =	**30.60**	**FILI =**	**1.14**

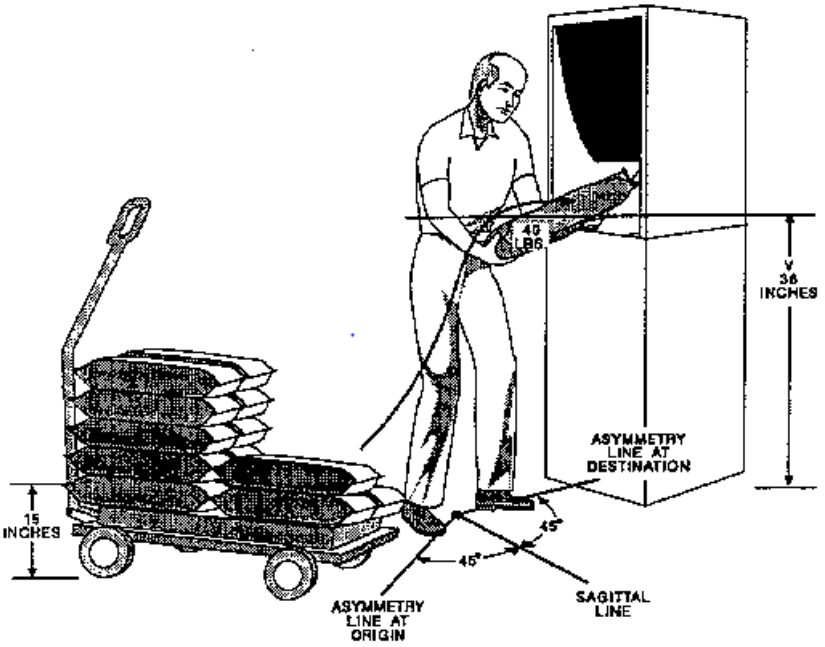
Recommendations:
Engineering or ergonomic intervention should be implemented.

The VM would be increased from .85 to 1.0; the H value would be decreased from 20 inches to 15 inches, which would increase HM from .50 to .67.; and the DM would be increased from .93 to 1.0. Thus, the final RWL would be increased from 18.1 lb. to 30.6 lb., and the LI at the destination would decrease from 1.94 to 1.14. In some cases, redesign may not be feasible. In these cases, use of a mechanical lift may be more suitable. As an interim control strategy, two or more workers may be assigned to lift the supply roll.

Comments:
The horizontal distance (H) is a significant factor that may be difficult to reduce because the size of the paper rolls may be fixed. Moreover, redesign of the machine may not be practical. Therefore, elimination of the manual lifting component of the job may be more appropriate than job redesign.

Example 3: Loading Bags into a Hopper

Job Description:
The worker positions himself midway between the hand truck and the mixing hopper, as illustrated in the picture below. Without moving his feet, he twists to the right and picks up a bag off the hand truck. In one continuous motion he then twists to his left to place the bag on the rim of the hopper. A sharp edged blade within the hopper cuts open the bag to allow the contents to fall into the hopper. This task is done infrequently (i.e., 1-12 times per shift) with large recovery periods between lifts (i.e., > 1.2 Recovery Time/Work Time ratio). In observing the worker perform the job, it was determined that the non-lifting activities could be disregarded because they require minimal force and energy expenditure. Significant control is not required at the destination, but the worker twists at the origin and destination of the lift. Although several bags are stacked on the hand truck, the highest risk of overexertion injury is associated with the bag on the bottom of the stack; therefore, only the lifting of the bottom bag will be examined. Note, however, that the frequency multiplier is based on the overall frequency of lifting for all of the bags.



