NIOSH RWL Method for lifting tasks

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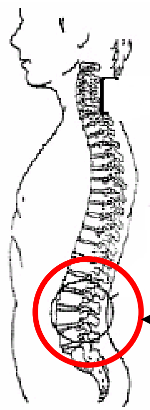
Manual Material Handling (MMH) Task

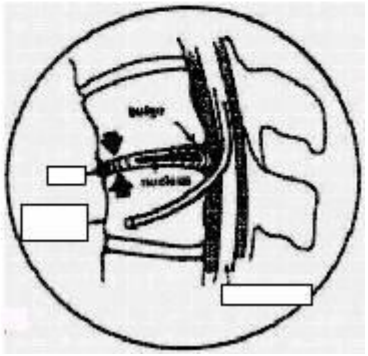
- Lifting
- Pulling
- Pushing
- Carrying

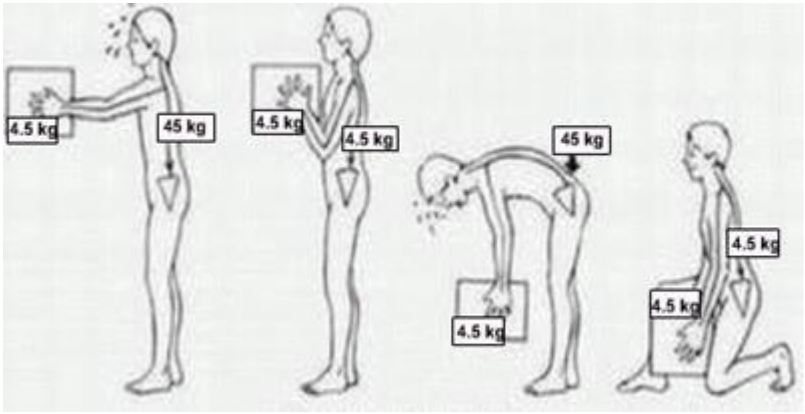
Injury Risk

- Low back pain
- Back injuries



- Compression force at L5/S1 disc





MMH Assessment

Biomechanical approach

- Estimates body mechanical stresses using models with varying degrees of complexity
- Usually compressive & shear components calculated at L5/S1

MMH Assessment

Physiological approach

- Based on energy cost of the activity
- Most suited to repeated handling tasks
- May be linked to biomechanical model *via* muscle activation

MMH Assessment

Psychophysical approach

- Uses worker's perception of physical strain to guide activity levels
- Suitable for frequent and infrequent loading

- "The load that nearly all healthy workers could perform over a substantial period of time (e.g. up to 8 hours) without an increased risk of musculoskeletal injury" (NIOSH)

NIOSH Lifting Guidelines based on:

Biomechanical	**Physiological**	**Psychophysical**
Maximum disc compression force	**Maximum energy Expenditure**	**Maximum acceptable Weight**
3.4KN (770 lbs)	**4.7 kcal/min**	**Acceptable to 75% of female workers and about 99 % of male workers**

