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A Step-by-Step Guide to the NIOSH Lifting Equation (Single Tasks)

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INTRODUCTION TO THE NIOSH LIFTING EQUATION (SINGLE TASKS)

The NIOSH Equation is a tool used by occupational health and safety professionals to assess the manual material handling risks associated with lifting and lowering tasks in the workplace. This equation considers job task variables to determine safe lifting practices and guidelines. The primary product of the NIOSH equation is the Recommended Weight Limit (RWL), which defines the maximum acceptable weight (load) that nearly all healthy employees could lift over the course of an 8 hour shift without increasing the risk of musculoskeletal disorders (MSD) to the lower back. In addition, a Lifting Index (LI) is calculated to provide a relative estimate of the level of physical stress and MSD risk associated with the manual lifting tasks evaluated.

NIOSH Equation Outputs:

Recommended Weight Limit (RWL): Answers the question… "Is this weight too heavy for the task?"

Lifting Index (LI): Answers the question… "How significant is the risk?"

A Lifting Index value of less than 1.0 indicates a nominal risk to healthy employees. A Lifting Index of 1.0 or more denotes that the task is high risk for some fraction of the population. As the LI increases, the level of low back injury risk increases correspondingly. Therefore, the goal is to design all lifting jobs to accomplish an LI of less than 1.0.

The NIOSH equation always uses a load constant (LC) of 51 pounds, which represents the maximum recommended load weight to be lifted under ideal conditions. From that starting point, the equation uses several task variables expressed as coefficients or multipliers (In the equation, M = multiplier) that serve to decrease the load constant and calculate the RWL for that particular lifting task

NIOSH Equation:

LC (51) x HM x VM x DM x AM x FM x CM = RWL

Task variables needed to calculate the RWL:

- H = Horizontal location of the object relative to the body
- V = Vertical location of the object relative to the floor
- D = Distance the object is moved vertically
- A = Asymmetry angle or twisting requirement
- F = Frequency and duration of lifting activity

- C = Coupling or quality of the workers grip on the object

Lifting Index (LI): Weight ÷ RWL = LI

Additional task variables needed to calculate the LI:

- Average weight of the objects lifted
- Maximum weight of the objects lifted

The RWL and LI can be used to guide lifting task design in the following ways: 1) The individual multipliers the determine the RWL can be used to identify specific weaknesses in the design. 2) The LI can be used to estimate the relative physical stress and injury risk for a task or job. The higher the LI value, the smaller the percentage of workers capable of safely performing these job demands. Thus, injury risk of two or more job designs could be compared. 3) The LI can also be used to prioritize ergonomic redesign efforts. Jobs can be ranked by LI and a control strategy can be implemented based on a priority order of the jobs or individual lifting tasks.

The Frequency-Independent Recommended Weight Limit (FIRWL) and the Frequency-Independent Lifting Index (FILI) are additional outputs of the NIOSH lifting calculator. The FIRWL is calculated by using a frequency multiplier (FI) of 1.0 along with the other task variable multipliers. This effectively removes frequency as a variable, reflecting a weight limit for a single repetition of that task and allows equal comparison to other single repetition tasks. The Frequency-Independent Lifting Index (FILI) is calculated by dividing the weight lifted by the FIRWL. The FILI can help identify problems with infrequent lifting tasks if it exceeds the value of 1.0.

USING THE NIOSH EQUATION

Step 1: Measure and Record Task Variables

The first step is to gather the needed information and measurements for lifting task variables, and record the data to be used later to calculate the RWL and LI for the tasks being evaluated. The evaluator should prepare by interviewing and observing workers to gain a complete understanding of all required lifting tasks. Selection of the lifting tasks to be evaluated should be based on the most significant and demanding manual material handling tasks. If the job requires a wide variety of lifting tasks, a multi-task evaluation can be performed using a composite of all single-task lifting assessments performed. More on that later, but for now let's focus on single-task assessments.