Job Analysis:
The task variable data are measured and recorded on the Ergonomics Plus data collection worksheet as follows:

Data collection worksheet:

Department: *Batch Processing* Job: *Dumping bags into mixing hopper*

ERGONOMICS PLUS	NIOSH Lifting Variables								
Lifting Task	**H** Horizontal Location (10-25")	**V** Vertical Location (0-70")	**D** Travel Distance (10-70")	**A** Angle of Asymmetry (0° - 135°)	**C** Coupling (1=good, 2=fair, 3=poor)	**F** Frequency (0.2 - 15 lifts/min)	**L** Ave. Load Lifted (lbs.)	**L** Max. Load Lifted (lbs.)	**Dur** Duration (1, 2, 8 hours)
Lifting bags from cart - Origin	18	15	21	45	2	0.2	40	40	1
Dumping bags into hopper - Destination	10	36	21	45	2	0.2	40	40	1

The vertical location of the hands is 15 inches at the origin and 36 inches at the destination. The horizontal location of the hands is 18 inches at the origin and 10 inches at the destination. The asymmetric angle is 45 degrees at the origin and 45 degrees at the destination of the lift, and the frequency is less than .2 lifts/min for less than 1 hour. The coupling is classified as fair because the worker flexes the fingers about 90 degrees and the bags are semi-rigid (i.e., they do not sag in the middle).

Hazard Assessment:

Analyst: Mark Middlesworth **Task:** Dumping bags into hopper - Origin

Inputs:		Multipliers:	
Horizontal Location (min. 10", max. 25")	**18**	HM	**0.56**
Vertical Location (min. 0", max. 70")	**15**	VM	**0.89**
Travel Distance (min 10", max. 70")	**21**	DM	**0.91**
Angle of Asymmetry (min. 0, max. 135)	**45**	AM	**0.86**
Coupling (1=good | 2=fair | 3=poor)	**2**	CM	**0.95**
Frequency (min. 0.2 lifts/min.)	**0.2**	FM	**1.00**
Avg. Load (lbs.)	**40**		
Max Load (lbs.)	**40**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds): Lifting Index:

RWL = **18.52** **LI =** **2.16**

FIRWL =	**18.52**	**FILI =**	**2.16**

Recommendations:
Engineering or ergonomic intervention should be implemented.

Significant control of the object is not required at the destination of the lift so the RWL is computed only at the origin. The RWL for this activity is 18.5 lb. The weight to be lifted (40 lb.) is greater than the RWL (18.5 lb.). Therefore, the LI is 40/18.5 or 2.16. This job would be physically stressful for many industrial workers.

Redesign Suggestions:
The smallest multipliers (i.e., the greatest penalties) are .56 for the HM, .86 for the AM, and .89 for the VM. The following job modifications are suggested:

1. Bringing the load closer to the worker to increase the HM.
2. Reducing the angle of asymmetry to increase AM. This could be accomplished either by moving the origin and destination points closer together or further apart.
3. Raising the height at the origin to increase the VM.

Analyst:	Mark Middlesworth	**Task:**	Dumping bags into hopper - Modified Origin

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**10**	HM	**1.00**
Vertical Location (min. 0", max. 70")	**15**	VM	**0.89**
Travel Distance (min 10", max. 70")	**21**	DM	**0.91**
Angle of Asymmetry	**45**	AM	**0.86**

(min. 0, max. 135)			
Coupling (1=good | 2=fair | 3=poor)	**2**	CM	**0.95**
Frequency (min. 0.2 lifts/min.)	**0.2**	FM	**1.00**
Avg. Load (lbs.)	**40**		
Max Load (lbs.)	**40**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds):

RWL = **33.34**

FIRWL = **33.34**

Lifting Index:

LI = **1.20**

FILI = **1.20**

Recommendations:
Engineering or ergonomic intervention should be implemented.

As shown in the modified worksheet above, if the worker could get closer to the bag before lifting, the H value could be decreased to 10 inches, which would increase the HM to 1.0, the RWL would be increased to 33.3 lb., and the LI would be decreased to 1.20.