NIOSH Recommended Weight Limit (RWL) Model

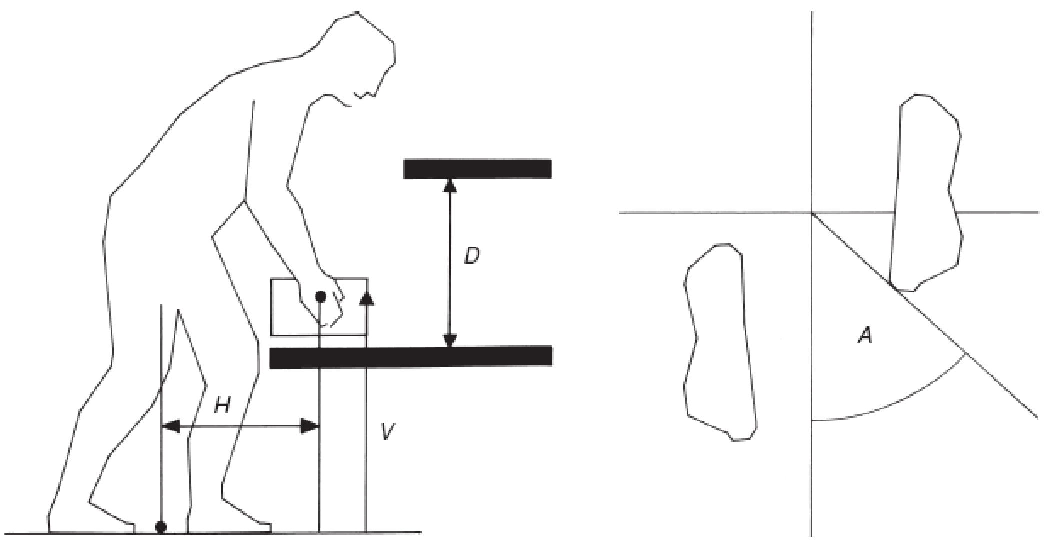
RWL= LC * HM * VM * DM * AM * FM * CM

Theoretically ideal state:

- RWL = 23 x 1 x 1 x 1 x 1 x 1 x 1 = 23kg

Definition of terms

- *RWL* = Recommended weight limit
- *LC* = Load constant = 23
- *HM* = Horizontal multiplier
- *VM* = Vertical multiplier
- *DM* = Distance multiplier
- *AM* = Asymmetric multiplier
- *FM* = Frequency multiplier
- *CM* = Coupling multiplier



NIOSH Recommended Weight Limit (RWL) Model

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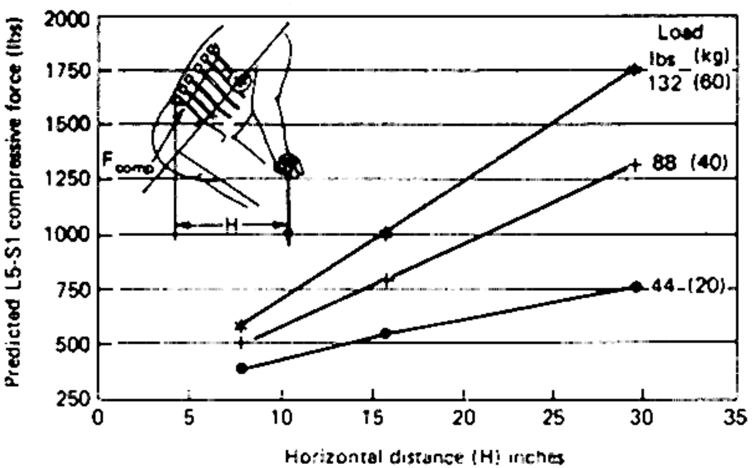
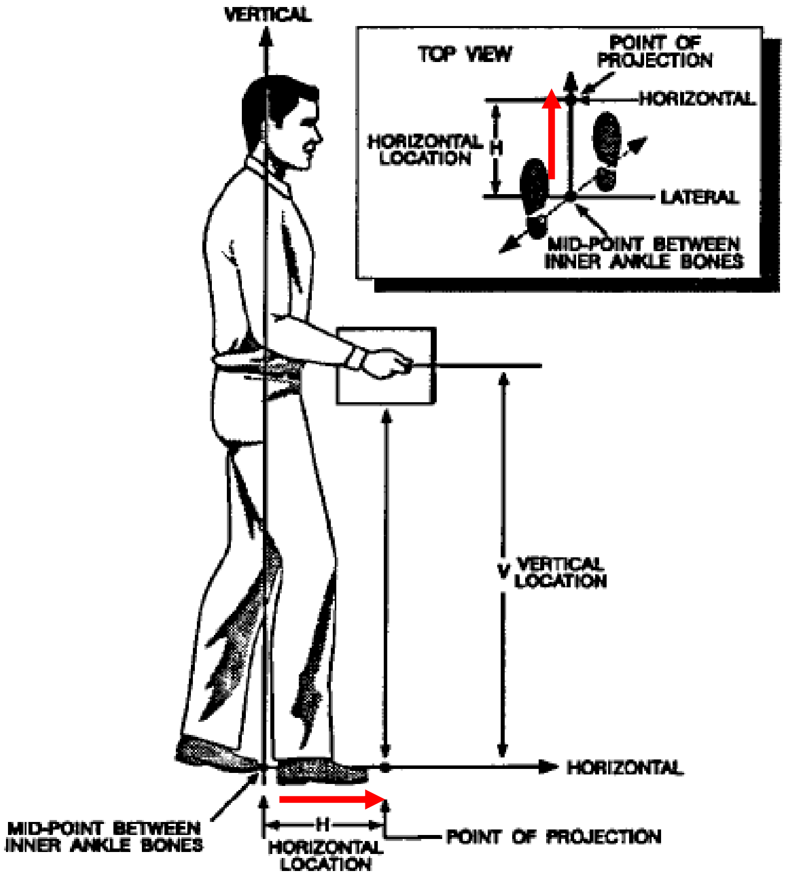
Horizontal Multiplier (HM)

