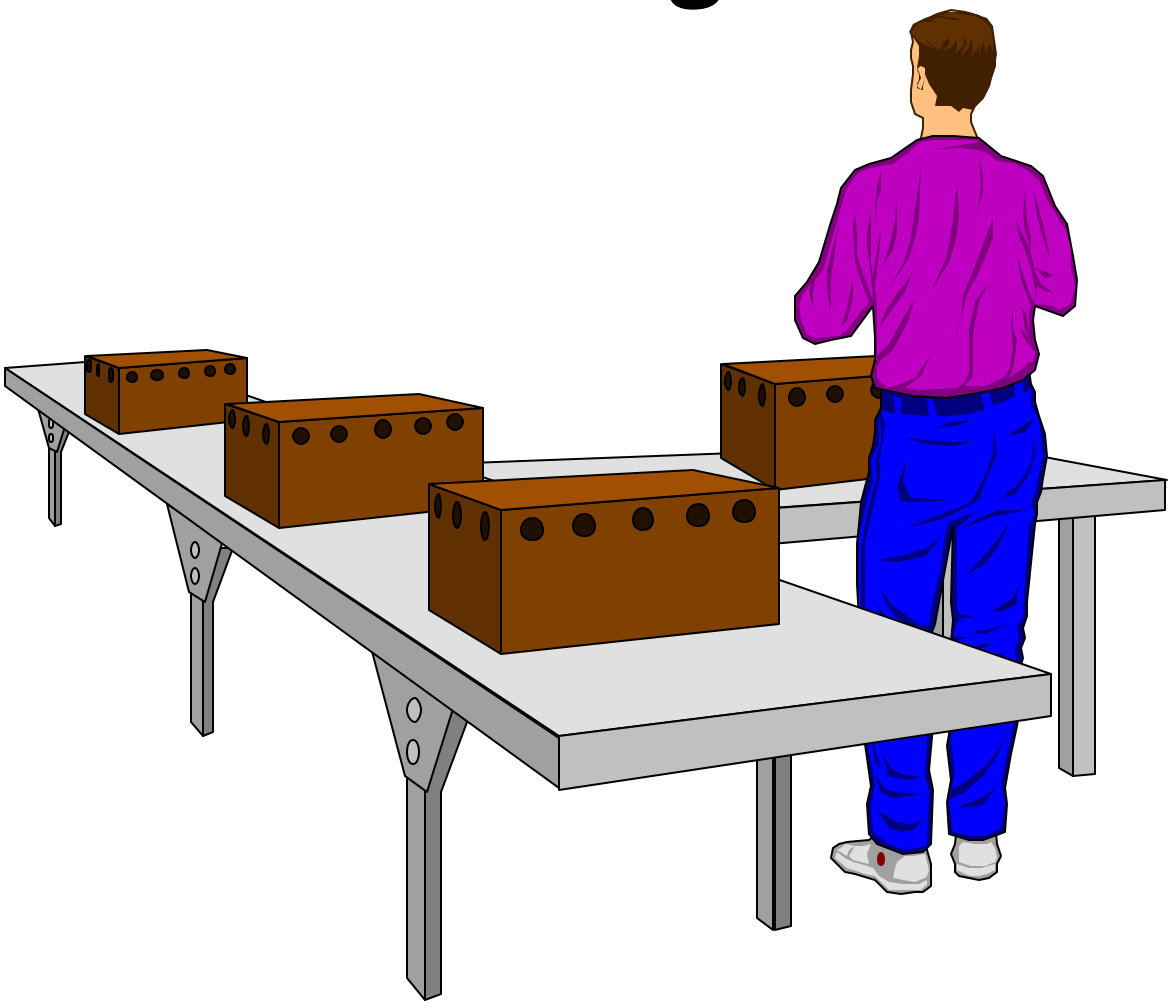
Introduction to the Ergonomics of

Manual Materials Handling



Presented by the Public Education Section
Department of Business and Consumer Business
Oregon OSHA

OR-OSHA Mission Statement

To advance and improve workplace safety and health for all workers in Oregon.

Consultative Services

- Offers no-cost on-site safety and health assistance to help Oregon employers recognize and correct safety and health problems in their workplaces.
- Provides consultations in the areas of safety, industrial hygiene, ergonomics, occupational safety and health programs, new-business assistance, the Safety and Health Achievement Recognition Program (SHARP), and the Voluntary Protection Program (VPP).