Comments:

This example demonstrates that certain lifting jobs may be evaluated as a single-task or multi-task job. In this case, only the most stressful component of the job was evaluated. For repetitive lifting jobs, the multi-task approach may be more appropriate.

Example 4: Package Inspection

Job Description:
This job consists of a worker inspecting compact containers for damage on a low shelf, and then lifting them with both hands directly in front of the body from shelf 1 to shelf 2 at a rate of 3 per minute for a duration of 45 minutes. For this analysis, assume that (1) the worker cannot take a step forward when placing the object at the destination, due to the bottom shelf, and (2) significant control of the object is required at the destination. The containers are of optimal design, but without handles.

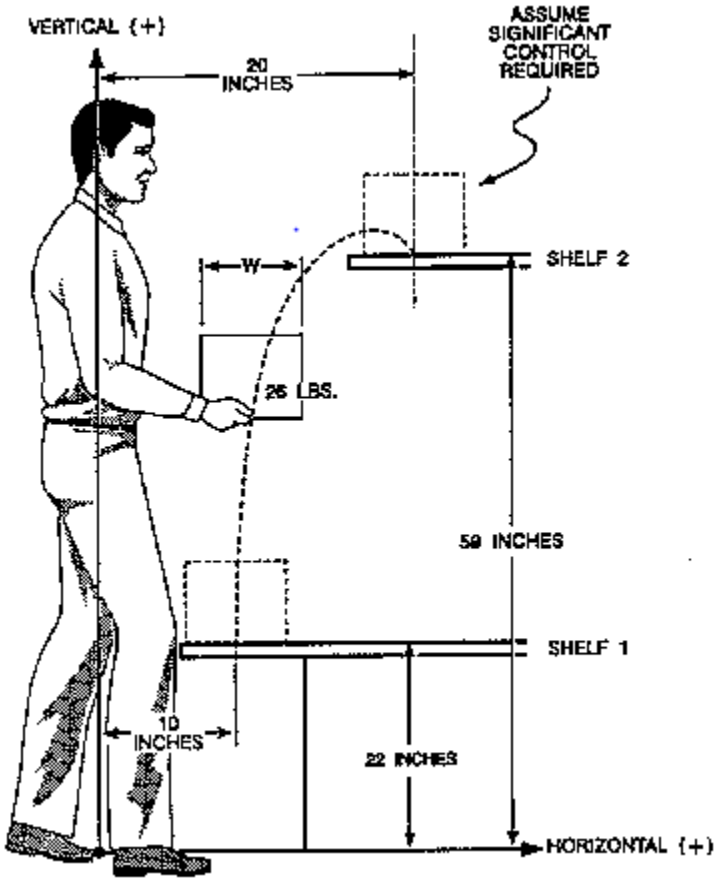


Figure 13 Package Inspection, Example 4

Job Analysis:
The task variable data are measured and recorded on the Ergonomics Plus data collection worksheet as follows:

Data collection worksheet:

Department: *Quality Control* Job: *Packing Inspector*

ERGONOMICS PLUS	NIOSH Lifting Variables								
Lifting Task	**H** Horizontal Location (10-25")	**V** Vertical Location (0-70")	**D** Travel Distance (10-70")	**A** Angle of Asymmetry (0° - 135°)	**C** Coupling (1=good, 2=fair, 3=poor)	**F** Frequency (0.2 - 15 lifts/min)	**L** Ave. Load Lifted (lbs.)	**L** Max. Load Lifted (lbs.)	**Dur** Duration (1, 2, 8 hours)
Lifting from shelf 1 - Origin	*10*	*22*	*37*	*0*	*2*	*3*	*26*	*26*	*1*
Placing onto shelf 2 - Destination	*20*	*59*	*37*	*0*	*2*	*3*	*26*	*26*	*1*

The horizontal distance at the origin of the lift is 10 inches and the horizontal distance at the destination of the lift is 20 inches. The height of shelf one is 22 inches and the height of shelf two is 59 inches. Since the container is of optimal design, but does not have handles or handhold cutouts, the coupling is defined as "fair" (i.e., C=2). No asymmetric lifting is involved (i.e., A = 0). Since the lifting pattern is continuous over the 45 minute work session, the lifting frequency is not adjusted. Significant control of the load is required at the destination of the lift. Therefore, the RWL is computed at both the origin and the destination of the lift.