- HM = 25 / H
- *Where*
- H = distance from hands to mid-point between medial malleoli measured at origin and destination
- If H > 63 cm, HM = 0
- If H < 25 cm, HM = 1



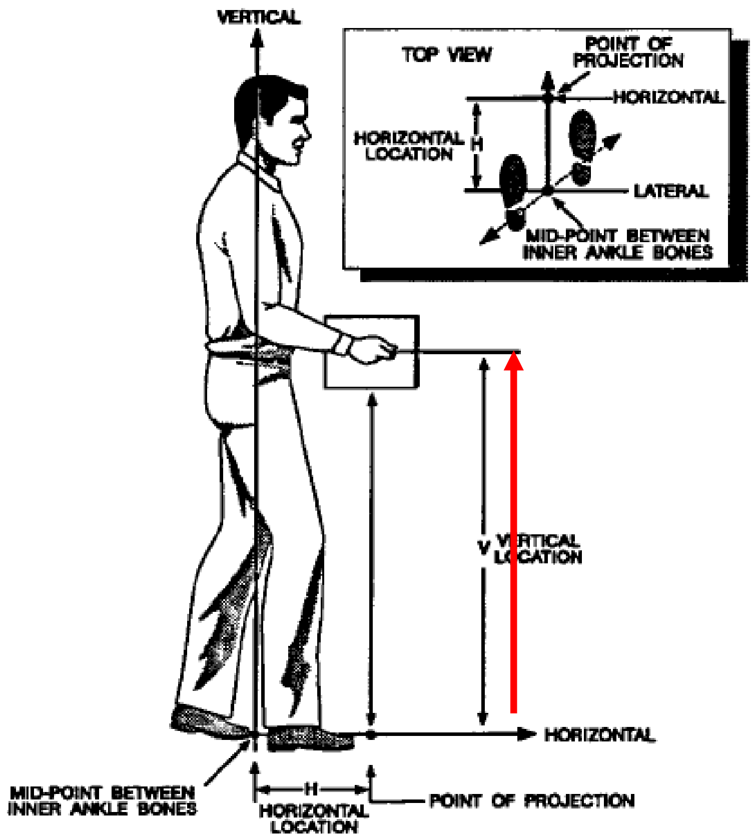


NIOSH Recommended Weight Limit (RWL) Model

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

Vertical Multiplier (VM)

- VM = 1 – (0.003 x |V-75|)
- *Where*
- V = distance of hands above floor measured at origin and destination
- If V > 175 cm, VM = 0
- If V = 0 cm, VM = 0.78