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- Discusses OR-OSHA's requirements and clarifies workplace safety or health violations.
- Discusses abatement dates and negotiates settlement agreements to resolve disputed citations.

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- Develops, interprets, and provides technical advice on safety and health standards.
- Provides copies of all OR-OSHA occupational safety and health standards.
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Welcome!

Welcome to Oregon OSHA's Manual Materials Handling (MMH) workshop. This workshop is designed to include you as much as possible in the learning experience. The more you contribute, the more you will get out of this training, so please don't hold back...participate and have fun!

Purpose

The purpose of this workshop is to give those who attend the basic information and concepts needed for Manual Materials Handling hazard/risk recognition.

Objectives

Given the information and exercises in this workshop, you will be able to:

Section 1. Identify the costs of MMH injuries,

Section 2. Clearly define the activities involved in MMH,

Section 3. Apply the concepts of MMH modeling to hazard recognition,

Section 4. Recognize the factors that influence MMH,

Section 5. Understand and apply the guidelines for safe lifting,

Section 6. Return to the workplace and conduct a basic survey of MMH risks.

Please Note: This material, or any other material used to inform employers of compliance requirements of Oregon OSHA standards through simplification of the regulations should not be considered a substitute for any provisions of the Oregon Safe Employment Act or for any standards issued by Oregon OSHA.

What Is Manual Materials Handling?

Manual Materials Handling (MMH) is an important application of ergonomic principles that particularly addresses back injury prevention.

Your instructor is going to give a demonstration. Please pay close attention and join in on the discussion as we explore the components of Manual Materials Handling.

On your own: Your instructor has completed the demonstration. Make a list of anything that the instructor did that you believe could result in an injury to the back.

What did you see?

1. _____

2. _____

3. _____

4. _____

5. _____

6. (bonus)_____

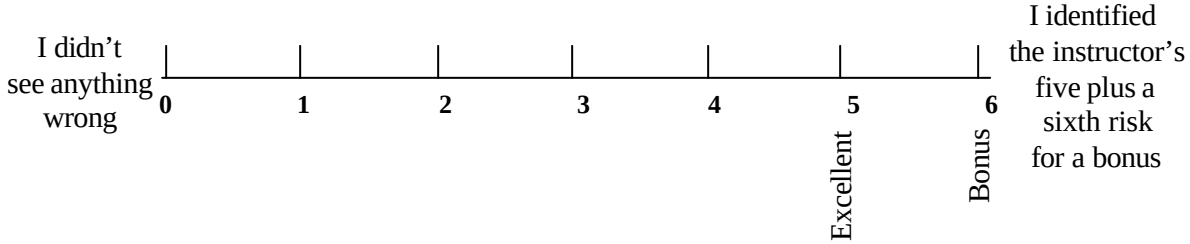
Discussion Notes: _____

_____

_____

_____

How well did you do? Rate your observation skill level on the following chart.



Section 1: The Costs of MMH Injuries

Oregon employers spent roughly $600,000,000 on accepted disabling claims relative to soft tissue injuries in three years from 1990 thru 1992.

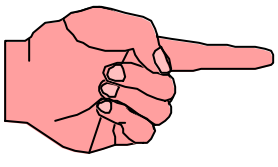
= $6.00 sec.

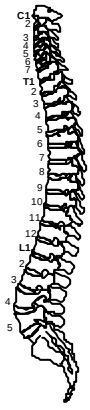
Of the 30,741 accepted disabling claims in 1993, 55 percent were filed for sprains and strains.

Over 16,900 disabling claims

Back strains (7,789) were the single most frequent disabling injury.

The trunk area (back, chest, hips, shoulders, and abdomen) accounted for 40.9 percent of the claims recorded in 1993.





Working surfaces were the leading source of injury

Boxes and containers were the second most frequent sources of injury

Bodily motion was third

Section 1: The Costs of MMH Injuries (cont..)

Form a Group

1. Introduce yourself to those at your table
2. Pick a Leader for your group Name: _____
3. Name your group Group Name: _____
4. Write the group name in bold letters on the back of the name tent provided
5. Everyone in your group should take notes

As a group: Make a list of all of the possible costs to the employer, supervisor, and the injured worker. Include those that may be secondary and away from the work site.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Discussion Notes: _____

_____

_____

Section 2: Five Activities Involved in MMH

Manual Materials Handling involves five types of activities:

* Lifting/Lowering * Pushing/Pulling * Twisting

* Carrying * Holding

As a group and from your experiences: List as many of these activities as you can in the next five minutes.