Hazard Assessment:

Analyst: Mark Middlesworth **Task:** Packing inspection - Origin

Inputs:		Multipliers:	
Horizontal Location (min. 10", max. 25")	**10**	HM	**1.00**
Vertical Location (min. 0", max. 70")	**22**	VM	**0.94**
Travel Distance (min 10", max. 70")	**37**	DM	**0.87**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**2**	CM	**0.95**
Frequency (min. 0.2 lifts/min.)	**3**	FM	**0.88**
Avg. Load (lbs.)	**26**		
Max Load (lbs.)	**26**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds): Lifting Index:

RWL = **34.81** **LI =** **0.75**

FIRWL = **39.56** **FILI =** **0.66**

Recommendations:
Nominal risk.

Analyst: Mark Middlesworth **Task:** Packing inspection - Destination

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**20**	HM	**0.50**
Vertical Location (min. 0", max. 70")	**59**	VM	**0.78**
Travel Distance (min 10", max. 70")	**37**	DM	**0.87**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**2**	CM	**1.00**
Frequency (min. 0.2 lifts/min.)	**3**	FM	**0.88**
Avg. Load (lbs.)	**26**		
Max Load (lbs.)	**26**		
Duration (hours)	**1**		

(enter 1, 2 or 8)

Results

Recommended Weight Limit (in pounds):

RWL = **15.25**

FIRWL = **17.33**

Lifting Index:

LI = **1.70**

FILI = **1.50**

Recommendations:
Engineering or ergonomic intervention should be implemented.

The RWL for this activity is 34.8 lb. at the origin and 15.3 lb. at the destination. The weight to be lifted (26 lb.) is less than the RWL at the origin (34.9 lb.) but greater than the RWL at the destination (15.2 lb.). The LI is 26/34.8 is .75 at the origin, and the LI is 26/15.3 or 1.70 at the destination. These values indicate that the destination of the lift is more stressful than the origin, and that some healthy workers would find this task physically stressful.

Redesign Suggestions:
The multipliers with the smallest magnitude (i.e., those that provide the greatest penalties) are .50 for the HM at the destination, .78 for the VM, .87 for the DM, and .88 for the FM at the destination of the lift. The following job modifications are suggested:

1. Bring the destination point closer to the worker to increase the HM value.
2. Lower the height of shelf 2 to increase the VM value.
3. Decrease the vertical distance between origin and destination of lift to increase the DM value.
4. Reduce the lifting frequency rate to increase the FM value.
5. Modify the task so that there is no need for significant control of the object at the destination to eliminate the lower RWL value.

Analyst: Mark Middlesworth **Task:** Packing inspection - Modified Destination

Inputs:		Multipliers:	
Horizontal Location (min. 10", max. 25")	**14**	HM	**0.71**
Vertical Location (min. 0", max. 70")	**39**	VM	**0.93**
Travel Distance (min 10", max. 70")	**17**	DM	**0.93**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**2**	CM	**1.00**
Frequency (min. 0.2 lifts/min.)	**3**	FM	**0.88**
Avg. Load (lbs.)	**26**		
Max Load (lbs.)	**26**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds): **RWL = 27.68**

