A Step-by-Step Guide to the

# NIOSH Lifting Equation

ERGONOMICS PLUS

The Revised NIOSH Lifting Equation is an ergonomic assessment tool in the public domain. You can view the original source materials and applications manual here:

Source: Revised Applications Manual for the NIOSH Lifting Equation

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# INTRODUCTION TO THE NIOSH LIFTING EQUATION (SINGLE TASKS)

The Revised NIOSH Lifting 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. A lifting or lowering task is defined as the act of manually grasping an object with two hands, and vertically moving the object without mechanical assistance.

**NIOSH Lifting Equation:**

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

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 Recommended Weight Limit (RWL) for that lifting or lowering task.

**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 lowering task

This equation considers job task variables to determine safe lifting practices and guidelines. The lifting equation is widely accepted as valid in the field of occupational ergonomics, providing occupational health and safety professionals an objective risk assessment tool for manual material handling tasks. The lifting equation is a great way to identify ergonomic opportunities and prioritize ergonomic improvement efforts, and it also provides an objective baseline from which you can document MSD risk reduction and ergonomic improvements.

**NIOSH Equation Outputs:**

The primary product or output of the NIOSH lifting equation is the **Recommended Weight Limit (RWL)**, which defines the maximum acceptable weight (load) that nearly all healthy employees could lift or lower for a substantial period of time (up to 8 hours) without increasing the risk of lifting related musculoskeletal disorders (MSD).

**The RWL answers the question… "Is this weight too heavy for the task?"**

In addition, a **Lifting Index (LI)** is calculated by dividing the actual load lifted/lowered by the RWL (LI = Weight ÷ RWL). The LI provides a relative estimate of the level of physical stress and MSD risk associated with the manual lifting and lowering tasks evaluated. A LI value of 1.0 or less indicates a nominal risk to healthy employees. A Lifting Index greater than 1.0 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 lower than 1.0.

**The LI answers the question… "How significant is the risk?"**

The RWL and LI can be used to guide manual material handling task design in the following ways: 1) Individual multipliers that 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 lifting 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.

**Additional Outputs:**

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 (FM) 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.

## Origin & Destination:

The NIOSH Lifting Equation uses the terms "Origin" and "Destination" of the lifting or lowering task to denote the starting point and ending point respectively. The "Origin" is the starting point of a lifting task, the point at which the weight of the object is loaded onto the hands and moved vertically. The "Destination" is ending point of the lifting task, the point at which the weight of the object is unloaded from the hands and stops moving vertically.

## NIOSH Lifting Equation Calculator:

| | Origin | Destination |
|---|---|---|
| Horizontal Location | 10 | 16 |
| Vertical Location | 36 | 56 |
| Travel Distance | 20 | 20 |
| Angle of Asymmetry | 20 | 0 |
| Coupling | Fair | Fair |
| Frequency | 0.5 | 0.5 |
| Avg. Load | 25 | 25 |
| Max Load | 28 | 28 |
| Duration | Moderate (1-2 hours) | Moderate (1-2 hours) |

Calculate

Clear | Print | Save

| | Origin | Destination |
|---|---|---|
| Recommended Weight Limit (RWL) | 38.13 lb(s) | 21.52 lb(s) |
| Frequency Ind. RWL (FIRWL) | 41.44 lb(s) | 23.39 lb(s) |
| Lifting Index (LI) | 0.66 | 1.16 |
| Frequency Ind. Lifting Index (FILI) | 0.68 | 1.20 |

| | Origin | Dest. |
|---|---|---|
| HM | 1.00 | 0.63 |
| VM | 0.95 | 0.80 |
| DM | 0.91 | 0.91 |
| AM | 0.94 | 1.00 |
| CM | 1.00 | 1.00 |

The NIOSH Lifting Equation can be calculated by hand, but it's much easier and a huge time saver to use our Excel or Web-based calculators. The task variables are simply entered into the Origin and Destination fields of the calculator. When the "calculate" button is pressed, the multipliers and the RWL and LI Outputs are automatically calculated.

Ergonomics Plus Web-based NIOSH Calculator

# USING THE NIOSH EQUATION

## Step 1: Determine Task Variables Needed

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.

To determine the task variables needed: Gather information, interview supervisors, group leaders, and workers to determine the origin (start position) and the destination (ending position) of the lifting or lowering task, and whether significant control of the object being lifted or lowered is required at the destination of the lift. Significant control is a condition of the task that requires precision placement of the load at the destination of the lift. For example, when an object is fragile and careful placement is needed to protect the object from damage. Or, the worker needs to change grip or hold or guide the object at the lifting or lowering destination.

If any of these conditions exist, significant control at the destination is required. You will then need to collect all other task variable data at the destination (in addition to the origin) to accurately determine the RWL. If significant control is not required at the destination, the only measurement you will need at the destination is the vertical location (V) of the hands in order to determine the vertical travel distance (D) from the origin of the lifting task.

