3.3. Single Task, Performed Repetitively

3.3.1. Package Inspection, Example 4

3.3.1.1. Job Description

The job illustrated in Figure 13 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/min 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 (For classification, refer to Table 6).

3.3.1.2. Job Analysis

The task variable data are measured and recorded on the task analysis worksheet (Figure 14). 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" (see Table 6). No asymmetric lifting is involved (i.e., A = 0). 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.

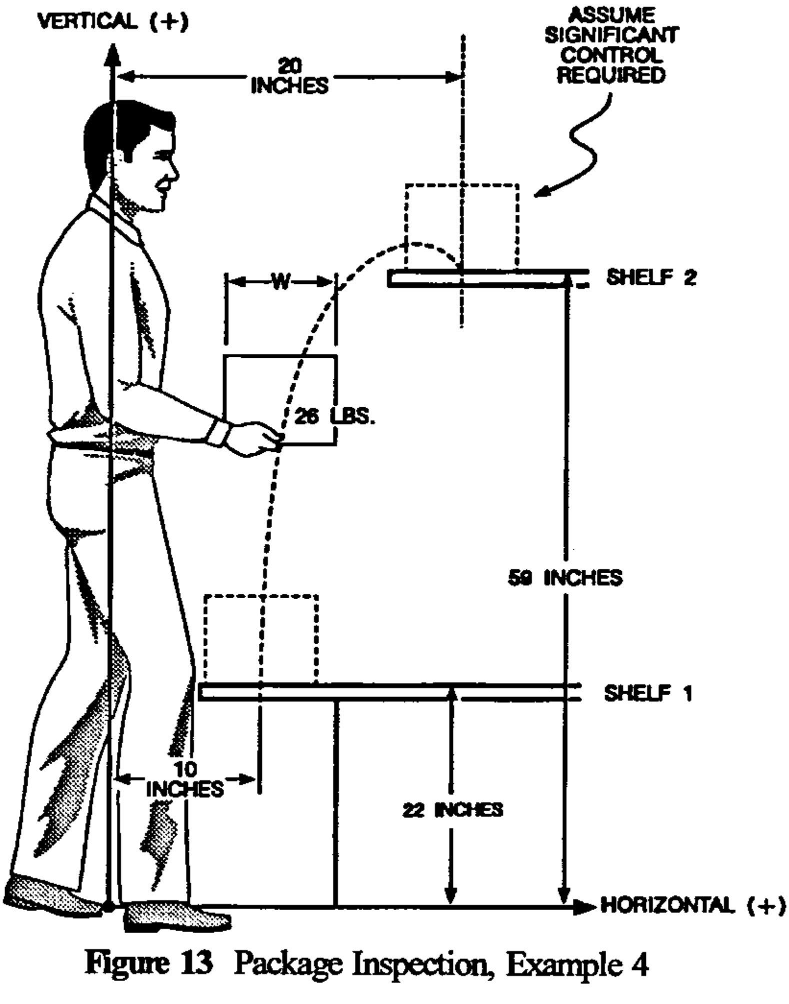

Figure 13 Package Inspection, Example 4

JOB ANALYSIS WORKSHEET

DEPARTMENT Quality Control
JOB TITLE Packing Inspector
ANALYST'S NAME
DATE

JOB DESCRIPTION
Inspect packages

Example 4

STEP 1. Measure and record task variables

Object Weight (lbs)		Hand Location (in)				Vertical Distance (in)	Asymmetric Angle (degrees)		Frequency Rate	Duration	Object Coupling
		Origin		Dest.			Origin	Destination	lifts/min	(HRS)	
L (AVG.)	L (Max.)	H	V	H	V	D	A	A	F		C
26	26	10	22	20	59	37	0	0	3	.75	Fair

STEP 2. Determine the multipliers and compute the RWL's

RWL = LC × HM × VM × DM × AM × FM × CM

ORIGIN RWL = 51 × 1.0 × .94 × .87 × 1.0 × .88 × .95 = 34.9 Lbs

DESTINATION RWL = 51 × .50 × .78 × .87 × 1.0 × .88 × 1.0 = 15.2 Lbs

STEP 3. Compute the LIFTING INDEX

ORIGIN LIFTING INDEX = OBJECT WEIGHT (L) / RWL = 26 / 34.9 = .8

DESTINATION LIFTING INDEX = OBJECT WEIGHT (L) / RWL = 26 / 15.2 = 1.7

Figure 14: Example 4, Job Analysis Worksheet

The multipliers are computed from the lifting equation or determined from the multiplier tables (Tables 1 to 5, and Table 7). As shown in Figure 14, the RWL for this activity is 34.9 lbs at the origin and 15.2 lbs at the destination.

3.3.1.3. Hazard Assessment

The weight to be lifted (26 lbs) is less than the RWL at the origin (34.9 lbs) but greater than the RWL at the destination (15.2 lbs). The LI is 26/34.9 or .76 (rounded to .8) at the origin, and the LI is 26/15.2 or 1.7 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.

3.3.1.4. Redesign Suggestions

The worksheet illustrated in Figure 14 shows that 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. Using Table 8, 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 in no need for significant control of the object at the destination to eliminate the lower RWL value.

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.

3.3.1.5. Comments

Since the lifting pattern is continuous over the 45 minute work session, the lifting frequency is not adjusted using the special procedure described on page 27.

3.3.2. Dish-Washing Machine Unloading, Example 5

3.3.2.1. 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 in Figure 15. 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.

3.3.2.2. Job Analysis

The task variable data are measured and recorded on the job analysis worksheet (Figure 16). 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 30^0. At the destination of the lift, H is 20 inches, V is 7 inches, and A is 30^0. The trays normally weigh from 5 lbs to 20 lbs, but for this example, assume that all of the trays weigh 20 lbs.