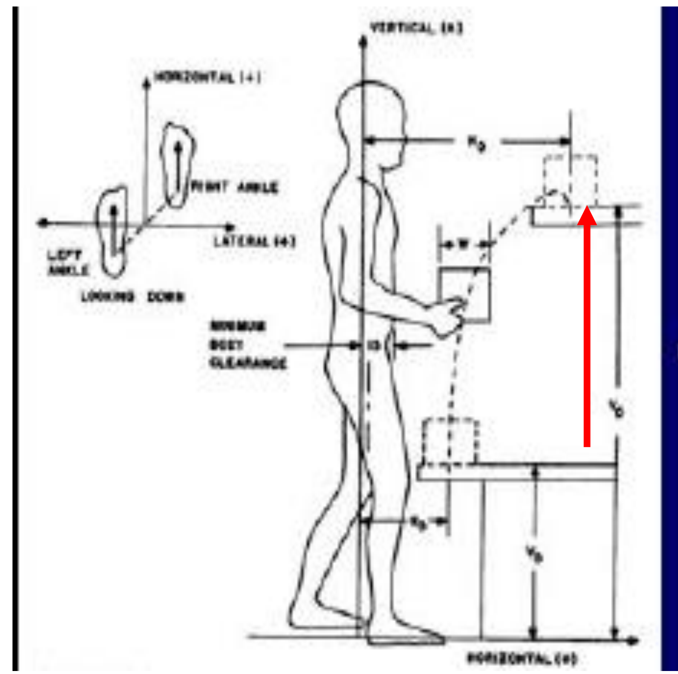


NIOSH Recommended Weight Limit (RWL) Model

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

Distance Multiplier (DM)

- DM = 0.82 + (4.5/D)
- *Where*
- D = vertical travel = high – low
- If D > 175 cm, DM = 0
- If D < 25 cm, DM = 1

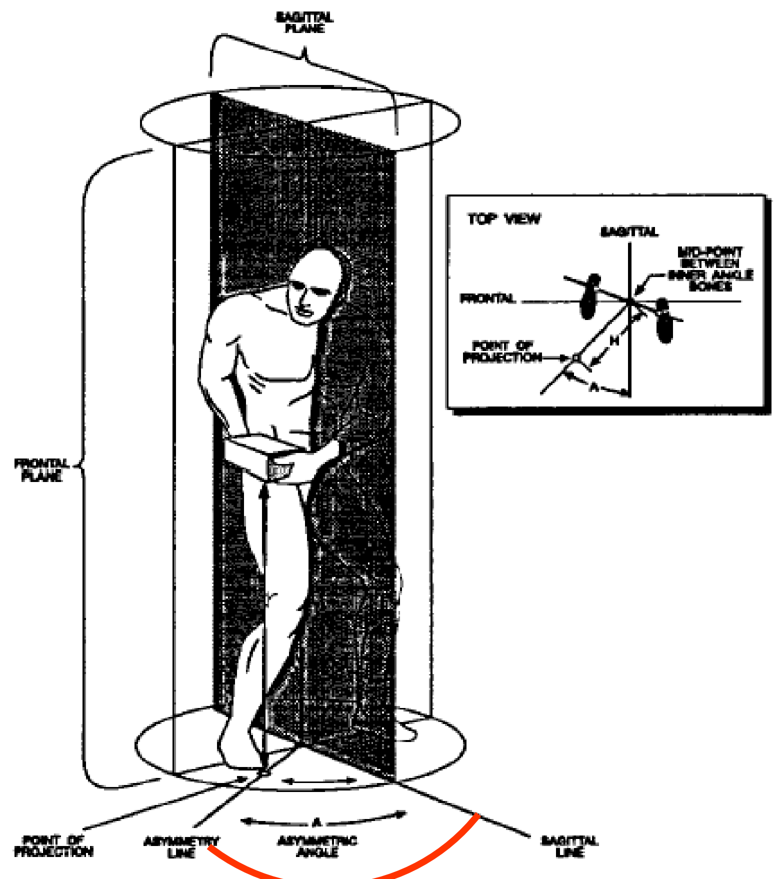


NIOSH Recommended Weight Limit (RWL) Model

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

Asymmetry Multiplier (AM)

