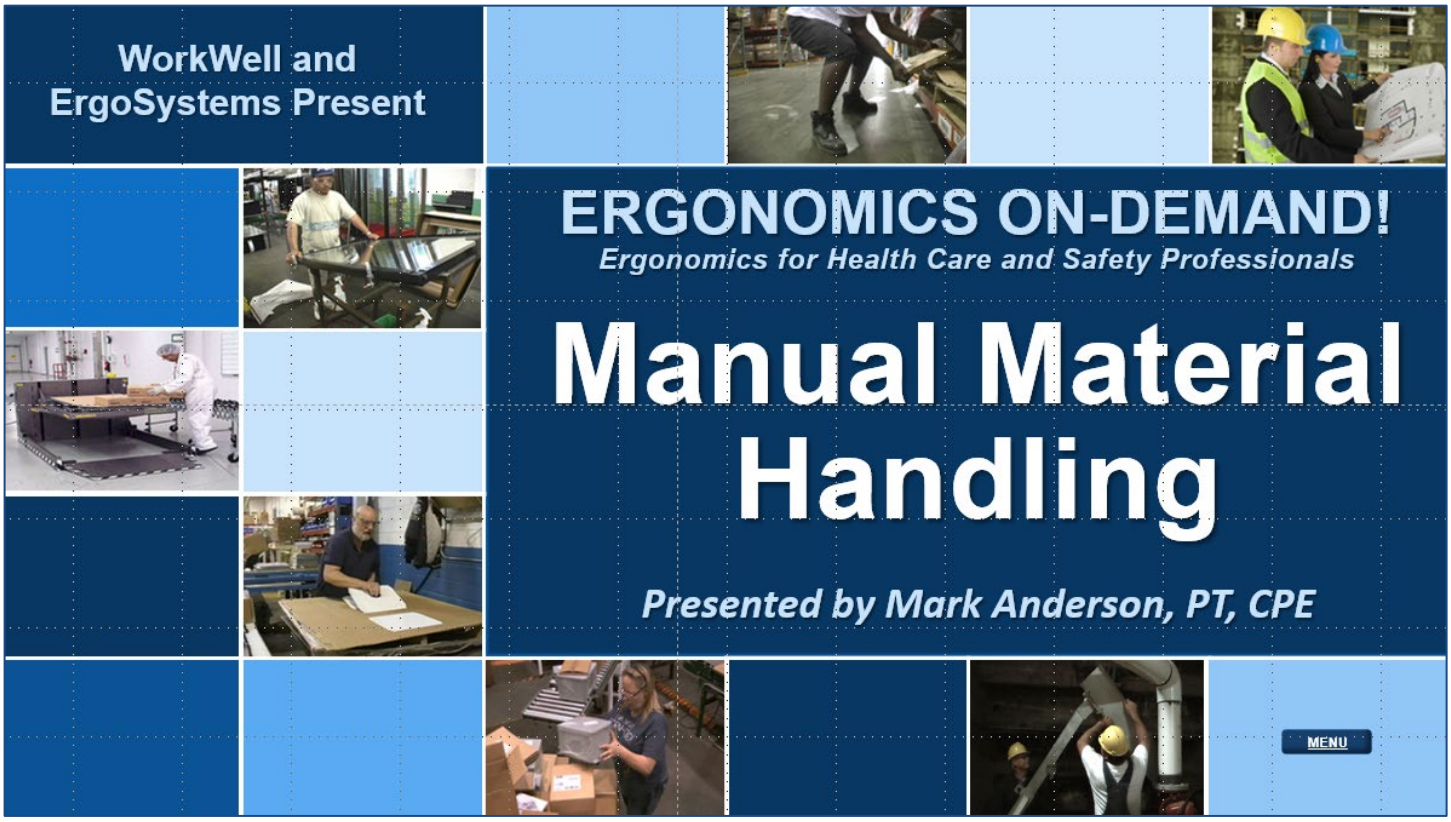
WORKWELL
Musculoskeletal Care for Organizations



Developed by:

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MANUAL MATERIAL HANDLING TRACK

Welcome

Welcome to the ***Ergonomics Manual Material Handling Track.***

Hi everyone, I'm Mark Anderson. I am a Certified Professional Ergonomist and Physical Therapist with more than 30 years of experience working with ergonomics. Thanks for your interest in Ergonomics and Manual Material Handling.