For each lifting task analyzed, the evaluator will need to determine the task variables as outlined above. We have developed the following worksheet to assist you with data collection:

Department: Job:

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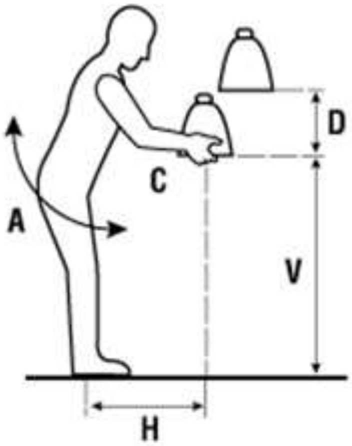
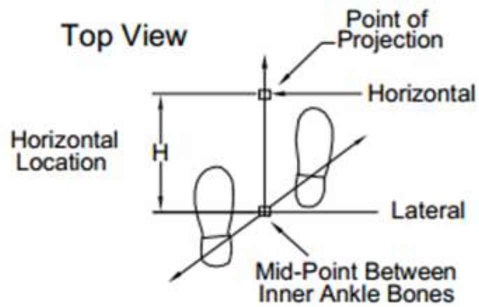
	NIOSH Lifting Variables								
Lifting Task	H Horizontal Location (10-25")	V Vertical Location (0-70")	D Travel Distance (10-70")	A Angle of Asymmetry (0° - 135°)	C Coupling (1=good, 2=fair, 3=poor)	F Frequency (0.2 - 15 lifts/min)	L Ave. Load Lifted (lbs.)	L Max. Load Lifted (lbs.)	Dur Duration (1,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

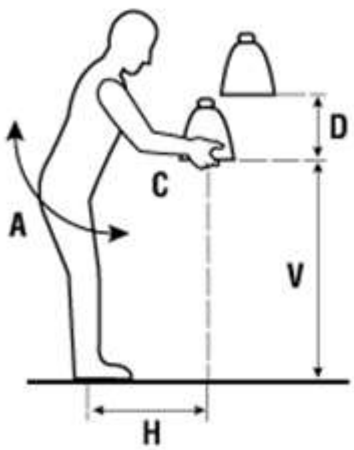
The following task variables are evaluated to calculate the multipliers that are used in the NIOSH equation to determine the RWL. Here are some quick explanations and guidelines that you can use to gather the needed measurements:

1) Horizontal Location of the Hands (H) – Measure and record the horizontal location of the hands at both the start (origin) and end (destination) of the lifting task. The horizontal location is measured as the distance (inches) between the employee's ankles to a point projected on the floor directly below the mid-point of the hands grasping the object as pictured below:



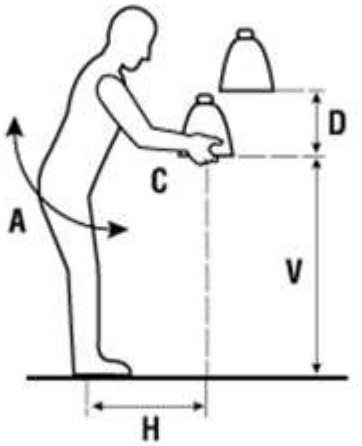


2) Vertical Location of the Hands (V) – Measure and record the vertical location of the hands above the floor at the start (origin) and end (destination) of the lifting task. The vertical location is measured from the floor to the vertical mid-point between the two hands as shown below. The middle knuckle can be used to

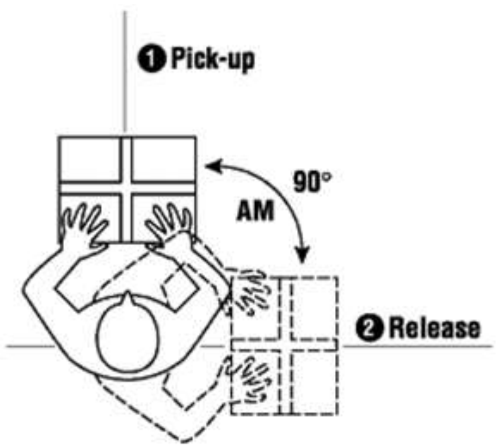


define the mid-point.