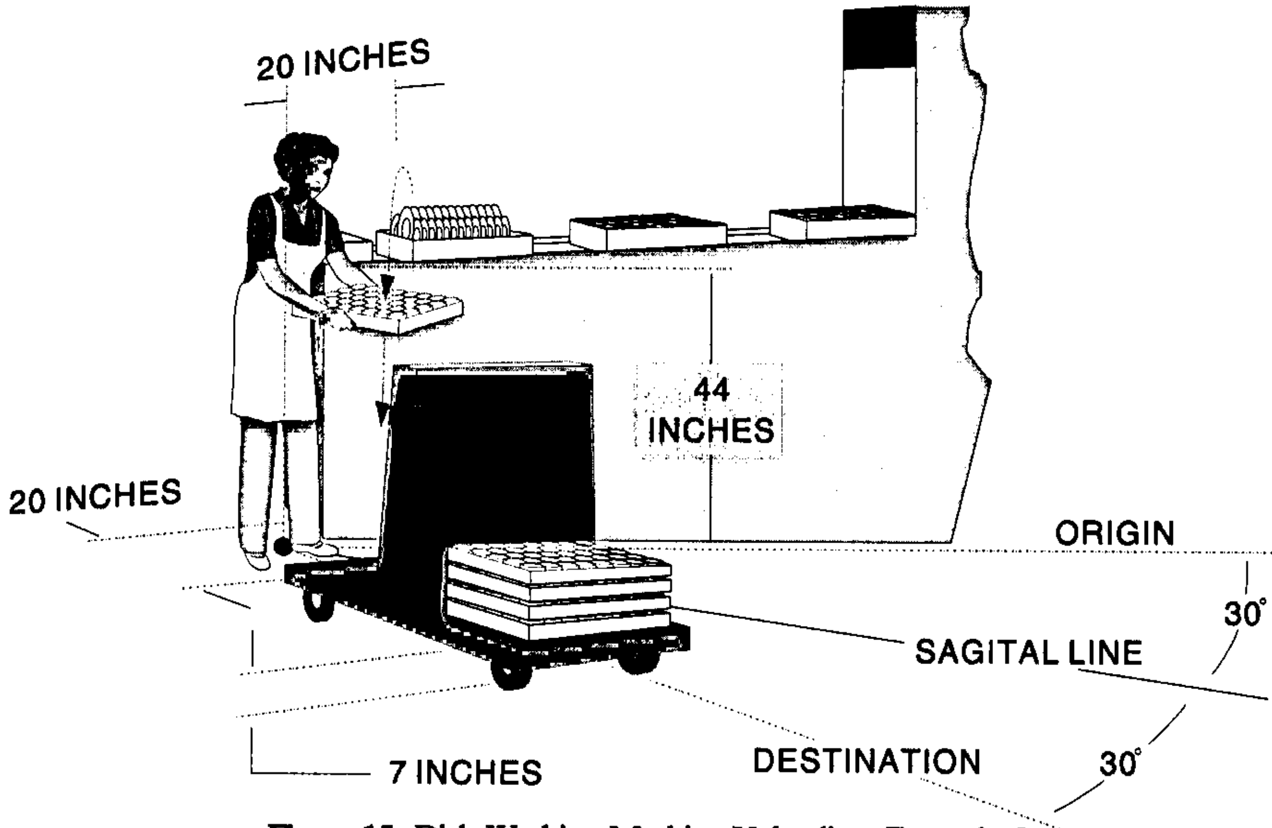

Figure 15 Dish-Washing Machine Unloading, Example 5

JOB ANALYSIS WORKSHEET

DEPARTMENT Food Service
JOB TITLE Cafeteria Worker
ANALYST'S NAME
DATE

JOB DESCRIPTION
Unloading a dish-washing machine
Example 5

STEP 1. Measure and record task variables

Object Weight (lbs)		Hand Location (in)				Vertical Distance (in)	Asymmetric Angle (degrees)		Frequency Rate	Duration	Object Coupling
		Origin		Dest.			Origin	Destination	lifts/min	(HRS)	
L (AVG.)	L (Max.)	H	V	H	V	D	A	A	F		C
20	20	20	44	20	7	37	30	30	5	< 1	Good

STEP 2. Determine the multipliers and compute the RWL's

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM$$

ORIGIN $RWL = 51 \times .50 \times .90 \times .87 \times .90 \times .80 \times 1.0 =$ 14.4 **Lbs**

DESTINATION $RWL = 51 \times .50 \times .83 \times .87 \times .90 \times .80 \times 1.0 =$ 13.3 **Lbs**

STEP 3. Compute the LIFTING INDEX

ORIGIN $\text{LIFTING INDEX} = \dfrac{\text{OBJECT WEIGHT (L)}}{\text{RWL}} = \dfrac{20}{14.4} = 1.4$

DESTINATION $\text{LIFTING INDEX} = \dfrac{\text{OBJECT WEIGHT (L)}}{\text{RWL}} = \dfrac{20}{13.3} = 1.5$

Figure 16: Example 5, Job Analysis Worksheet

Using Table 6, the coupling is classified as **Good**. Significant control is required at the destination of the lift. Using Table 5, the FM is determined to be .80. As shown in Figure 16, the RWL is 14.4 lbs at the origin and 13.3 lbs at the destination.

3.3.2.3. Hazard Assessment

The weight to be lifted (20 lbs) is greater than the RWL at both the origin and destination of the lift (14.4 lbs and 13.3 lbs, respectively). The LI at the origin is 20/14.4 or 1.4 and the LI at the destination is 1.5. These results indicate that this lifting task would be stressful for some workers.