How Much Weight Can a Person Lift?

A basic question I get on a regular basis is, ***"How much weight can a person lift in a safe and effective way?***

To answer this question, I think we need to ask another question, ***"What are the factors that influence how much weight a person can safely lift?"***

And a third question, ***"Based on these factors, can a mathematical formula be developed to predict how much a person can safely and effectively lift?"***

Not surprisingly, these questions have been studied extensively over the past 50 years.

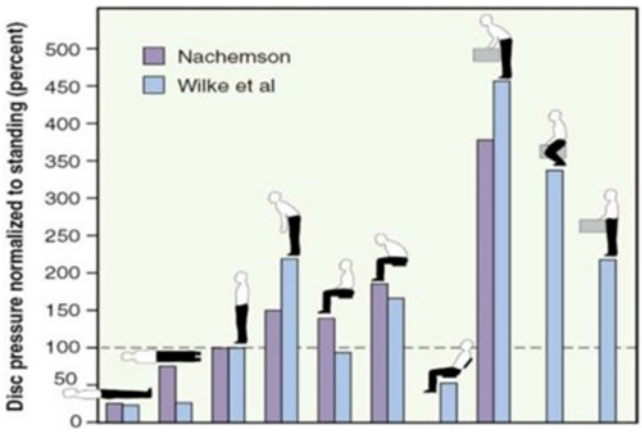
And then we should ask one more question, ***"How can we apply this information to identify the level of risk of manual material handling and then offer reasonable interventions?"***

These are the topics we will explore in the ***Ergonomics Manual Material Handling Track***.

Occupational Biomechanics

You might recall in the ***Introduction to Ergonomics Track*** one of the ergonomics principles we introduced was to ***Control Manual Material Handling***. We looked at Occupational Biomechanics information specific to intra-discal pressures generated with manual handling. In the 1970's, what have become classic research studies in the investigation of postural influences on in-vivo lumbar intervertebral disc pressures were conducted by Alf Nachemson, MD, PhD and colleagues. Results revealed increased discal pressures based on lever arm lengths in the spinal column.

With in-vivo lumbar intervertebral disc pressures normalized to 100% when in a neutral upright standing position, discal pressures with lifting about a 30 lb. box from a 30^0 flexed forward posture of the low back position were almost 500%! Holding the same box in an upright posture as close to the body as possible resulted in about half that of about 225%. Decreasing the lever arm distance makes a huge difference.



Disc Pressure Measurements

Nachemson, AL

Spine, 31 Dec 1980, 6(1):93-97

New In Vivo Measurements of Pressures in the Intervertebral Disc in Daily Life

Hans–Joachim Wilke, PhD, Peter Neef, MD,† Marco Caimi, MD,‡ Thomas Hoogland, MD,§ and Lutz E. Claes, PhD**

Spine, Volume 24, Number 8, pp 755–762

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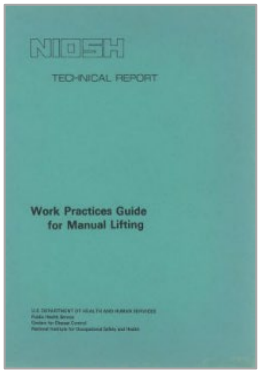
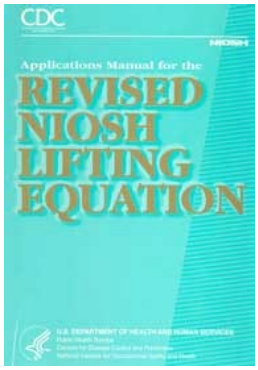
Lifting Calculators

We noted that a number of Lifting Calculators and Guidelines have been developed to analyze lifting tasks. One of the first guidelines was the ***NIOSH (National Institute for Occupational Safety and Health) Work Practices Guide for Manual Lifting*** published in 1981 with a ***Revised Guide*** published in 1994.