Lifting/Lowering: _____ _____

_____ _____

_____ _____

_____ _____

Pushing/Pulling: _____ _____

_____ _____

_____ _____

_____ _____

Twisting: _____ _____

_____ _____

_____ _____

_____ _____

Carrying: _____ _____

_____ _____

_____ _____

_____ _____

Holding: _____ _____

_____ _____

_____ _____

_____ _____

Lifting/Lowering: Lifting is to raise from a lower to a higher level. The range of a lift can be from the ground to as high as you can reach your hands. Lowering is the opposite activity from lifting.

Notes:_____

_____

_____

Pushing/Pulling: Pushing is to press against with force in order to move the object. The opposite is to pull.

Notes:_____

_____

_____

Twisting: As applied to MMH is the act of moving the upper body to one side or the other while the lower body remains in a relatively fixed position. *(Twisting can take place while the entire body is in a state of motion.)*

Notes:_____

_____

_____

Carrying: Having an object in ones grasp or attached while in the act of moving. The weight of the object becomes a part of the total weight of the person doing the work.

Notes:_____

_____

_____

Holding: Having an object in ones grasp while in a static body position.

Notes:_____

_____

Section 3: Modeling for MMH Hazard Recognition

We usually think of a model as a scaled or actual size replication of data, equipment, materials, work station or people. These models help us to visualize a task, its characteristics, functionality and/or adaptability.

Often times re-enactments, mock-ups, replicas, charts and tables can help us in hazard recognition. These tools can demonstrate the relationship of different variables which could be adding stress to the body. The common name used when referring to these tools is "Model"

Anything used to compare one thing with another is considered to be a model.

On your own: List some examples of models that you have used or been exposed to.

_____

_____

_____

_____

_____

_____

_____

_____

We are going to discuss three scientific models for use as tools in MMH hazard recognition.

The Biomechanical Models
The Physiological Approach
The NIOSH Lifting Guidelines

Biomechanical Model

A Biomechanical model attempts to establish the physical stresses imposed on the musculoskeletal system while working.

Sprains and strains have consistently been the major nature of injury, accounting for more than half of all disabling claims. Back sprains and strains were the single most frequent work injury, responsible for 25.3 percent of total claims in 1993. *(Oregon Workers' Compensation Claim Characteristics Calendar Year 1993)*

Low back stress occurs in many tasks requiring bending and lifting.

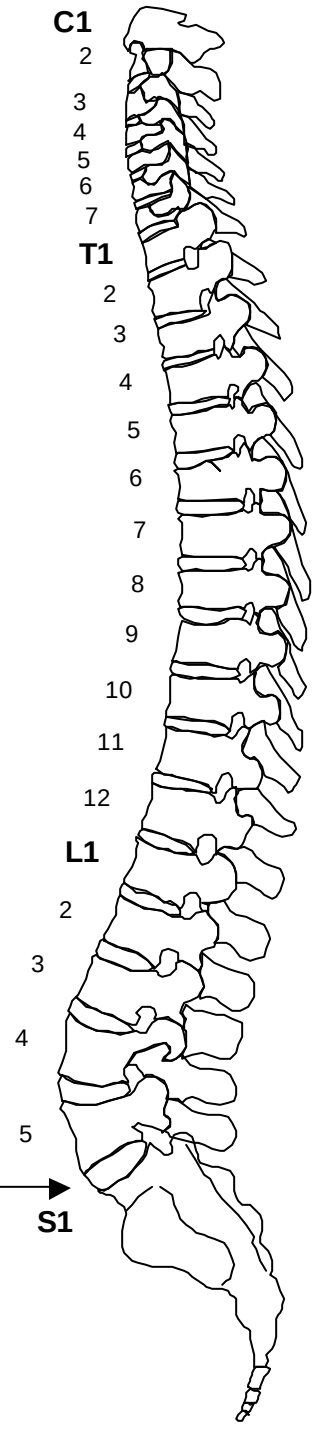
Many injuries to the back are located at L5 / S1 disc (The lower back). This drawing shows the location of L5 / S1 disc.

The numbers C1 through 7, T1 through 12, and L1 through 5 are the designations assigned to vertebra.