Lifting Index: **LI = 0.94**

FIRWL =	**31.45**	**FILI =**	**0.83**

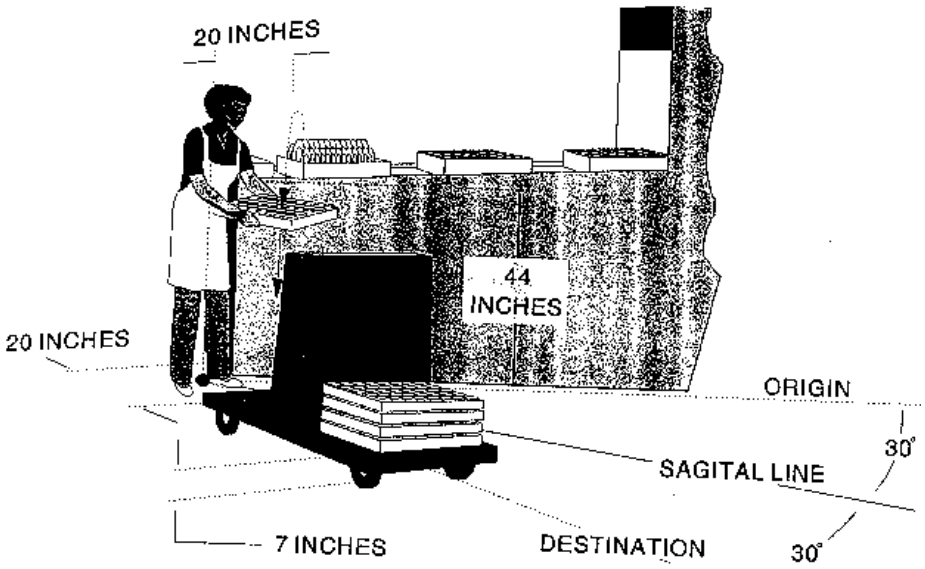
Recommendations:
Nominal risk.

Practical job modifications could include bringing shelf 2 closer to the worker to reduce H, raising the height of shelf 1 to increase the CM value, lowering the height of shelf 2 to reduce D, or reducing the need for significant control at the end of the lift by providing a receiving chute.

Comments:
As the modified worksheet above shows, if the H is reduced to 14" and the destination V is lowered to 39", the RWL would now be 27.7 lb. and the LI would be .94. This ergonomic design improvement would significantly lower the injury risk to healthy employees.

Example 5: Dish-Washing Machine Unloading

Job Description:
A worker manually lifts trays of clean dishes from a conveyor at the end of a dish washing machine and loads them on a cart as shown below. The trays are filled with assorted dishes (e.g., glasses, plates, bowls) and silverware. The job takes between 45 minutes and 1 hour to complete, and the lifting frequency rate averages 5 lifts/min. Workers usually twist to one side of their body to lift the trays (i.e., asymmetric lift) and then rotate to the other side of their body to lower the trays to the cart in one smooth continuous motion. The maximum amount of asymmetric twist varies between workers and within workers, however, there is usually equal twist to either side. During the lift the worker may take a step toward the cart. The trays have well designed handhold cutouts and are made of lightweight materials.



Job Analysis:
The task variable data are measured and recorded on the Ergonomics Plus data collection worksheet as follows:

Data collection worksheet:

Department: *Food Service* Job: *Unload dish-washing machine*

ERGONOMICS PLUS	NIOSH Lifting Variables								
Lifting Task	**H** Horizontal Location (10-25")	**V** Vertical Location (0-70")	**D** Travel Distance (10-70")	**A** Angle of Asymmetry (0° - 135°)	**C** Coupling (1=good, 2=fair, 3=poor)	**F** Frequency (0.2 - 15 lifts/min)	**L** Ave. Load Lifted (lbs.)	**L** Max. Load Lifted (lbs.)	**Dur** Duration (1, 2, 8 hours)
Lift trays off conveyor - Origin	*20*	*44*	*37*	*30*	*1*	*5*	*20*	*20*	*1*
Lower trays to cart - Destination	*20*	*7*	*37*	*30*	*1*	*5*	*20*	*20*	*1*

At the origin of the lift, the horizontal distance (H) is 20 inches, the vertical distance (V) is 44 inches, and the angle of asymmetry (A) is 30 degrees. At the destination of the lift, H is 20 inches, V is 7 inches, and A is 30 degrees. The trays normally weigh from 5 lb. to 20 lb., but for this example, assume that all of the trays weigh 20 lb.. The coupling is classified as “good”.