- AM = 1 – (0.0032 x A)
- *Where*
- A = asymmetric angle, the angle between asymmetry line & sagittal line
- Asymmetry line = line between malleoli mid-point & point between hands mid-point
- Sagittal line = line between malleoli mid-point and sagittl plane if in anatomical position
- If A > 135°, AM = 0
- If A = 0°, AM = 1



NIOSH Recommended Weight Limit (RWL) Model

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

Frequency Multiplier (FM)

- Obtained from a table & depends on:
- Frequency: (repetitiveness) lifts / minute
- Duration: short, medium, long
- Lift height, V

Example:
V < 75 cm.
Work duration < 1 hour
Frequency = 10 lift/min
FM=0.45

Table 5
Frequency Multiplier Table (FM)

Frequency Lifts/min (F) ‡	Work Duration					
	≤ 1 Hour		>1 but ≤ 2 Hours		>2 but ≤ 8 Hours	
	V < 75	V ≥ 75	V < 75	V ≥ 75	V < 75	V ≥ 75
≤0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

NIOSH Recommended Weight Limit (RWL) Model

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Coupling Multiplier (CM)

- Obtained from a table and depends on:
- Coupling quality: good, fair or poor
- Lift height, V

Coupling Multiplier

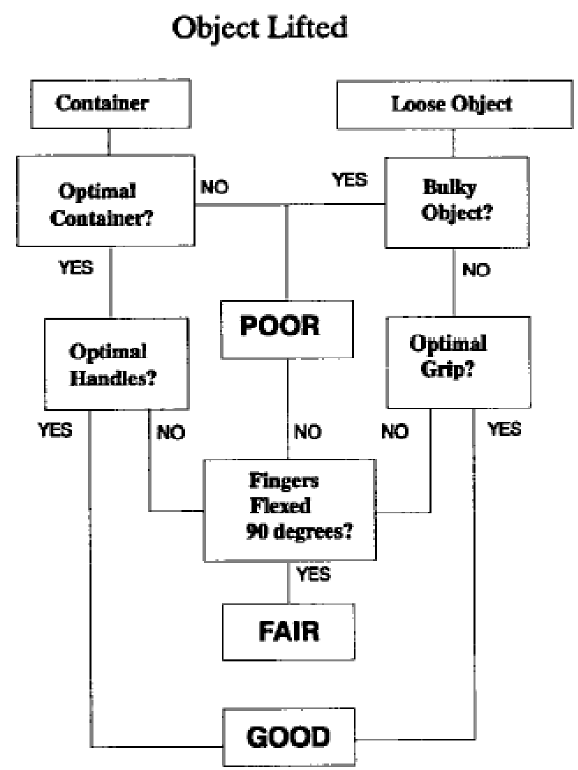
Coupling Type	Coupling Multiplier	
	V< 30 inches (75 cm)	V ≥ 30 inches (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

V < 75 cm.
Coupling Type : Fair
CM=0.95

NIOSH Recommended Weight Limit (RWL) Model

Coupling Multiplier (CM)

Decision Tree for Coupling Quality



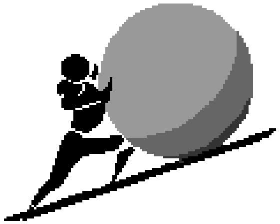
NIOSH Recommended Weight Limit (RWL) Model

Load Index → $LI = \dfrac{\text{Load Weight}}{\text{Recommended Weight Limit}} = \dfrac{L}{RWL}$

Where **Load Weight (L)** = weight of the object lifted (lbs or kg).

LI > 1 → Significant MMH risk - redesign

LI ≤ 1 → MMH risk is within acceptable limits



NIOSH Recommended Weight Limit (RWL) Model

LI-BASED RISK LEVEL ASSESSMENT

Supplementary reading

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

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Applied Ergonomics

Understanding outcome metrics of the revised NIOSH lifting equation

Robert R. Fox[a,*], Ming-Lun Lu[b], Enrico Occhipinti[c], Matthias Jaeger[d]

[a] *General Motors Company, Warren, MI, USA*
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[d] *IfADo–Leibniz Research Centre for Working Environment and Human Factors at Dortmund University of Technology, Germany*