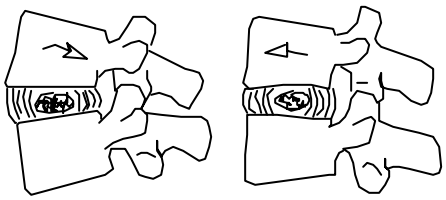
A vertebra is one of the bony segments composing the spinal column.

Compressive forces on L5 / S1 disc exceeding 550 lbs. (250 kg.) causes four times the injuries than forces of less than 550 lbs. *(The Joice Institute, Principles and Applications of Ergonomics)*

The spinal forces can occur with loads as little as 25 pounds.



The discs allow flexibility in your spine and act as shock absorbers. The center of the disc is jelly-like. It is surrounded by tough rubber-like bands of tussue that are attached to the bones (vertebral bodies.)



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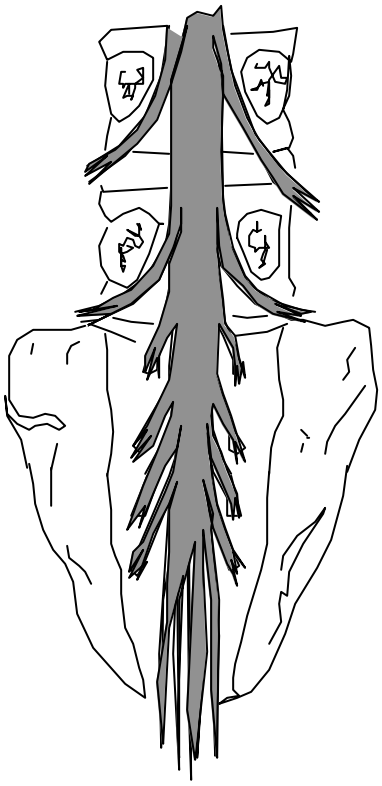
The nerves provide the stimulus to make the muscles work. Please note the nerve locations with regards to the locations of the discs.



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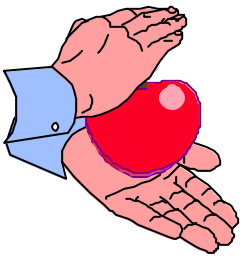
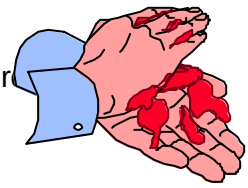
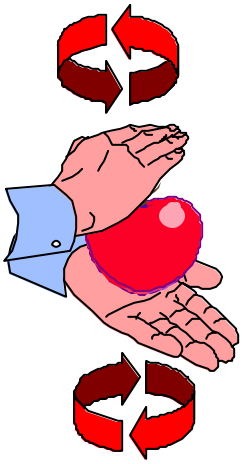
The Great Herniated Tomato Experiment

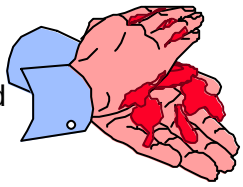


Imagine placing a tomato between the palms of your hands and applying pressure with both hands. It is well within our abilities to apply enough force to cause the tomato to burst.





Now imagine using another tomato and apply force while at the same time twisting your hands is opposite directions. The tomato would burst under much less force.



The results would be similar but the latter example would happen much quicker and with less warning.

The compressive forces on L5 / S1 are a function of the following:

* The weight of the upper extremities exerting force on the spine.
* Posture of the upper body from erect posture.
* The weight of the load and location of load in from of the body.