3.3.2.4. 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. Using Table 8, 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 are 1.0, as shown in the modified worksheet (Figure 17). Moreover, if the cart is moved so that the twist is eliminated, the AM can be increased from .90 to 1.00. As

shown in Figure 17, with these redesign suggestions the RWL can be increased from 13.3 lbs to 20.4 lbs, and the LI values are reduced to 1.0.

3.3.2.5. 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.

As in the previous example, since the lifting pattern is continuous over the full duration of the work sample (i.e., more than 15 minutes), the lifting frequency is not adjusted using the special procedure described on page 27.

JOB ANALYSIS WORKSHEET

DEPARTMENT Food Service
JOB TITLE Cafeteria Worker
ANALYST'S NAME
DATE

JOB DESCRIPTION
Unloading a dish-washing machine
Modified Example 5

STEP 1. Measure and record task variables

Object Weight (lbs)		Hand Location (in)				Vertical Distance (in)	Asymmetric Angle (degrees)		Frequency Rate lifts/min	Duration (HRS)	Object Coupling
		Origin		Dest.			Origin	Destination			
L (AVG.)	L (Max.)	H	V	H	V	D	A	A	F		C
20	20	20	30	20	30	0	0	0	5	< 1	Good

STEP 2. Determine the multipliers and compute the RWL's

RWL = LC × HM × VM × DM × AM × FM × CM

ORIGIN RWL = 51 × .50 × 1.0 × 1.0 × 1.0 × .80 × 1.0 = 20.4 Lbs

DESTINATION RWL = 51 × .50 × 1.0 × 1.0 × 1.0 × .80 × 1.0 = 20.4 Lbs

STEP 3. Compute the LIFTING INDEX

ORIGIN LIFTING INDEX = $\frac{\text{OBJECT WEIGHT (L)}}{\text{RWL}} = \frac{20}{20.4} = 1.0$

DESTINATION LIFTING INDEX = $\frac{\text{OBJECT WEIGHT (L)}}{\text{RWL}} = \frac{20}{20.4} = 1.0$

Figure 17: Example 5, Modified Job Analysis Worksheet

3.3.3. Product Packaging I, Example 6

3.3.3.1. Job Description

In the job illustrated in Figure 18, products weighing 25 lbs 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 90^0 angle to grasp the container. The job is performed for a normal 8-hour shift, including regular rest allowance breaks.

3.3.3.2. Job Analysis

The task variable data are measured and recorded on the job analysis worksheet (Figure 19). 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.

Using Table 6, the coupling is classified as **fair**. The worker twists 90^0 to pick up the product. The job is performed for an 8-hour shift with a frequency rate of 1-lift per minute. Using Table 5, the FM is determined to be .75. Since significant control is not required at the destination, then the RWL is only computed at the origin of the lift. The multipliers are computed from the lifting equation or determined from the multiplier tables (Tables 1 to 5, and Table 7). As shown in Figure 19, the RWL for this lifting task is 16.4 lbs.

3.3.3.3. Hazard Assessment

The weight to be lifted (25 lbs) is greater than the RWL (16.4 lbs). Therefore, the LI is 25/16.4 or 1.5. This task would be stressful for some healthy workers.