ARTICLE INFO

Keywords:
Revised NIOSH lifting equation
Manual lifting tasks
ISO standard

ABSTRACT

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1. Introduction

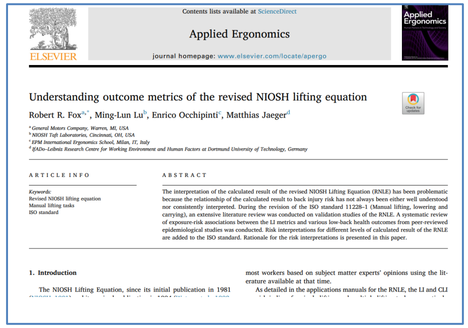
The NIOSH Lifting Equation, since its initial publication in 1981

most workers based on subject matter experts' opinions using the literature available at that time.

As detailed in the applications manuals for the RNLE, the LI and CLI

NIOSH Recommended Weight Limit (RWL) Model

LI-BASED RISK LEVEL ASSESSMENT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Interpretation of Lifting Index and derivates (*LI, CLI, VLI, SLI*).

Lifting Index Value (Exposure level)	Risk Implication	Recommended Actions
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1,5 < LI ≤ 2,0	Moderate	Redesign tasks and workplaces according to priorities to reduce the LI, followed by analysis of results to confirm effectiveness.
2,0 < LI ≤ 3,0	High	Changes to the task to reduce the LI should be a high priority.
LI > 3,0	Very high	Changes to the task to reduce the LI should be made immediately.
For Any level of Risk/Exposure	Identify any workers who may have special needs or vulnerabilities in lifting tasks and assign or design the work accordingly. Training workers on recognizing and eliminating material handling hazards is regarded as beneficial. Limiting the weight to be lifted, to less than the Reference Mass may also be considered.	

RWL Model: Example-1

Suppose you are an IE in a manufacturing plant. You are assigned to analyze lifting tasks performed in packaging department. The packages moving on the conveyor line are manually loaded into the big cardboard boxes.

***Horizontal distance** between mid-point of the packages and the spine = 30 cm.

*__The vertical height__ of the packages while on the conveyor = 60 cm.

*The **height of the cardboard box** = 110 cm.

***Assymetry angle** of the spine = 45 degrees.

*__The duration of the task__ = 3 hours/day

*__Lift frequency__ = 6 times/minute.

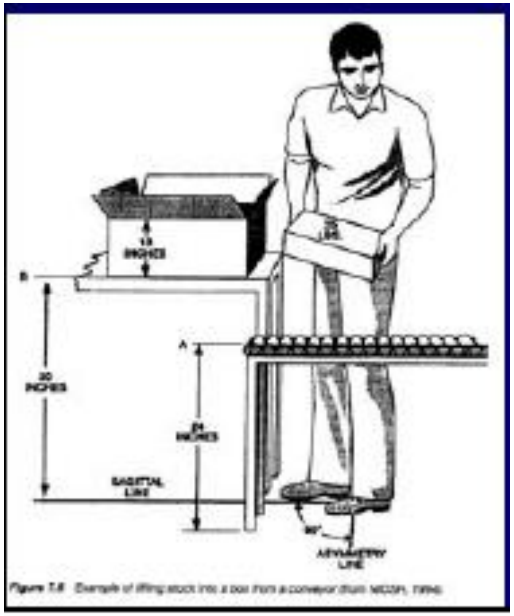
*__Coupling__ for the package is fair.

*__Actual weight__ of the box is 6 kg.

Apply NIOSH RWL model. Evaluate the risk level.