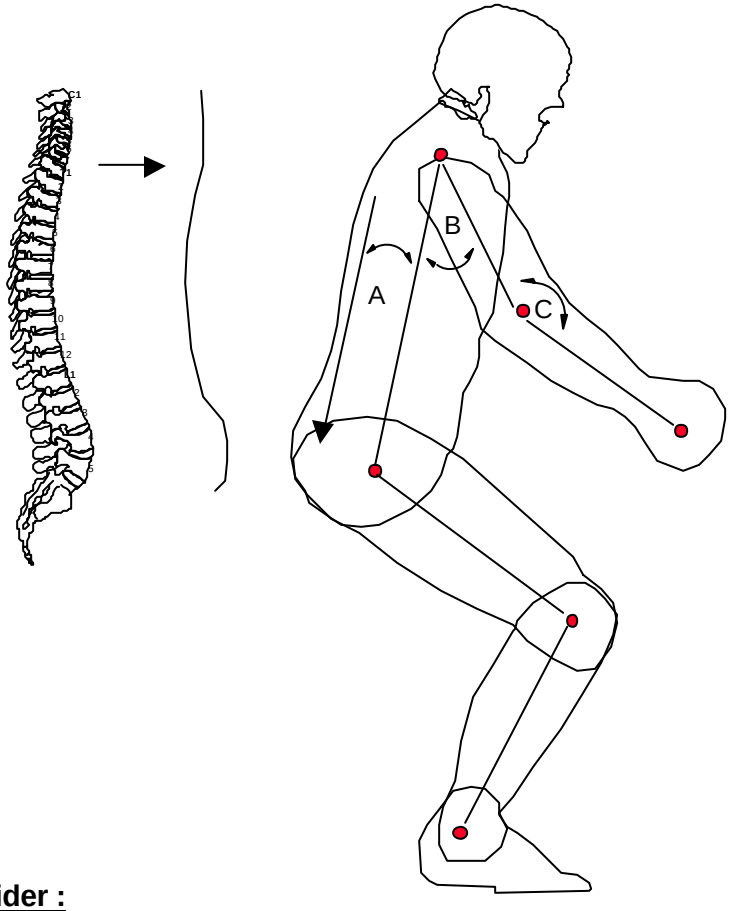
Twisting in the middle of a lift amplifies the negative results of forces on the lower back. For purposes of illustration consider the following:

Cumulative Trauma: It is appropriate that there be a discussion about the effects of repeated application of force to areas of the body. Nearly everyone has heard of cumulative trauma disorders, CTD. A good definition of CTD would be a term describing a variety of disorders affecting bone, nerve and soft tissues that are caused, precipitated, or aggravated by repeated exertions or movements of the body. Repeated application of compressive force to the back, shoulders, and/or arms can contribute to disorders that fall into this group.

The net impact on a worker, over time, of the cumulative forces that cause an injury can be as dramatic as that of a one time high force injury.

The following model shows the sources of force on L5 / S1 disc. It does not address
the impact of added forces during twist/bend lifting and backward bending situations.

Angle from upper vertical of trunk . . . . . A
Angle from lower vertical of upper arm . .B
Angle from upper vertical of lower arm . .C



Factors to consider :

- *** Factor 1 = Subject weight, subject height, and Angle A**
- *** Factor 2 = Subject weight, subject height, Angle A, and Angle B**
- *** Factor 3 = Subject weight, subject height, Angle A, Angle B, and Angle C**
- *** Factor 4 = Object weight, subject height, Angle A, Angle B, and Angle C**

Angles →	A	B	C	Object
F1	●			
F2	●	●		
F3	●	●	●	
F4	●	●	●	●
	4	3	2	1

Note: The complete Biomechanical Formula is included in the appendices

Biomechanical Model (cont.)

As a group and from your experiences: List as many specific tasks as you can that need have the upper body weight included in the factoring of forces that contribute to back strains and sprains and herniation of lower back discs. You have 5 minutes.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____
24. _____
25. _____
26. _____
27. _____
28. _____
29. _____
30. _____