3) Vertical Travel Distance (D) – The vertical travel distance of a lift is determined by subtracting the vertical location (V) at the start of the lift from the vertical location (V) at the end of the lift. For a lowering task, subtract the V location at the end from the V location at the start.



4) Asymmetric Angle (A) – Measure the degree to which the body is required to twist or turn during the lifting task. The asymmetric angle is the amount (in degrees) of trunk and shoulder rotation required by the lifting task. Note: Sometimes the twisting is not caused by the physical aspects of the job design, but rather by the employee using poor body mechanics. If this is the case, no twisting (0 degrees) is required by the job. If twisting is required by the design of the job, determine the number of degrees the back and body trunk must twist or rotate to accomplish the lift. (i.e. 90° as pictured below)



5) Coupling (C) – Determine the classification of the quality of the coupling between the worker's hands and the object as good, fair, or poor (1, 2, or 3). A good coupling will reduce the maximum grasp forces required and increase the

acceptable weight for lifting, while a poor coupling will generally require higher maximum grasp forces and decrease the acceptable weight for lifting.

1 = Good - Optimal design containers with handles of optimal design, or irregular objects where the hand can be easily wrapped around the object.

2 = Fair - Optimal design containers with handles of less than optimal design, optimal design containers with no handles or cut-outs, or irregular objects where the hand can be flexed about 90°.

3 = Poor - Less than optimal design container with no handles or cut-outs, or irregular objects that are hard to handle and/or bulky (e.g. bags that sag in the middle).

6) Frequency (F) - Determine the appropriate lifting frequency of lifting tasks by using the average number of lifts per minute during an average 15 minute sampling period. For example, count the total number of lifts in a typical 15 minute period of time and divide that total number by 15.
Minimum = 0.2 lifts/minute
Maximum is 15 lifts/minute.

7) Load (L) – Determine the weight of the object lifted. If necessary, use a scale to determine the exact weight. If the weight of the load varies from lift to lift, you should record the average and maximum weights lifted.

8) Duration (Dur) – Determine the lifting duration as classified into one of three categories: Enter 1 for short-duration, 2 for moderate-duration and 8 for long-duration as follows:
1 = Short - lifting ≤ 1 hour with recovery time ≥ 1.2 X work time
2 = Moderate - lifting between 1 and 2 hours with recovery time ≥ 0.3 X lifting time
8 = Long - lifting between 2 and 8 hours with standard industrial rest allowances

Step 2: Enter Data / Calculate RWL and LI

In step 1, we determined and recorded the lifting task variables in our worksheet. The following is an example of a completed worksheet:

Department: *250*

Job: *Unload product boxes from conveyor and place onto cart*

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	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)
Origin - Lift product box from conveyor	*15*	*38*	*6*	*0*	*1*	*2*	*24*	*24*	*8*
Destination - Place product box onto cart	*20*	*32*	*6*	*30*	*1*	*2*	*24*	*24*	*8*

Now we are ready to input the collected data into our calculator to determine the RWL and LI:

Origin and Destination Calculations:

Analyst		Task	
Mark Middlesworth		Department 250	

	Origin	Destination
Horizontal Location (min. 10", max. 25")	15	20
Vertical Location (min. 0", max. 70")	38	32
Travel Distance (min. 10", max. 70")	6	6
Angle of Asymmetry (min. 0, max. 135)	0	30
Coupling (1=good | 2=fair | 3=poor)	1	1
Frequency (min. 0.2 lifts/min.)	2	2
Avg. Load	24	24
Max Load	24	24
Duration (enter 1, 2 or 8)	8	8

		Origin		Destination
		51		51
Horizontal Multiplier (HM)	x	0.67	x	0.50
Vertical Multiplier (VM)	x	0.94	x	0.99
Distance Multiplier (DM)	x	1.00	x	1.00
Frequency Multiplier (FM)	x	0.65	x	0.65
Angle Multiplier (AM)	x	1.00	x	0.90
Coupling Multiplier (CM)	x	1.00	x	1.00

	Origin	Destination
Recommended Weight Limit (RWL)	20.77	14.76
Frequency Independent RWL (FIRWL)	31.96	22.71
Lifting Index (LI)	1.16	1.63
Frequency Independent LI (FILI)	0.75	1.06

EXAMPLE - SINGLE TASK LIFTING ANALYSIS

Task Description - This job task (pictured below) consists of a worker lifting compact containers full of copper component parts from the bottom shelf of storage rack with both hands directly in front of the body, and then placing on a cart for transport to the assembly line. For this analysis, assume that significant control of the object is required at the destination. The containers are of optimal design with handholds.