Procedure

- Determine task variables (H,V,D,A,F,C)
- Compute multipliers
- Compute RWL
- Compute LI
- Conclusions: Safe/Unsafe?
- Recommendations



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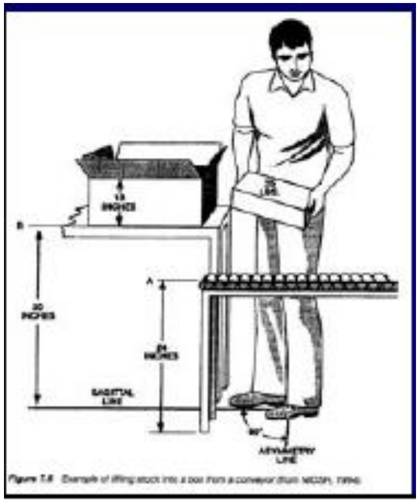

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Load constant (LC) = 23 kg.

Horizontal multiplier (HM) = 25 / 30 = 0.833

Vertical multiplier (VM) = 1 – (0.003 x **l** 60-75 **l**) = 0.955

Distance multiplier (DM) = 0.82 + ((4.5 / (110 – 60)) = 0.91

Assymetry multiplier (AM) = 1 – (0.0032 (45)) = 0.856

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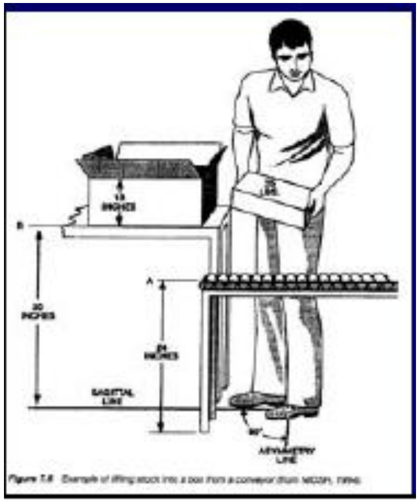

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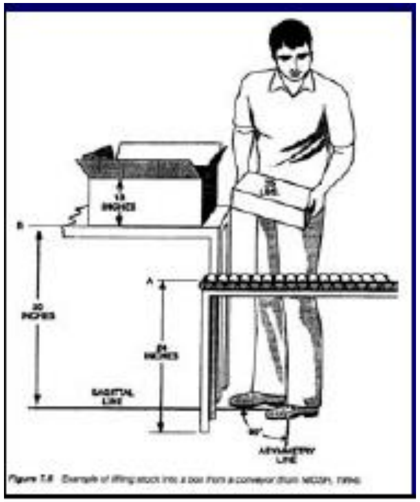

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Coupling Multiplier

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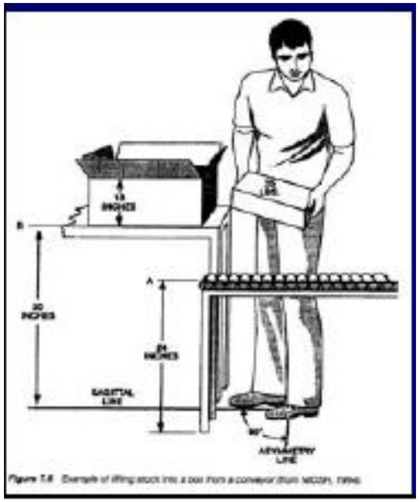

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RWL = 23 x 0.833 x 0.955 x 0.91 x 0.856 x 0.27 x 0.95 = 3.66 kg.

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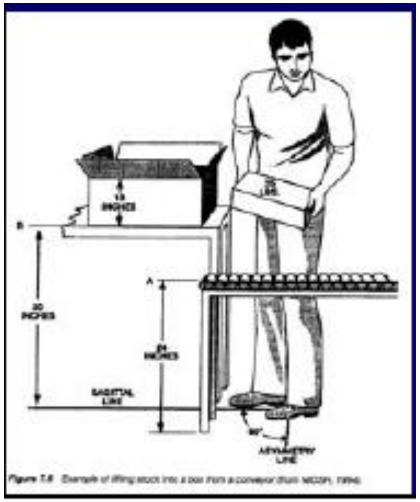

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RWL = 23 x 0.833 x 0.955 x 0.91 x 0.856 x 0.27 x 0.95 = 3.66 kg.

Load Index (LI) = Actual weight / RWL = 6 / 3.66 = 1.64

1.64 > 1 : This lifting task is not safe, it should be improved.