Significant control of the load is required at the destination of the lift. Therefore, the RWL is computed at both the origin and the destination of the lift.

Hazard Assessment:

Analyst: Mark Middlesworth **Task:** Unloading dish-washing machine - Origin

Inputs:		Multipliers:	
Horizontal Location (min. 10", max. 25")	**20**	HM	**0.50**
Vertical Location (min. 0", max. 70")	**44**	VM	**0.90**
Travel Distance (min 10", max. 70")	**37**	DM	**0.87**
Angle of Asymmetry (min. 0, max. 135)	**30**	AM	**0.90**
Coupling (1=good | 2=fair | 3=poor)	**1**	CM	**1.00**
Frequency (min. 0.2 lifts/min.)	**5**	FM	**0.80**
Avg. Load (lbs.)	**20**		
Max Load (lbs.)	**20**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds): Lifting Index:

RWL =	**14.34**	**LI =**	**1.39**
FIRWL =	**17.92**	**FILI =**	**1.12**

Recommendations:
Engineering or ergonomic intervention should be implemented.

Analyst: Mark Middlesworth **Task:** Unloading dish-washing machine - Destimation

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**20**	HM	**0.50**
Vertical Location (min. 0", max. 70")	**7**	VM	**0.83**
Travel Distance (min 10", max. 70")	**37**	DM	**0.87**
Angle of Asymmetry (min. 0, max. 135)	**30**	AM	**0.90**
Coupling (1=good | 2=fair | 3=poor)	**1**	CM	**1.00**
Frequency (min. 0.2 lifts/min.)	**5**	FM	**0.80**
Avg. Load (lbs.)	**20**		
Max Load (lbs.)	**20**		

Duration (hours) (enter 1, 2 or 8)	1

Results

Recommended Weight Limit (in pounds):		Lifting Index:	
RWL =	**13.26**	**LI =**	**1.51**
FIRWL =	**16.57**	**FILI =**	**1.21**

Recommendations:
Engineering or ergonomic intervention should be implemented.

The weight to be lifted (20 lb.) is greater than the RWL at both the origin and destination of the lift (14.3 lb. and 13.3 lb., respectively). The LI at the origin is 20/14.4 or 1.39 and the LI at the destination is 1.51. These results indicate that this lifting task would be stressful for some workers and controls should be implemented.

Redesign Suggestions:
The worksheet shows that the smallest multipliers (i.e., the greatest penalties) are .50 for the HM, .80 for the FM, .83 for the VM, and .90 for the AM. The following job modifications are suggested:

1. Bring the load closer to the worker to increase HM.
2. Reduce the lifting frequency rate to increase FM.
3. Raise the destination of the lift to increase VM.
4. Reduce the angle of twist to increase AM by either moving the origin and destination closer together or moving them further apart. Since the horizontal distance (H) is dependent on the width of the tray in the sagittal plane, this variable can only be reduced by using smaller trays. Both the DM and VM, however, can be increased by lowering the height of the origin and increasing the height of the destination. For example, if the height at both the origin and destination is 30 inches, then VM and DM

will be increased to 1.0. Moreover, if the cart is moved so that the twist is eliminated, the AM can be increased from .90 to 1.00.