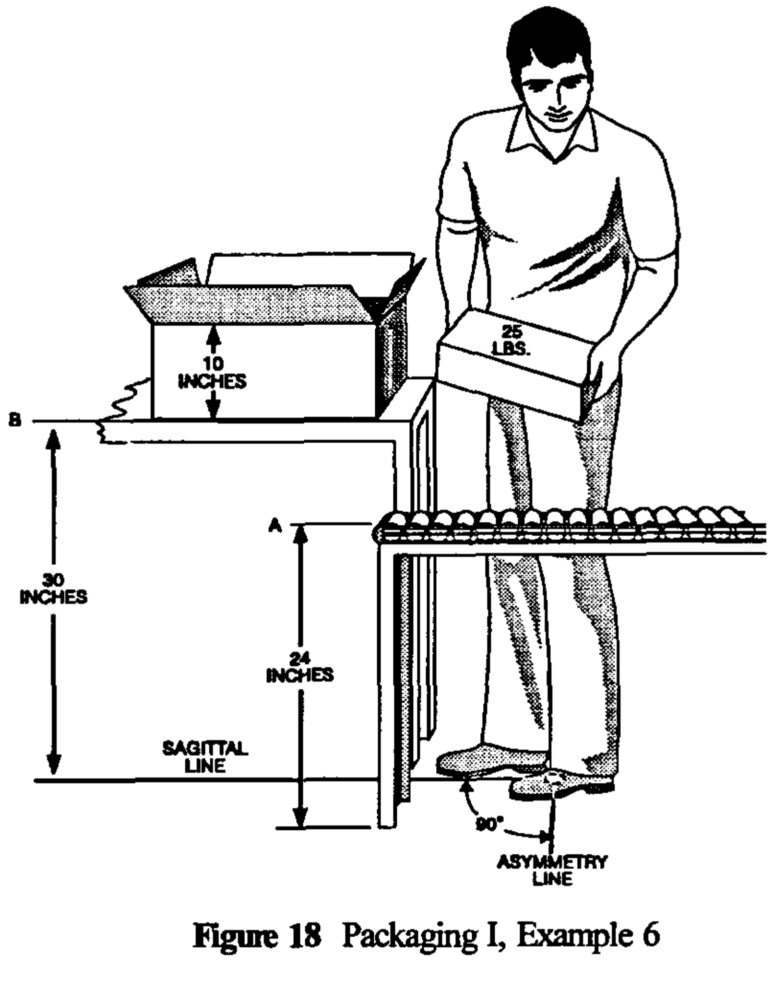

Figure 18 Packaging I, Example 6

JOB ANALYSIS WORKSHEET

DEPARTMENT Distribution
JOB TITLE Line Packer
ANALYST'S NAME
DATE

JOB DESCRIPTION
Packing products for distribution

Example 6, Product Packaging I

STEP 1. Measure and record task variables

Object Weight (lbs)		Hand Location (in)				Vertical Distance (in)	Asymmetric Angle (degrees)		Frequency Rate	Duration	Object Coupling
		Origin		Dest.			Origin	Destination	lifts/min	(HRS)	
L (AVG.)	L (Max.)	H	V	H	V	D	A	A	F		C
25	25	14	24	16	40	16	90	0	1	8	Fair

STEP 2. Determine the multipliers and compute the RWL's

RWL = LC × HM × VM × DM × AM × FM × CM

ORIGIN RWL = 51 × .71 × .96 × .93 × .71 × .75 × .95 = 16.4 Lbs

DESTINATION RWL = 51 × ___ × ___ × ___ × ___ × ___ × ___ = ___ Lbs

STEP 3. Compute the LIFTING INDEX

ORIGIN LIFTING INDEX = OBJECT WEIGHT (L) / RWL = 25 / 16.4 = 1.5

DESTINATION LIFTING INDEX = OBJECT WEIGHT (L) / RWL = ___ = ___

Figure 19: Example 6, Job Analysis Worksheet

3.3.3.4. Redesign Suggestions

The worksheet 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. Using Table 8, 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. For this modified job (worksheet shown in Figure 20), 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 lbs to 25 lbs, 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.

JOB ANALYSIS WORKSHEET

DEPARTMENT Distribution
JOB TITLE Line Packer
ANALYST'S NAME
DATE

JOB DESCRIPTION
Packing products for distribution

Modified Example 6

STEP 1. Measure and record task variables

Object Weight (lbs)		Hand Location (in)				Vertical Distance (in)	Asymmetric Angle (degrees)		Frequency Rate lifts/min	Duration (HRS)	Object Coupling
		Origin		Dest.			Origin	Destination			
L (AVG.)	L (Max.)	H	V	H	V	D	A	A	F		C
25	25	13	24	16	40	16	0	0	1	8	Fair

STEP 2. Determine the multipliers and compute the RWL's

RWL = LC × HM × VM × DM × AM × FM × CM

ORIGIN RWL = 51 × .77 × .96 × .93 × 1.0 × .75 × .95 = 25.0 Lbs

DESTINATION RWL = 51 × ___ × ___ × ___ × ___ × ___ × ___ = ___ Lbs

STEP 3. Compute the LIFTING INDEX

ORIGIN LIFTING INDEX = OBJECT WEIGHT (L) / RWL = 25 / 25.0 = 1.0

DESTINATION LIFTING INDEX = OBJECT WEIGHT (L) / RWL = ___ = ___

Figure 20: Example 6, Modified Job Analysis Worksheet

3.3.3.5. 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.

As in the earlier examples, the lifting pattern is continuous over the full duration of the work sessions. Thus, the lifting frequency is not adjusted using the special procedure described in the Frequency Component section on page 27.

3.4. Repetitive Multi-Task, Short-Duration

3.4.1. Depalletizing Operation, Example 7

3.4.1.1. Job Description

A worker unloads 12-lb cartons from a pallet onto a conveyor, as illustrated in Figure 21. The cartons are vertically stacked from the floor in five tiers. No twisting is required when picking up and putting down the cartons, and the worker is free to step on the pallet to get close to each carton (i.e., only one layer in depth from the front of the pallet must be analyzed). Walking and carrying are minimized by keeping the pallets close to the conveyor, and significant control of the object is not required at the destination of the lift. The vertical location (V) at the origin, horizontal location (H), and vertical travel distance (D), vary from one lift to the next.

3.4.1.2. Job Analysis

Since the job consists of more than one distinct task and the task variables often change, the multi-task lifting analysis procedure should be used.