RWL Model: Example-1 LI-based risk assessment

LI-BASED RISK LEVEL ASSESSMENT

RWL = 23 x 0.833 x 0.955 x 0.91 x 0.856 x 0.27 x 0.95 = 3.66 kg.

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RISK LEVEL: MODERATE

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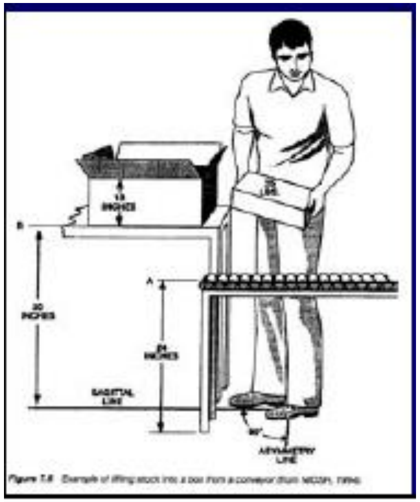
RWL Model: Example-1 Improvement ideas



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RWL = 3.66 kg.

LI = 1.64

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Assymetry multiplier (AM) = 1 – (0.0032 (45)) = 0.856

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Task improvements to decrease the risk and increase multiplier values:

Engineering Controls:

- Set the conveyor height to 75 cm to increase VM and DM
- Lower the work surface height to decrease travel distance and increase DM

Administrative Controls:

- Rotate the worker to decrease task duration – increase FM (the lowest multiplier)
  If work duration < 2 hours; FM = 0.5; RWL = 6.76
  LI = 0.88

RWL can be used;

- As a design aid to compare job designs
- To prioritise tasks for re-design
- To set max loads if task variables are fixed

ESSENTIAL READING

International Journal of Occupational Safety and Ergonomics (JOSE) 2009, Vol. 15, No. 1, 113–124

NOTES

An Ergonomics Approach Model to Prevention of Occupational Musculoskeletal Injuries

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The objective of this study was to prevent occupational musculoskeletal injuries. Our workers stacked boxes of ceramics weighing 10–27 kg, making low back pain common in our enterprise. In all the stacking stations, recommended weight limits (RWL) were separately calculated using the revised National Institute for Occupational Health lifting equation. Since the boxes weighed significantly more than the RWL, we developed a new ergonomic design that completely changed the stacking process. The load put on the workers' waist vertebrae in the new and the old stacking methods was compared to evaluate the success of the new ergonomic design, using Newton's third law of motion. Thanks to the new ergonomic design, the load on the workers' vertebrae decreased by 80%. Due to its simple technology and its very low cost compared to robots, the new ergonomic design can be commonly used in enterprises with repeated and constraining stacking.

low back pain ergonomic design heavy lifting stacking musculosceletal injury organizational stress

Textbook: Pamela McCauley Bush, *Ergonomics: Foundational Principles, Applications, and Technologies*, CRC Press, (2012)

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Ergonomics interventions to reduce musculoskeletal risk factors in a truck manufacturing plant

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ABSTRACT

Ergonomic interventions may potentially reduce MSDs, but the context of industries (barriers, ever-changing situations, dialogue processes) might play a significant role in the success of interventions. This study evaluates the effectiveness of ergonomic interventions including engineering/technical and organizational interventions, and the involvement of the stakeholders in reducing musculoskeletal risk factors/symptoms. A pre-post-test experimental study in non-randomized groups was performed over three years in a sector of a truck assembly plant. The mean age of the operators in the sector for the initial and second assessment time was 42.0 (±7.6) years and 39.0 (±8.7), respectively. The mean length of work experience in the current job was 15.2 (±7.2) years and 13.9 (±7.3) for the initial and second assessment times, respectively. Five engineering ergonomic solutions and organizational interventions were implemented after a comprehensive ergonomic analysis.

Textbook: Pamela McCauley Bush, *Ergonomics: Foundational Principles, Applications, and Technologies*, CRC Press, (2012)