A mathematical formula to predict how much a person can safely lift was introduced in the ***Guide***.

Lifting Guide Criteria

Four criteria were studied to develop the original ***Guide***:

- Epidemiology – Identification of incidence, distribution and potential controls for illness and injury in a population.
- Biomechanical – Study of the impact on the musculoskeletal structure, (particularly the low back) from lifting.
- Physiological – Study of the body's metabolic and circulatory responses to lifting.
- Psychophysical – Studies performed to quantify the subjective tolerance of people to the stresses of manual material handling.

I would encourage you to read the ***Guides*** if you are interested in an in-depth look at the factors. They are readily available on-line.

1991 Version

https://www.cdc.gov/niosh/docs/81-122/pdf/81-122.pdf?id=10.26616/NIOSHPUB81122

1994 Version

https://www.cdc.gov/niosh/docs/94-110/pdfs/94-110.pdf?id=10.26616/NIOSHPUB94110

Lifting Scenario

To gain an appreciation of the nuts and bolts of assessing manual material handling operations, let's work on developing a list of parameters that influence how much a person can lift based on our experiences of lifting.

For our lifting scenario, imagine we are assessing a warehouse worker palletizing boxes coming off of a conveyor line by loading them onto a pallet.

The manual handling tasks are repetitive (handling one box every minute) and the worker starts with a row of boxes on the pallet and then builds up box levels to about a five foot height (shoulder level).

Potential Lifting Factors

What are the factors that influence the worker's performance? Make it personal by imagining you are doing the material handling or even better yet, imagine your mother is palletizing the boxes!

I'll kick off a brainstorming session by thinking about the last time I was lifting some bags of sand into the bed of my truck at the big box store. When I reached out to pick up a bag, the farther away I reached to the bag. the heavier the bag seemed to get! This a phenomenon we have all experienced.

Let's name this factor Horizontal Distance and define it as, "how far away from our body is the item or box when we lift it; the farther away the greater the stress into the body."

Brainstorm – Potential Lifting Factors

Brainstorm – list as many factors as you can think of that will influence the palletizing operation.

1. Horizontal Distance – how far away from our body is the box when we lift it; the farther away the greater the stress into the body
2.
3.
4.
5.
6.
7.
8.
9.
10.

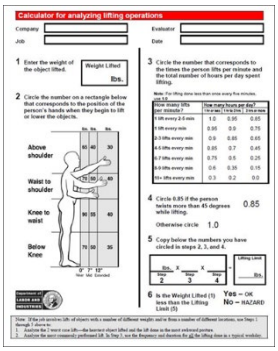
Potential Lifting Factors

How did you do? Check out this list.

- **Horizontal Distance** – how far away from our body is the box when we lift it; the farther away the greater the stress into the body
- **Frequency** – how often do we have to lift the box; how many times per minute
- **Duration** – over how long a period of time during the shift does the lifting occur; less than an hour, one to two hours, two to four hours, more than four hours
- **Spine Twisting** – does twisting or rotating of the spine (of the lower back particularly) occur to perform the lift
- **Vertical Distance Origin** – how high the box is from the floor at the start of the lift; at higher than mid-chest level the greater the stress on the body to handle the load
- **Vertical Distance Destination** – how high the box is from the floor at the end of the lift; at lower than waist to mid-chest level the greater the stress on the body to handle the load
- **Item/Box size** – is the item or box large and unwieldy, out of balance, difficult or even impossible to hold close the body thereby increasing the horizontal distance
- **Grip on the box** – is the box easy to grip with handholds/handles or hard to grip with no handholds and maybe even slippery
- **Actual object weight** – how much does the box weigh or what is the range of weights if the boxes vary in weight.

You probably came up with many if not all of the factors and when you reflect on the ***Ergonomics Principles*** found in the ***Introduction to Ergonomics Track*** you can see how these factors influence lifting performance.

Simplified Lifting Calculator



If we compare what we came up with in our brainstorming session to the ***NIOSH Work Practices Guide for Manual Lifting (Revised)*** we would see these are the primary parameters in the ***Guides***.

Refer to the ***Guides*** if you would like more details. For our purposes we will introduce a simplified version of the lifting calculator.