Origin

Destination

Step 1 – Measure and record lifting task variables:

The horizontal distance at the origin of the lift is 15 inches and the horizontal distance at the destination of the lift is 12 inches. The height of the lift origin (bottom rack shelf) is 11 inches and the height of the lift at the destination (cart) is 40 inches. The travel distance between the origin and the destination is 29”. Ten degrees of asymmetric lifting is involved at the origin and no asymmetry is involved at the destination. The container is of optimal design with handholds; therefore coupling is defined as "good”. The average frequency of lifting in this manner is 2 lifts/minute over a duration of 1–2 hours per day. The average load lifted is 12.5 lb., and the maximum load lifted is 26 lb. 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.

Variable summary:

H = 15” at the origin and 12” at the destination

V = 11” at the origin and 40” at the destination

D = 29”

A = 10° at the origin and 0° at the destination

C = 1 (good - container is of optimal design with handhold cutouts)

F = 2 lifts/minute

L = 12.5 lb. average load and 26 lb. maximum load

Dur = 2 (task takes 1 - 2 hours per day with recovery time)

Record the task variables onto worksheet:

Department: *253* | Job: *Unload parts from storage rack and place on cart*

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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)
Origin - Lift product container from rack	*15*	*11*	*29*	*10*	*1*	*1*	*12.5*	*26*	*2*
Destination - Place container on cart	*20*	*32*	*6*	*0*	*1*	*1*	*12.5*	*26*	*2*

Step 2 – Conduct risk assessment using NIOSH Equation calculator:

Origin and Destination Calculations:

Analyst	Task
Mark Middlesworth	Department 253 - Assembly Line Utility

	Origin	Destination
Horizontal Location (min. 10", max. 25")	15	12
Vertical Location (min. 0", max. 70")	11	40
Travel Distance (min. 10", max. 70")	29	29
Angle of Asymmetry (min. 0, max. 135)	10	0
Coupling (1=good | 2=fair | 3=poor)	1	1
Frequency (min. 0.2 lifts/min.)	2	2
Avg. Load	12.5	12.5
Max Load	26	26
Duration (enter 1, 2 or 8)	2	2

		Origin		Destination
		51		51
Horizontal Multiplier (HM)	x	0.67	x	0.83
Vertical Multiplier (VM)	x	0.8575	x	0.93
Distance Multiplier (DM)	x	0.88	x	0.88
Frequency Multiplier (FM)	x	0.84	x	0.84
Angle Multiplier (AM)	x	0.97	x	1.00
Coupling Multiplier (CM)	x	1.00	x	1.00

	Origin	Destination
Recommended Weight Limit (RWL)	20.91	29.13
Frequency Independent RWL (FIRWL)	24.89	34.68
Lifting Index (LI)	0.60	0.43
Frequency Independent LI (FILI)	1.04	0.75

Origin Summary: The average weight to be lifted (12.5 lb.) is less than the RWL at the origin (20.9 lb.), however the maximum load to be lifted (26 lbs.) is greater than the RWL and FIRWL. The LI is .60 and the FILI is slightly above 1.0 at 1.04, indicating a nominal overall risk to healthy employees and a slight risk when lifting the maximum load of 26 lb. from the origin.

Destination Summary: The average weight to be lifted (12.5 lb.) is less than the RWL at the destination (29.1 lbs.) and the maximum load to be lifted (26 lbs.) is less than the RWL and FIRWL. The LI is .43 and the FILI is .75, indicating a nominal risk to healthy employees at the destination.