## Step 2: Measure and Record Task Variables

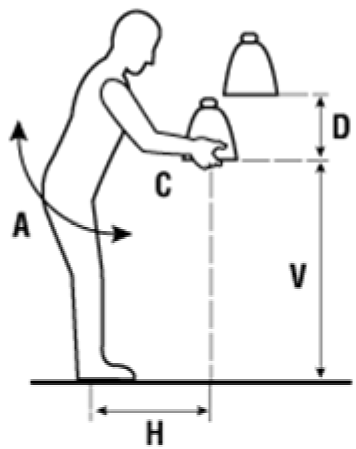
The next step is to gather the needed information and perform the measurements for each lifting task variable, and record the data to be used later to calculate the RWL and LI for the tasks being evaluated. For each lifting task analyzed, the evaluator will need to determine the task variables as outlined above. We have developed the following worksheet to assist you with data collection:

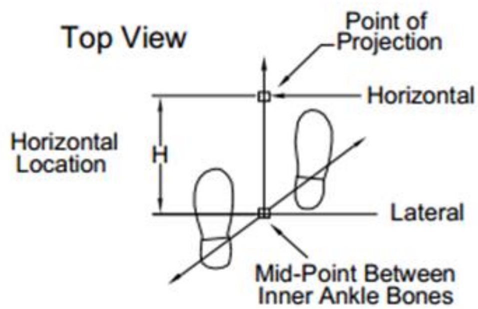
Department: Job:

| 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) |
| | | | | | | | | | |
| | | | | | | | | | |

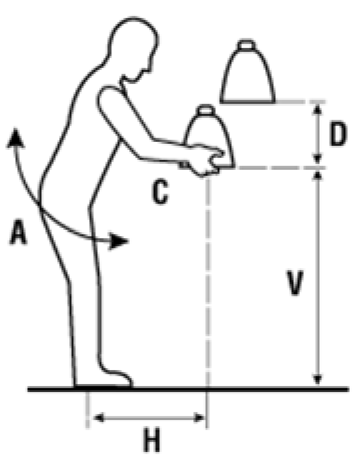
The following task variables are evaluated to calculate the multipliers that are used in the NIOSH equation to determine the RWL. Here are some quick explanations and guidelines that you can use to gather the needed measurements:

1) **Horizontal Location of the Hands (H)** – Measure and record the horizontal location of the hands at the start (origin). Then, measure and record and horizontal location of the hands at the end (destination) of the lifting task if significant control is required. 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:

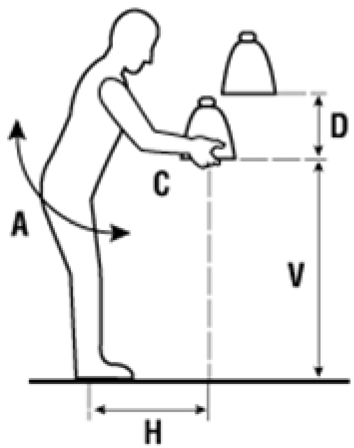


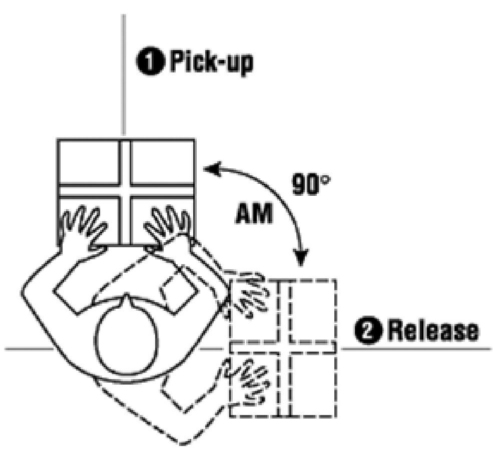

2) **Vertical Location of the Hands (V)** – Measure and record the vertical location of the hands (defined as large middle knuckle) above the floor at the start (origin) of the lifting task. Measure and record and vertical location of the hands at the end (destination) of the lifting task if significant control is required. The vertical location is measured from the floor to the vertical mid-point between the two hands as shown below:




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. 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 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

For additional help measuring and recording task variables, register for our advanced ergonomic assessment training course. Click here to learn more.

## Step 3: 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 Excel 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

## Step 1: Determine Task Variables Needed

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. The starting point (Origin) of this lifting task is pictured on the left, and the ending point (Destination) of the lift is pictured on the right. The container frequently needs to be carefully placed onto the cart at the end of the lifting task, so we determined that significant control of the object is required at the destination. The containers are of near optimal design with handholds.

Origin

Destination

## Step 2 – Measure and Record 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 3 – Enter Data / Calculate RWL and LI:

Origin and Destination Calculations (using our web-based calculator):

| | Origin | Destination |
|---|---|---|
| Horizontal Location | 15 | 12 |
| Vertical Location | 11 | 40 |
| Travel Distance | 29 | 29 |
| Angle of Asymmetry | 10 | 0 |
| Coupling | Good | Good |
| Frequency | 2 | 2 |
| Avg. Load | 12.5 | 12.5 |
| Max Load | 26 | 26 |
| Duration | Moderate (1-2 hours) | Moderate (1-2 hours) |

Calculate

Clear | Print | Save

| | Origin | Destination |
|---|---|---|
| Recommended Weight Limit (RWL) | 21.07 lb(s) | 29.10 lb(s) |
| Frequency Ind. RWL (FIRWL) | 25.08 lb(s) | 34.64 lb(s) |
| Lifting Index (LI) | 0.59 | 0.43 |
| Frequency Ind. Lifting Index (FILI) | 1.04 | 0.75 |

| | Origin | Dest. |
|---|---|---|
| HM | 0.67 | 0.83 |
| VM | 0.86 | 0.93 |
| DM | 0.88 | 0.88 |
| AM | 0.97 | 1.00 |
| CM | 1.00 | 1.00 |
| FM | 0.84 | 0.84 |

Origin Summary: The average weight to be lifted (12.5 lb.) is less than the RWL at the origin (21 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.

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