The States of Washington and Oregon Departments of Labor and Industries developed a version of the ***NIOSH Work Practices Guide for Manual Lifting***. It is called the ***LNI Lifting Calculator***.

A few issues to be aware of when you use the LNI lifting calculator include:

- The estimated Lifting Limit is based on the predicted capability of health adults to handle the weight; this includes about 95% of healthy males and about 75% of healthy females. There certainly are some individuals who can safely handle more than the predicted Lifting Limit.
- Stature of the individual is not considered in the calculation.
- Gender of the individual is not considered in the calculation.

LNI Lifting Calculator Online App

The LNI Lifting Calculator is available as an online app and I encourage you to check it out at https://osha.oregon.gov/OSHAPubs/apps/liftcalc/lift-calculator.html

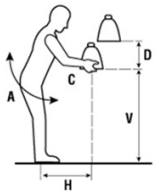
Manual Material Handling Basic Criteria

So, in overview, the ***LNI Lifting Calculator*** considers basic criteria of the manual material handling event:

Actual Object Weight

Determine the actual weight of the object. If a range of weights is noted; for example, 30 to 40# (13.5 to 18.1 kg), use the higher value in your calculations because it would be the "worst case".

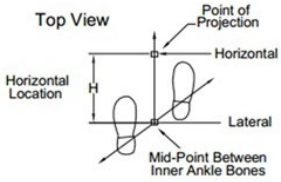
Horizontal Distance (H)



How far from the body is the object being handled?

The farther away, the longer the lever arm and the more stress into the body.

Estimating Horizontal Distance (H) can be a little tricky. The horizontal location is determined by measuring the distance between the point projected on the floor directly below the mid-point of the hands grasping the object (center of mass), and the mid-point of a line between the inside ankle bones as pictured.

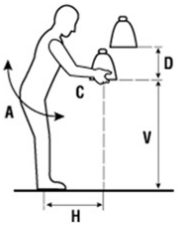


The ***LNI Lifting Calculator*** uses predetermined Horizontal Distance values of: 0", 7" or 12" (0 cm, 18 cm or 30 cm).

Vertical Position

At what level from the floor is the object being handled?

The farther away from the Optimal Lifting Zone (about waist level) the more stress into the body.



The vertical location is measured from the floor (or standing surface) to the vertical mid-point between the hand grasps as defined by large middle knuckle of the hand.

You may need to determine two Vertical Position measurements (V is the origin position and V + D is the destination position) and perform two calculations.

Frequency and Duration

How often and for how long is the object being handled?

From the physiological fatigue standpoint, once every five minutes is dramatically different than 10 times per minute. Frequency has a huge impact. Frequency is categorized as lifts per minute. Look at the ***LNI Lifting Calculator Worksheet*** to see the categories of 'How many lifts per minute'.

Duration is how long throughout the shift the handling is occurring? Over the course of the shift is the manual handling occurring for an hour total or two or the entire shift?

How many lifts per minute?	How many hours per day?		
	1 hr or less	1 hr to 2 hrs	2 hrs or more
1 lift every 2-5 min	1.0	0.95	0.85
1 lift every min	0.95	0.9	0.75
2-3 lifts every min	0.9	0.85	0.65
4-5 lifts every min	0.85	0.7	0.45
6-7 lifts every min	0.75	0.5	0.25
8-9 lifts every min	0.6	0.35	0.15
10+ lifts every min	0.3	0.2	0.0

Longer duration is related to increased exposure to stress and results in lower weight limits.

Relationship between hours/day and multiplier.

Look at the ***LNI Lifting Calculator Worksheet*** to see the relationship between the hours/day and the multiplier. For example, for one lift occurring every 2-5 minutes at a cumulative duration of one hour or less in the shift, the multiplier is 1.0 and has no impact on the calculation.

On the other end of the spectrum for 10+ lifts occurring every minute at a cumulative duration of two hours or more in the shift, the multiplier is 0.0 and essentially indicates this lift should not be performed.