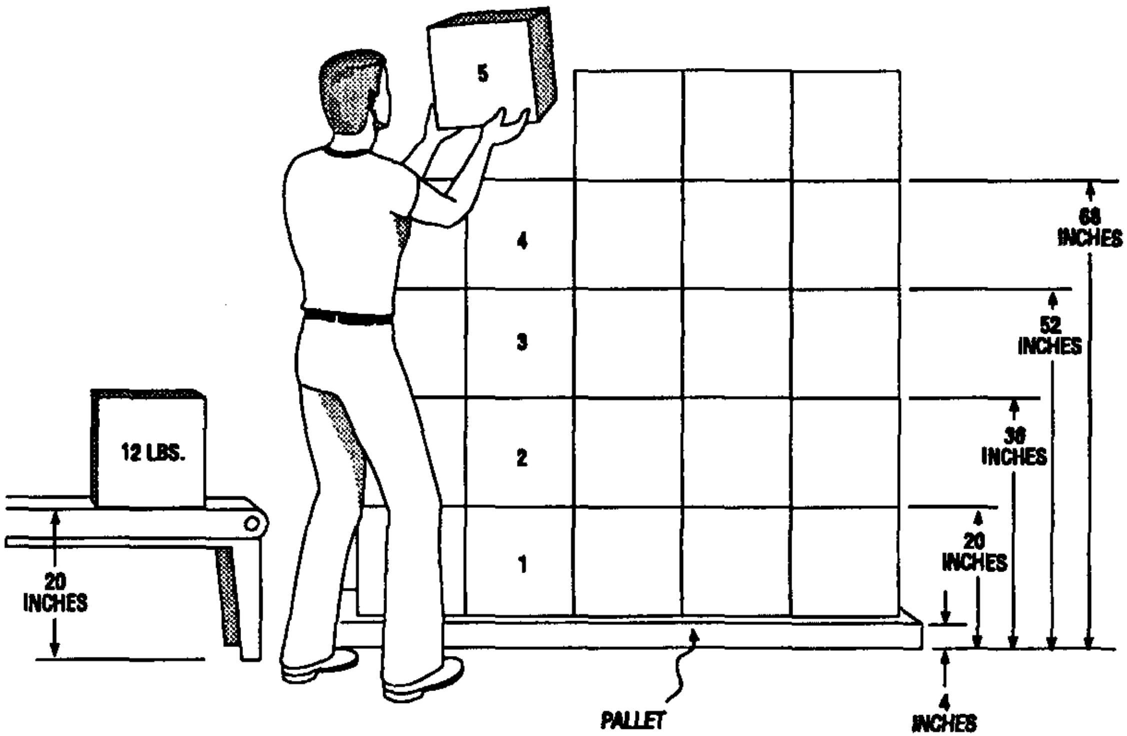

Figure 21 Depalletizing Operation, Example 7

This job is divided into five tasks representing the five tiers of loaded pallets. Task numbering is arbitrary and the sequencing does not reflect the order in which the tasks are performed. It is important, however, to identify each distinct type of lifting task. Note, it may not be appropriate to use the lifting equation for mixed-task jobs that require significant amounts of pushing, pulling, or carrying.

The following measurements/observations were made and recorded on the job analysis worksheet (Figure 22):

1. Carton dimensions are 16 inches x 16 inches x 16 inches.

2. The vertical locations at the origin represent the position of the hands under the cartons. The top of the conveyor is 20 inches from the floor.

3. For this example, assume that the horizontal locations were not measured, but estimated using the formulas provided in the Horizontal Multiplier section on page 14. From these formulas, H = (8 + 16/2) or 16 inches for the top four tiers and H = (10 + 16/2) or 18 inches for the bottom tier.

4. The pallet is 4 inches in height.

5. No asymmetric lifting is involved (i.e., A = 0).

6. Cartons are continuously unloaded at the rate of 12-per minute (i.e, 2.4 lifts/min per tier) for 1 hour.

7. The job consists of continuous 1-hour work sessions separated by 90-minute recovery periods.

8. Using Table 6, the coupling is classified as fair.

MULTI-TASK JOB ANALYSIS WORKSHEET

DEPARTMENT Recieving
JOB TITLE Warehouseman
ANALYST'S NAME ____
DATE ____

JOB DESCRIPTION
Unloading boxes onto a conveyor
Example 7

STEP 1. Measure and Record Task Variable Data

Task No.	Object Weight (lbs)		Hand Location (in)				Vertical Distance (in)	Asymmetry Angle (degs)		Frequency Rate lifts/min	Duration Hrs	Coupling
			Origin		Dest.			Origin	Dest.			
	L (Avg.)	L (Max.)	H	V	H	V	D	A	A	F		C
1	12	12	18	4	16	20	16	0	0	2.4	1	Fair
2	12	12	16	20	16	20	0	0	0	2.4	1	Fair
3	12	12	16	36	16	20	16	0	0	2.4	1	Fair
4	12	12	16	52	16	20	32	0	0	2.4	1	Fair
5	12	12	16	68	16	20	48	0	0	2.4	1	Fair

STEP 2. Compute multipliers and FIRWL, STRWL, FILI, and STLI for Each Task

Task No.	LC	x HM	x VM	x DM	x AM	x CM	FIRWL	x FM	STRWL	FILI = L/FIRWL	STLI = L/STRWL	New Task No.	F
1	51	.56	.81	.93	1.0	.95	20.4	.90	18.4	.6	.7	2	2.4
2	51	.63	.93	1.0	1.0	.95	28.4	.90	25.6	.4	.5	4	2.4
3	51	.63	.96	.93	1.0	1.0	28.7	.90	25.8	.4	.5	5	2.4
4	51	.63	.84	.88	1.0	1.0	23.8	.90	21.4	.5	.6	3	2.4
5	51	.63	.72	.86	1.0	1.0	19.9	.90	17.9	.6	.7	1	2.4

STEP 3. Compute the Composite Lifting Index for the Job (After renumbering tasks)

CLI =	$STLI_1$ +	$\Delta FILI_2$ +	$\Delta FILI_3$ +	$\Delta FILI_4$ +	$\Delta FILI_5$	
		$FILI_2(1/FM_{1+2} - 1/FM_1)$	$FILI_3(1/FM_{1+2+3} - 1/FM_{1+2})$	$FILI_4(1/FM_{1+2+3+4} - 1/FM_{1+2+3})$	$FILI_5(1/FM_{1+2+3+4+5} - 1/FM_{1+2+3+4})$	
		.6(1/.81-1/.9)	.5(1/.68-1/.81)	.4(1/.48-1/.68)	.4(1/.37-1/.48)	
CLI =	.7	.07	.12	.26	.26	1.4

Figure 22: Example 7, JOB ANALYSIS WORKSHEET

The multi-task lifting analysis consists of the following three steps:

1. Compute the frequency-independent-RWL (FIRWL) and frequency-independent- lifting index (FILI) values for each task using a default FM of 1.0.

2. Compute the single-task-RWL (STRWL) and single-task-lifting index (STLI) for each task. Note, in this example, interpolation was used to compute the FM value for each task because the lifting frequency rate was not a whole number (i.e., 2.4).