Analyst: Mark Middlesworth **Task:** Unloading dish-washing machine - Modified

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**20**	HM	**0.50**
Vertical Location (min. 0", max. 70")	**30**	VM	**1.00**
Travel Distance (min 10", max. 70")	**0**	DM	**1.00**
Angle of Asymmetry (min. 0, max. 135)	**0**	AM	**1.00**
Coupling (1=good | 2=fair | 3=poor)	**1**	CM	**1.00**
Frequency (min. 0.2 lifts/min.)	**5**	FM	**0.80**
Avg. Load (lbs.)	**20**		
Max Load (lbs.)	**20**		
Duration (hours) (enter 1, 2 or 8)	**1**		

Results

Recommended Weight Limit (in pounds): Lifting Index:

RWL =	**20.40**	**LI =**	**0.98**
FIRWL =	**25.50**	**FILI =**	**0.78**

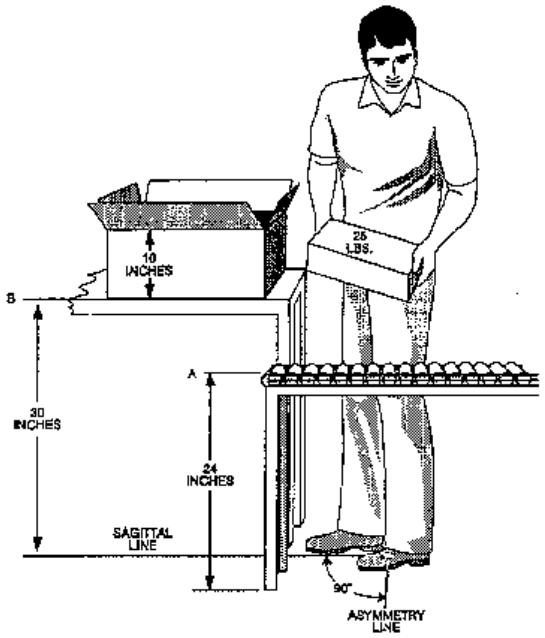
Recommendations:
Nominal risk.

As shown in the above modified worksheet, with these redesign suggestions the RWL can be increased from 13.3 lb. to 20.4 lb., and the LI values are reduced to .98 indicating nominal risk.

Comments:
This analysis was based on a one-hour work session. If a subsequent work session begins before the appropriate recovery period has elapsed (i.e., 1.2 hours), then the eight-hour category would be used to compute the FM value.

Example 6: Product Packaging I

Job Description:
In the job illustrated below, products weighing 25 lb. arrive via a conveyor at a rate of 1-per minute, where a worker packages the product in a cardboard box and then slides the packaged box to a conveyor behind table B. Assume that significant control of the object is not required at the destination, but that the worker twists to pick up the product; also assume that the worker can flex the fingers to the desired 90 degrees angle to grasp the container. The job is performed for a normal 8-hour shift, including regular rest allowance breaks.



Job Analysis:
The task variable data are measured and recorded on the Ergonomics Plus data collection worksheet as follows:

Data collection worksheet:

Department: *Distribution* Job: *Line Packer*

ERGONOMICS PLUS	NIOSH Lifting Variables								
Lifting Task	**H** Horizontal Location (10-25")	**V** Vertical Location (0-70")	**D** Travel Distance (10-70")	**A** Angle of Asymmetry (0° - 135°)	**C** Coupling (1=good, 2=fair, 3=poor)	**F** Frequency (0.2 - 15 lifts/min)	**L** Ave. Load Lifted (lbs.)	**L** Max. Load Lifted (lbs.)	**Dur** Duration (1, 2, 8 hours)
Package Products - Origin	*14*	*24*	*16*	*90*	*2*	*1*	*25*	*25*	*8*
Package Products - Destination	*16*	*40*	*16*	*0*	*2*	*1*	*25*	*25*	*8*

At the origin, the vertical location (V) is 24 inches and the horizontal location is 14 inches. At the destination, the vertical location is 40 inches, which represents the height of table B plus the height of the box, and the horizontal location is 16 inches. The coupling is classified as “fair” (2). The worker twists 90 degrees to pick up the product. The job is performed for an 8-hour shift with a frequency rate of 1-lift per minute. Since significant control is not required at the destination, the RWL is only computed at the origin of the lift.