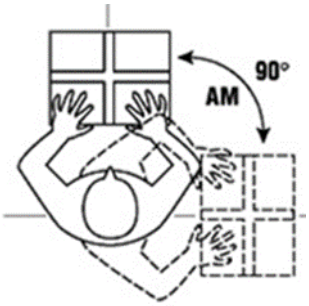
Then you will see the multiplier is on a sliding scale between these two points.

Spine Rotation

Is spinal rotation occurring during the lift?

Rotation of the spine, particularly with forward bending when lifting has been determined to result in significant shear and compression force into the spine.

Estimate spine rotation as the angle between the shoulders and hips from origin to destination of the lift. For spine rotation more than 45 degrees, the multiplier is 0.85.



Object size and grip

What shape and size is the object and how well can it be gripped? Smaller, well-balanced objects with handholds are easier to handle. The 1994 revised ***NIOSH Work Practices Guide for Manual Lifting*** added a hand-to-container coupling factor.

The ***LNI Lifting Calculator*** does not include a hand-to-container factor; if you identify this as an issue you will want to make note of this and perhaps decrease the recommended weight or recommend a change in object size or grasping.

LNI Lifting Calculator Worksheet

We will go through the LNI Lifting Calculator Worksheet so you can see the underlying strategy to use it.

Calculator for analyzing lifting operations

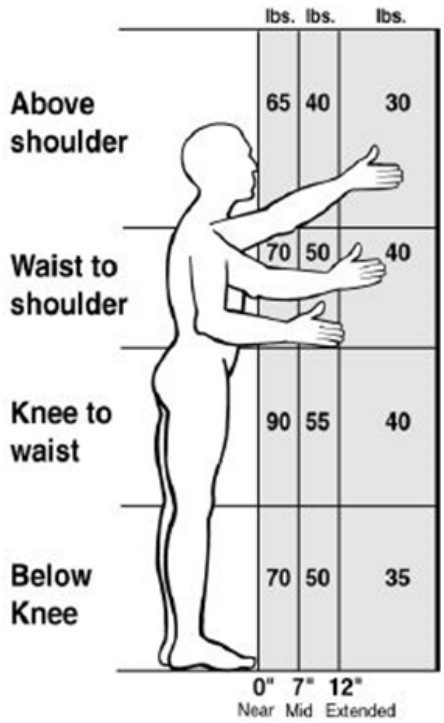
Company _____ Evaluator _____

Job _____ Date _____

1 Enter the weight of the object lifted.

Weight Lifted _____ lbs.

2 Circle the number on a rectangle below that corresponds to the position of the person's hands when they begin to lift or lower the objects.



3 Circle the number that corresponds to the times the person lifts per minute and the total number of hours per day spent lifting.

Note: For lifting done less than once every five minutes, use 1.0

How many lifts per minute?	How many hours per day?		
	1 hr or less	1 hr to 2 hrs	2 hrs or more
1 lift every 2-5 min	1.0	0.95	0.85
1 lift every min	0.95	0.9	0.75
2-3 lifts every min	0.9	0.85	0.65
4-5 lifts every min	0.85	0.7	0.45
6-7 lifts every min	0.75	0.5	0.25
8-9 lifts every min	0.6	0.35	0.15
10+ lifts every min	0.3	0.2	0.0

4 Circle 0.85 if the person twists more than 45 degrees while lifting. 0.85

Otherwise circle 1.0

5 Copy below the numbers you have circled in steps 2, 3, and 4.

_____ lbs. (Step 2) X _____ (Step 3) X _____ (Step 4) = Lifting Limit _____ lbs.

6 Is the Weight Lifted (1) less than the Lifting Limit (5)

Yes – OK
No – HAZARD

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Note: If the job involves lifts of objects with a number of different weights and/or from a number of different locations, use Steps 1 through 5 above to:

1. Analyze the 2 worst case lifts—the heaviest object lifted and the lift done in the most awkward posture.
2. Analyze the most commonly performed lift. In Step 3, use the frequency and duration for all the lifting done in a typical workday.