3. Renumber the tasks in order of decreasing physical stress, as determined from the STLI value, starting with the task with the largest STLI.

Step 1
Compute the FIRWL and FILI values for each task using a default FM of 1.0. The multi-task lifting analysis consists of the following three steps:

1. Compute the frequency-independent-RWL (FIRWL) and frequency-independent- lifting index (FILI) values for each task using a default FM of 1.0.

	FIRWL	FILI
Tier 1	20.4 lbs	.6
Tier 2	28.4 lbs	.4
Tier 3	28.7 lbs	.4
Tier 4	23.8 lbs	.5
Tier 5	19.9 lbs	.6

These results indicate that none of the tasks are particularly stressful, from a strength point of view, but that tiers 1 and 5 do require the most strength. Remember, however, that these results do not take the frequency of lifting into consideration.

Step 2
Compute the STRWL and STLI values for each task, where STRWL = FIRWL x FM. The FM for each task is determined by interpolating between the FM values for 2 and 3 lifts/minute from Column 2 of Table 5. The results are displayed in Figure 22.

	STRWL	STLI
Tier 1	18.4 lbs	.7
Tier 2	25.6 lbs	.5
Tier 3	25.8 lbs	.5
Tier 4	21.4 lbs	.6
Tier 5	17.9 lbs	.7

These results suggest that none of the tasks are stressful, if performed individually. Note, however, that these values do not consider the combined effects of all of the tasks.

Step 3

Renumber the tasks, starting with the task with the largest STLI value, and ending with the task with the smallest STLI value. If more than one task has the same STLI value, assign the lower task number to the task with the highest frequency.

3.4.1.3. Hazard Assessment

Compute the composite-lifting index (CLI) for the job, using the renumbered tasks as described in the Multi-Task procedures on page 43.

As shown on Figure 22, the CLI value for this job is 1.4. This means that some healthy workers would find this job physically stressful. Therefore, some redesign may be needed. Analysis of the results suggest that any three of these tasks would probably result in a CLI below 1.0, which would be acceptable for nearly all healthy workers. However, when the other two tasks are added, the overall frequency increases the lifting index above 1.0. This suggests that the overall frequency should be reduced to limit the physical stress associated with this job.

3.4.1.4. Redesign Suggestions

The worksheet illustrated in Figure 22 indicates that the multipliers with the smallest magnitude (i.e., those providing the greatest penalties) are .56 for the HM at Tier 1; .63 for the HM at Tiers 2 through 5; .72 for the VM at Tier 5; and .81 for the VM at Tier 1. Using Table 8, the following job modifications are suggested:

1. Bring the cartons closer to the worker to increase the HM value.

2. Lower the height for Tier five to increase the VM value.

3. Raise the height of tier one to increase the VM value.

The FILI values are all less than 1.0, indicating that strength should not be a problem for any of these tasks. Moreover, the STLI were all less than 1.0, indicating that none of the tasks would be physically stressful, if performed individually. When the combined physical demands of the tasks are considered, however, the resulting CLI exceeds 1.0. This is likely due to the high frequency rate for the combined job. Since a number of simplifying assumptions were made in this example, however, a more detailed metabolic analysis of such a job may be needed before implementing ergonomic redesign. Such an analysis is described in detail by Garg *et al*. (1978).

An engineering approach should be the first choice for job redesign (i.e., physical changes in layout, such as raising or lowering shelves, tables, or pallets) rather than worker compliance. In this case, the high frequency rate is a significant problem and should be reduced. A reduction in frequency could decrease the CLI to about 1.0.

3.4.1.5. Comments

With more complicated tasks, such a simple solution will not necessarily be possible, and more detailed analyses may be required to determine compressive forces, strength requirements, and energy expenditures.

3.4.2. Handling Cans of Liquid, Example 8

3.4.2.1. Job Description

A worker unloads cans of liquids from a cart to three storage shelves as shown in Figure 23. Although the cans are lifted in the sagittal plane when moved between shelves, they are usually lifted asymmetrically, from one side of the body to the other, when lifted from the cart to the shelves. The worker may take a step when placing the cans onto the shelf. The cans do not have molded handholds, so the worker hooks his fingers or slides his hand under the turned edge of the can to lift it. When lifting to the top shelf, workers usually reposition their grip near the end of the lift. The work pattern consists of intermittent, six-minute work sessions separated by three-minute recovery periods. The actual lifting frequency during the six-minute work sessions was 9 lifts/minute. There is a 90-minute break after each hour of work.

3.4.2.2. Job Analysis

Since the job consists of more than one distinct task and the task variables change often, the multi-task lifting analysis procedure should be used.