Hazard Assessment:

Analyst: Mark Middlesworth **Task:** Line Packer - Origin

Inputs:		Multipliers:	
Horizontal Location (min. 10", max. 25")	**14**	HM	**0.71**
Vertical Location (min. 0", max. 70")	**24**	VM	**0.96**
Travel Distance (min 10", max. 70")	**16**	DM	**0.93**
Angle of Asymmetry (min. 0, max. 135)	**90**	AM	**0.71**
Coupling (1=good | 2=fair | 3=poor)	**2**	CM	**0.95**
Frequency (min. 0.2 lifts/min.)	**1**	FM	**0.75**
Avg. Load (lbs.)	**25**		
Max Load (lbs.)	**25**		
Duration (hours) (enter 1, 2 or 8)	**8**		

Results

Recommended Weight Limit (in pounds): Lifting Index:

RWL = **16.46** **LI =** **1.52**

FIRWL =	**21.94**	**FILI =**	**1.14**

Recommendations:
Engineering or ergonomic intervention should be implemented.

As shown above the RWL for this lifting task is 16.5 lb. The weight to be lifted (25 lb.) is greater than the RWL (16.4 lb.). Therefore, the LI is 25/16.5 or 1.52. This task would be stressful for some healthy workers.

Redesign Suggestions:
The worksheet above shows that the multipliers with the smallest magnitude (i.e., those providing the greatest penalties) are .71 for the HM, .71 for the AM, and .75 for the FM. Therefore, the following job modifications are suggested:

1. Bring the load closer to the worker to increase HM.
2. Move the lift's origin and destination closer together to reduce the angle of twist and increase the AM.
3. Reduce the lifting frequency rate and/or provide longer recovery periods to increase FM.

Assuming that the large horizontal distance is due to the size of the object lifted rather than the existence of a barrier, then the horizontal distance could only be reduced by making the object smaller or re-orienting the object. An alternate approach would be to eliminate body twist by providing a curved chute to bring the object in front of the worker.

Analyst:	Mark Middlesworth	**Task:**	Line Packer - Modified Origin

Inputs:		**Multipliers:**	
Horizontal Location (min. 10", max. 25")	**13**	HM	**0.77**
Vertical Location	**24**	VM	**0.96**

(min. 0", max. 70")			
Travel Distance (min 10", max. 70")	16	DM	0.93
Angle of Asymmetry (min. 0, max. 135)	0	AM	1.00
Coupling (1=good | 2=fair | 3=poor)	2	CM	0.95
Frequency (min. 0.2 lifts/min.)	1	FM	0.75
Avg. Load (lbs.)	25		
Max Load (lbs.)	25		
Duration (hours) (enter 1, 2 or 8)	8		

Results

Recommended Weight Limit (in pounds):

RWL = **24.89**

FIRWL = **33.19**

Lifting Index:

LI = **1.00**

FILI = **0.75**

Recommendations:
Engineering or ergonomic intervention should be implemented.

As shown on the above modified worksheet based on the redesign suggestions, the AM is increased from 0.71 to 1.0, the HM is increased from 0.71 to 0.77, the RWL is increased from 16.4 lb. to 24.9 lb., and the LI is decreased from 1.5 to 1.00. Eliminating body twist reduces the physical stress to an acceptable level for most workers. Alternate redesign recommendations could include: (1) raising the height of conveyor A and/or reducing the height of work bench B; or, (2) Providing good couplings on the containers. For example, the curved chute could also be designed to bring the load to a height of 30 inches. This would increase the VM, DM, and CM values to 1.0, which would reduce the lifting index even further.

Comments:
Although several alternate redesign suggestions are provided, reducing the asymmetric angle should be given a high priority because a significant number of overexertion lifting injuries are associated with excessive lumbar rotation and flexion.