Manual Material Handling Case Study – Handle Speaker

Handle Speaker Background

Let' s work on a material handling case study to get a feel of how to use the LNI Lifting Calculator. Sound technicians at a company are responsible for setting up speaker systems on-site at various venues. Here are the specifics:

- Speaker weight is 45# (20.5 kg)
- Speaker is lifted from the floor and placed on the top of a stand (about 60"/152 cm) off the ground)
- Duration is for one hour or less/day
- Frequency is 1 lift/min

We need to perform the calculation twice; first for the lift from the floor and second for the speaker lift and placement on the stand. Let's check out the video.

Lift from Floor

Let's do the Lift from Floor calculation first.

The Weight Lifted is 45# (20.5 kg)

Hand Position is Below Knee at 7" (18 cm); you will see the 50# (22.7 kg) box is checked

Lifts/min is 1

Hours/day is 1 hr or less

So, the appropriate box is checked; the multiplier is 0.95

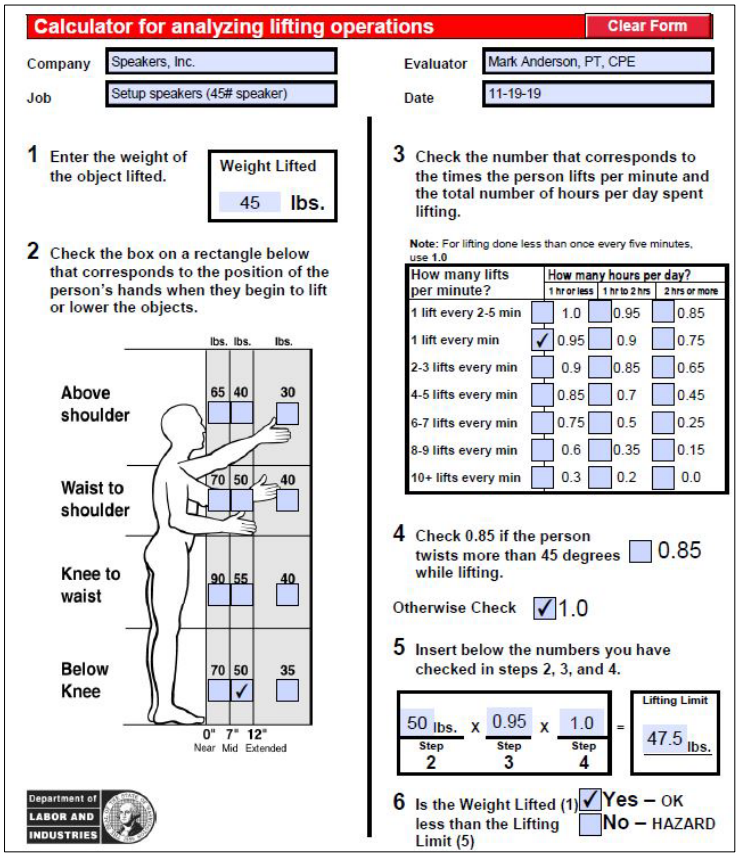
Twists more than 45 degrees: the answer is no. So the 1.0 multiplier box is checked.

Next, we do the math:

50# (22.7 kg) x 0.95 x 1.0 = 47.5# (21.5 kg).

Is the Weight Lifted (45#/20.5 kg) less than the Lifting Limit (47.5#/21.5 kg).

It is, so we answer YES – **OK.**



Calculator for analyzing lifting operations — Clear Form

Company: Speakers, Inc. — Evaluator: Mark Anderson, PT, CPE

Job: Setup speakers (45# speaker) — Date: 11-19-19

1 Enter the weight of the object lifted. Weight Lifted: 45 lbs.

2 Check the box on a rectangle below that corresponds to the position of the person's hands when they begin to lift or lower the objects.

	lbs.	lbs.	lbs.
Above shoulder	65	40	30
Waist to shoulder	70	50	40
Knee to waist	90	55	40
Below Knee	70	50 ✓	35

0" 7" 12"
Near Mid Extended

3 Check the number that corresponds to the times the person lifts per minute and the total number of hours per day spent lifting.