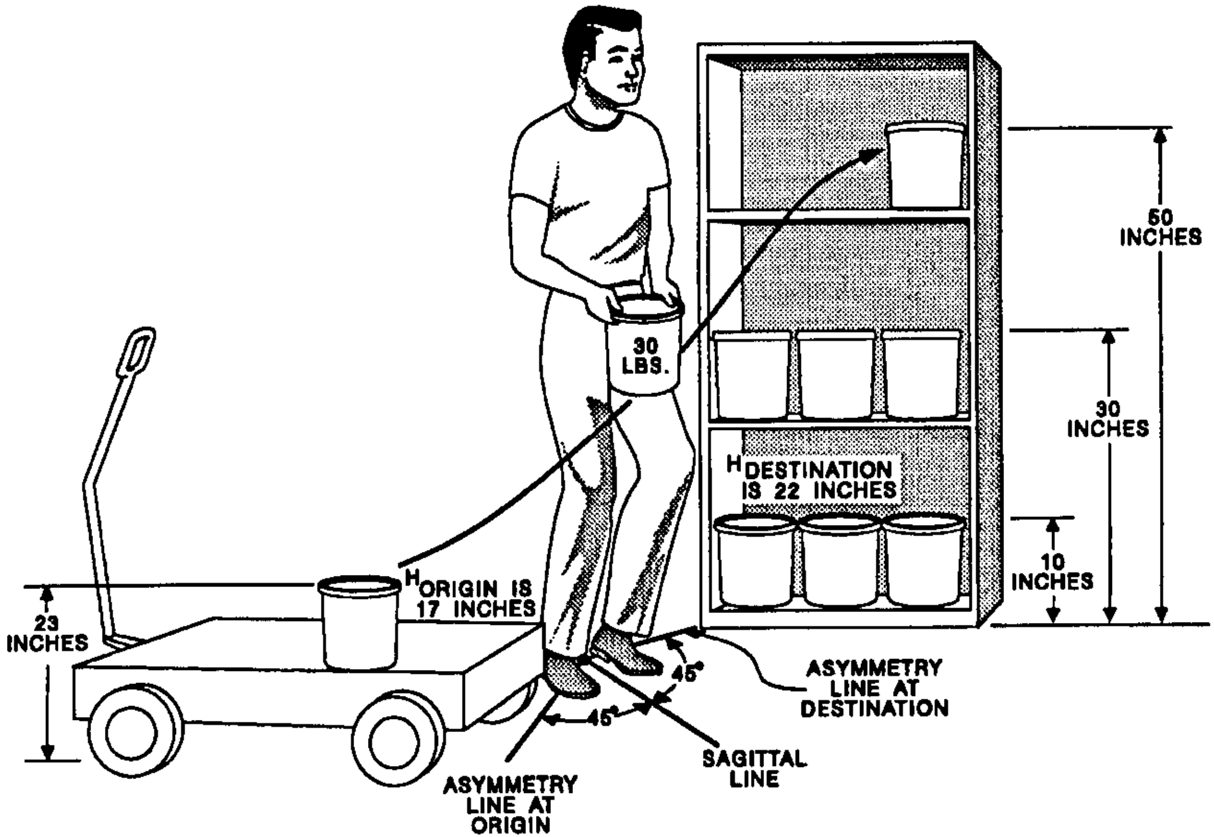

Figure 23 Handling Cans of Liquid, Example 8

This job is divided into three tasks. Task 1 is defined as lifting from the cart to the lower shelf. Task 2 is defined as lifting to the center shelf, and Task 3 is defined as lifting to the upper shelf. Since task 3 requires a reposition of grip at the destination, it must be analyzed at both the origin (Task 3a) and the destination of the lift (Task 3b). The left and right shelf positions are considered to be equivalent, since the worker can step toward the shelf during the lift.

The following task variable data were measured and recorded on the job analysis worksheet (Figure 24):

1. Cans are 8 inches in height.

2. Cart is 15 inches high.

3. Shelf 1 is 2 inches high.

4. Shelf 2 is 22 inches high.

5. Shelf 3 is 42 inches high.

6. At the origin, the horizontal distance (H) is 17 inches, the vertical height (V) is 23 inches, and the angle of asymmetry (A) is 45^0 for all lifts.

7. At the destination, H is 22 inches, and A is 45^0 for all lifts.

8. The cans are lifted in an intermittent work pattern at a rate of 9 lifts/min (i.e., 3 lifts/min per shelf) for a duration of 1 hour.
9. Using Table 6, the couplings are classified as poor.

The multi-task lifting analysis consists of the following three steps:

1. Compute the frequency-independent-RWL (FIRWL) and frequency-independent- lifting index (FILI) values for each task using a default FM of 1.0.

2. Compute the single-task-RWL (STRWL) and single-task-lifting index (STLI) for each task. Note: Since the work pattern is not continuous for the 15-minute sample, the lifting frequency is adjusted using the special procedure described on page 27.

3. Renumber the tasks in order of decreasing physical stress, as determined from the STLI value, starting with the task with the largest STLI.

Step 1

Compute the FIRWL and FILI values for each task using a default FM of 1.0. The other multipliers are computed from the lifting equation or determined from the multiplier tables (Table 1 to 5, and Table 7). The FIRWL and FILI values are computed only at the origin for Tasks 1 and 2, but since significant control is required for Task 3, the values must be computed at both the origin and destination of the lift.

	FIRWL	FILI
Task 1	21.2 lbs	1.4
Task 2	22.1 lbs	1.4
Task 3a	19.7 lbs	1.5
Task 3b	13.7 lbs	2.2

These results indicate that all of the tasks may ***require considerable strength***, especially at the destination of Task 3. Remember, however, that these results do not take the frequency of lifting into consideration.

Step 2

Compute the STRWL and STLI values for each task, where the STRWL for a task is equivalent to the product of the FIRWL and the FM for that task. In this example, the work pattern is intermittent so the frequency is adjusted using the special procedure. Thus, for this job, F = (3 lifts/minute x 6 minutes/period x 2 periods) / 15 minutes, which is equal to 36/15, or 2.4 lifts/minute. As in the previous example, the FM values must be determined by interpolating between the FM values for 2 and 3 lifts/minute from Column 2 of Table 5. The results are displayed in Figure 24 and summarized below.

	STRWL	STLI
Task 1	19.1 lbs	1.6
Task 2	19.9 lbs	1.5
Task 3a	17.7 lbs	1.7
Task 3b	12.4 lbs	2.4

These results indicate that all of the tasks would be particularly stressful, if performed individually. Note, however, that these values do not consider the combined effects of all of the tasks.