Note: For lifting done less than once every five minutes, use 1.0

How many lifts per minute?	How many hours per day? 1 hr or less	1 hr to 2 hrs	2 hrs or more
1 lift every 2-5 min	1.0	0.95	0.85
1 lift every min	✓ 0.95	0.9	0.75
2-3 lifts every min	0.9	0.85	0.65
4-5 lifts every min	0.85	0.7	0.45
6-7 lifts every min	0.75	0.5	0.25
8-9 lifts every min	0.6	0.35	0.15
10+ lifts every min	0.3	0.2	0.0

4 Check 0.85 if the person twists more than 45 degrees while lifting. ☐ 0.85

Otherwise Check ✓ 1.0

5 Insert below the numbers you have checked in steps 2, 3, and 4.

50 lbs. (Step 2) x 0.95 (Step 3) x 1.0 (Step 4) = Lifting Limit 47.5 lbs.

6 Is the Weight Lifted (1) less than the Lifting Limit (5) ✓ Yes – OK ☐ No – HAZARD

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Lift to Stand

Now, let's do the Lift to Stand calculation. The Weight Lifted is still 45# (20.5 kg).

To place the speaker on the stand the Hand Position is Above Shoulder at 7" (18 cm) and you will see the 40# (18.1 kg) box is checked.

The Lifts/min is still 1.

The Hours/day is still 1 hr or less.

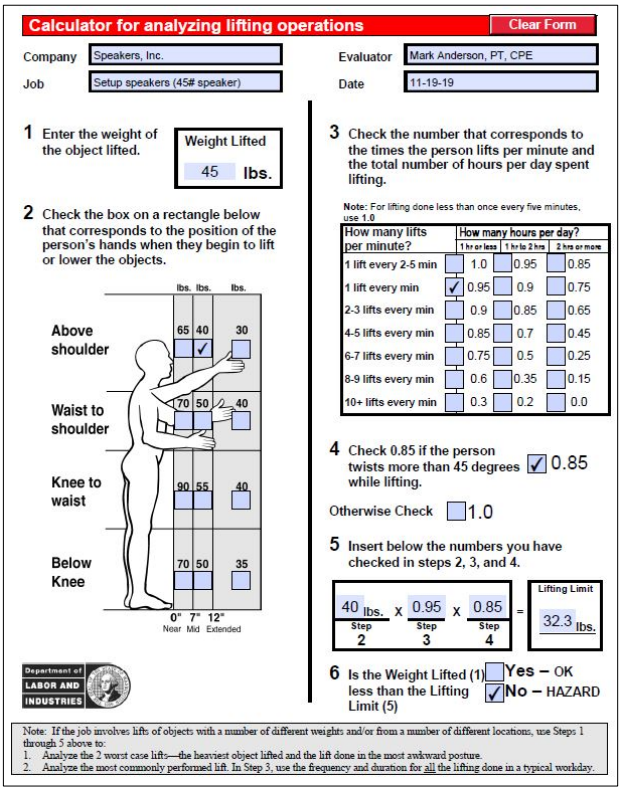
Now we do see twisting more than 45 degrees and the 0.85 multiplier box is checked.

Doing the math we get:

40# (18.1 kg) x 0.95 x 0.85 = 32.3# (14.7 kg).

Is the Weight Lifted (45#/20.5 kg) less than Lifting Limit (32.3#/14.7 kg)?

The answer is NO – **Hazard.**



Manual Material Handling Controls

Some type of manual material handling control is recommended to be considered.

Take a moment and list some options:

1. _____

2. _____

3. _____

4. _____

What did you come up with? This might include a two-person lift policy, a mechanical lifting device, worker body mechanics and technique training, functional capacity testing to identify if a particular individual has the functional capacity to safely handle the lift or perhaps some other options.

Manual Material Handling Guidelines

Take a look at the ***Manual Material Handling Checklist*** as needed for the general ergonomics analysis process in the ***Ergonomics Design Guidelines Track.***

A summary of the Guidelines includes:

- Eliminate (as feasible) manual handling by using mechanical handling equipment (forklifts, powered lifts, etc.).
- Reduce the physical stress of manual handling by using manual handing equipment (carts, two-wheelers, etc.).

Illustration of the lifting zone

(Left=Maximum Lifting Zone, Right=Optimal Lifting Zone)

Recommended dimensions for lifting comfort zone

Criteria	Dimension	Description
A. Maximum Zone bottom	Min. 20"	Minimum height
B. Maximum Zone top	Max. 60"	Maximum height
C. Optimal Zone bottom	Min. 30"	Minimum height in optimal zone
D. Optimal Zone top	Max. 50"	Maximum height in optimal zone
E. Distance from body to hand placement	Max. 10"	Optimal distance in front of the body.

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NIOSH Ergonomics Guidelines for Manual Material Handling

Check out the ***NIOSH Ergonomics Guidelines for Manual Material Handling*** at:

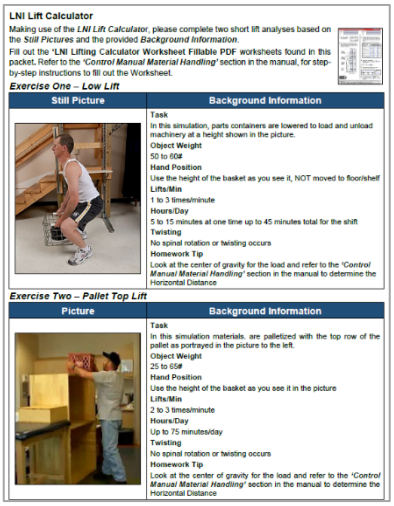
https://www.cdc.gov/niosh/docs/2007-131/default.html

Another good resource is the ***Canadian Centre for Occupational Health and Safet***y.

https://www.ccohs.ca/oshanswers/ergonomics/mmh/

The OSH Answers Fact Sheets on Manual Material Handling are informative.

Manual Material Handling Assessment Practice



LNI Lift Calculator

Making use of the *LNI Lift Calculator*, please complete two short lift analyses based on the *Still Pictures* and the provided *Background Information*.
Fill out the **'LNI Lifting Calculator Worksheet Fillable PDF** worksheets found in this packet. Refer to the *'Control Manual Material Handling'* section in the manual, for step-by-step instructions to fill out the Worksheet.

Exercise One – Low Lift

Still Picture	Background Information
	Task In this simulation, parts containers are lowered to load and unload machinery at a height shown in the picture. **Object Weight** 50 to 60# **Hand Position** Use the height of the basket as you see it, NOT moved to floor/shelf **Lifts/Min** 1 to 3 times/minute **Hours/Day** 5 to 15 minutes at one time up to 45 minutes total for the shift **Twisting** No spinal rotation or twisting occurs **Homework Tip** Look at the center of gravity for the load and refer to the *'Control Manual Material Handling'* section in the manual to determine the Horizontal Distance

Exercise Two – Pallet Top Lift

Picture	Background Information
	Task In this simulation materials, are palletized with the top row of the pallet as portrayed in the picture to the left. **Object Weight** 25 to 65# **Hand Position** Use the height of the basket as you see it in the picture **Lifts/Min** 2 to 3 times/minute **Hours/Day** Up to 75 minutes/day **Twisting** No spinal rotation or twisting occurs **Homework Tip** Look at the center of gravity for the load and refer to the *'Control Manual Material Handling'* section in the manual to determine the Horizontal Distance

To gain additional practice in using the LNI Lifting Calculator, download the ***Manual Material Handling Case Study***.

Here are some tips:

- Use the ***LNI Lifting Calculator Worksheet Fillable PDF*** (from your training materials) for the assignment. You can certainly check out the on-line version we discussed; however, we would encourage you to use the Worksheet to better understand how the calculator works.
- Review the basic criteria of the manual material handling event.
- Carefully read the instructions to get all the details you need to complete the exercise.
- If a range of weights is noted; for example, 30 to 40#/13.6 to 18.1 kg, use the higher value in your calculations because it would be the "worst case".

Ergonomics and Manual Material Handling

Manufacturing, office, warehouse, health care; no matter what work environment in which you apply ergonomics principles, controlling manual material handling is an integral part of a safe and productive workplace.

I hope our discussion on Manual Material Handling assessment and control methods has been informative for you. The ***Manufacturing Ergonomics Track*** includes very specific examples of applying control measures; check it out for additional ideas.

As always, thanks for your time and attention!