Step 3

Renumber the tasks, starting with the task with the largest STLI value, and ending with the task with the smallest STLI value. If more than one task has the same STLI value, assign the lower task number to the task with the highest frequency.

MULTI-TASK JOB ANALYSIS WORKSHEET

DEPARTMENT Paint Shop

JOB TITLE Stock Clerk

ANALYST'S NAME

DATE

JOB DESCRIPTION
Lifting cans of liquid from
from cart to shelves
Example 8

STEP 1. Measure and Record Task Variable Data

Task No.	Object Weight (lbs)		Hand Location (in)				Vertical Distance (in)	Asymmetry Angle (degs)		Frequency Rate lifts/min	Duration Hrs	Coupling
			Origin		Dest.			Origin	Dest.			
	L (Avg.)	L (Max.)	H	V	H	V	D	A	A	F		C
1	30	30	17	23	22	10	13	45	45	3	< 1	Poor
2	30	30	17	23	22	30	7	45	45	3	< 1	Poor
3	30	30	17	23	22	50	27	45	45	3	< 1	Poor

STEP 2. Compute multipliers and FIRWL, STRWL, FILI, and STLI for Each Task

Task No.	LC x	HM x	VM x	DM x	AM x	CM	FIRWL x	FM	STRWL	FILI = L/FIRWL	STLI = L/STRWL	New Task No.	F
1	51	.59	.95	.96	.86	.90	21.2	.90	19.1	1.4	1.6	2	2.4
2	51	.59	.95	1.0	.86	.90	22.1	.90	19.9	1.4	1.5	3	2.4
3a	51	.59	.95	.89	.86	.90	19.7	.90	17.7	1.5	1.7	X	2.4
3b	51	.46	.85	.89	.86	.90	13.7	.90	12.4	2.2	2.4	1	2.4
	51												

STEP 3. Compute the Composite Lifting Index for the Job (After renumbering tasks)

	$STLI_1$ +	$\Delta FILI_2$ +	$\Delta FILI_3$ +	$\Delta FILI_4$ +	$\Delta FILI_5$	
CLI =		$FILI_2(1/FM_{1,2} - 1/FM_1)$	$FILI_3(1/FM_{1,2,3} - 1/FM_{1,2})$	$FILI_4(1/FM_{1,2,3,4} - 1/FM_{1,2,3})$	$FILI_5(1/FM_{1,2,3,4,5} - 1/FM_{1,2,3,4})$	
		1.4(1/.8 - 1/.9)	1.4(1/.7 - 1/.8)			
CLI =	2.4	.19	.25			2.9

Figure 24: Example 8, JOB ANALYSIS WORKSHEET

3.4.2.3. Hazard Assessment

Compute the composite-lifting index (CLI) using the renumbered tasks. Recall that a special procedure is used to determine the appropriate FM values when (1) repetitive lifting is performed for short durations, and (2) sufficient recovery periods are provided. For example, the frequency for each task in this example is determined by multiplying the actual frequency rate (3 lifts per minute) times the duration (12 minutes), and dividing the result by 15 minutes to obtain an adjusted frequency rate of 2.4 lifts per minute, which is used to compute the CLI.

As shown in Figure 24, the CLI for this job is 2.9, which indicates that there is a significant level of physical stress associated with this job. It appears that strength is a problem for all three tasks, since the FILI values all exceed 1.0. Therefore, the overall physical demands of the job are primarily the result of excessive strength demands, rather than the lifting frequency rate. This may not be the case if the duration exceeds 15 minutes, due to an increase in endurance demands.

3.4.2.4. Redesign Suggestions

The worksheet illustrated in Figure 24 shows that the multipliers with the smallest magnitude (i.e., those providing the greatest penalties) are .46 for the HM for Task 3 at the destination; .59 for the HM for Tasks 1, 2, and 3 at the origin; .85 for the VM for Task 3 at the destination; .86 for the AM for all tasks at the origin and destination; and, .90 for the CM for all tasks.

Using Table 8, the following job modifications are suggested:

1. Bring the load closer to the worker to increase HM by reducing the size of the can and/or bringing the load between the worker's legs.

2. Reduce the angle of twist to increase AM by moving the origin and destination closer together or further apart.

3. Provide containers with handles or handhold cutouts to increase CM.
4. Raise the origin of the lift to increase VM.

Raising the vertical height at the origin would also decrease the vertical displacement (D), and reduce the angle of twist. Since the size of the H value at the origin depends on the size of the container, the only way to reduce H would be to reduce the container size. An additional benefit of reducing container size is an accompanying reduction in H at the destination for Task 3.

If (1) the height of the cart is increased, (2) twisting is eliminated, and (3) Task 3 is deleted, then the FIRWL for Tasks 1 and 2 would be 27.1 lbs (i.e., 51 x .59 x 1.0 x 1.0 x 1.0 x 1.0 x 0.90), and the FILI would be reduced from 1.4 to 1.1, which would be acceptable to many more workers than before.

As an alternative, an engineering modification could include a design that allows the shelves to either revolve vertically or rotate horizontally for more storage space at the optimum lifting height of 30 inches. This design would eliminate the need to bend or reach while lifting, which is a safer design.

3.4.2.5. Comments

In this example, the cans were not stacked higher than a single can on the cart. The cans, however, could be stacked higher. For a second layer, the vertical height (V) at the origin would be near knuckle height (i.e., about 31 inches). The vertical multiplier (VM) would be increased and the FIRWL would be higher than for lifting from the lowest layer, thus reducing the risk. A third layer, however, may increase the risk of overexertion injury and result in a more stressful job for some workers.