Discussion Notes: _____

_____

_____

Physiological Approach

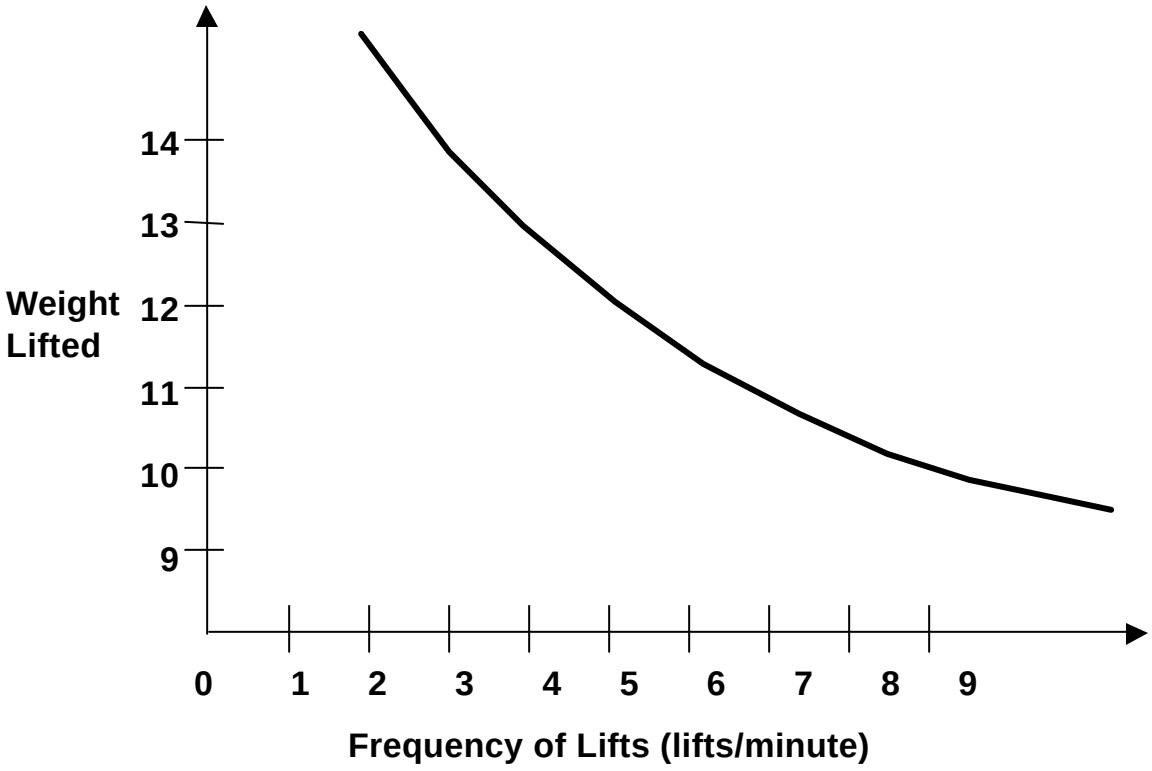
When a task requires more than 3 lifts per minute a second model must be considered in addition to the Biomechanical model. This second approach presumes that the load is within the physical strength of the worker. Note the following.

* A person's endurance is primarily limited by the capacity of the oxygen transport system.

* Increased metabolism demands an increase in the delivery of oxygen and nutrients to the tissue if the activity is to be continued once muscles become active.

* Energy cost, heart rate, blood pressure and blood lactate are common physiological responses used to measure physiological stress anytime there is physical work.

The following model demonstrates how much of a drop there is in the amount of load that can be repetitively handled as the frequency of lifts increases.



Aerobic Capacity

Aerobics has become a rage in our desire to become fit. Aerobic capacity is defined as the maximum level of metabolism of which a person is capable. An individual's aerobic capacity depends on the capacity to deliver oxygen to the working muscles.

On your own: Does aerobic capacity have an impact on an employees ability to do work?_____

If yes, how? _____

_____

_____

Effective Use of Muscles

It is advantageous to design / select the task load which maximizes efficiency. When a muscle is asked to work it will contract automatically. As the load on the muscle fiber increases, the displacement decreases.

For dynamic effort (work) the optimal load is approx... 30% of maximum.

*** Dynamic Effort:** The muscle acts as a local pump in the circulatory system. Compression squeezes blood out of the muscle and the subsequent relaxation releases a fresh flow of blood into it several times greater than normal. In fact, the muscle may receive between 10 and 20 times as much blood as when it is resting. *(A muscle performing dynamic work is therefore constantly flushed out with blood and returns the energy-rich sugar and oxygen balance contained in it, while at the same time waste products are removed.)*

Overloading or underloading the muscular system is not efficient.

For static effort (work) the optimal load is approx... 10% of maximum.

*** Static Effort:** During static effort the muscle is not allowed to extend, but remains in a state of heightened tension, with force exerted over an extended period. *(During static effort the blood vessels are compressed by the internal pressure of the muscle tissue, so that blood no longer flows through the muscle.)*

Physiological Approach (cont.)

As a group and from your experiences: List as many specific tasks as you can that involve 3 or more lifts per minute. You have 5 minutes.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
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22. _____
23. _____
24. _____
25. _____
26. _____
27. _____
28. _____
29. _____
30. _____

Discussion Notes: _____

_____

_____

Section 4: Factors that Influence MMH

Manual Materials Handling is influenced by the following factors:

* Worker Characteristics
* Task Characteristics / Work Practices
* Material / Container Characteristics

Worker characteristics are different in each of us and affect the kind and amount of work that we can perform.

When considering worker characteristics include the following:

Consideration	**Discussion Notes**
* Height	_____
	_____
* Weight	_____
	_____
* Reach	_____
	_____
* Fitness (aerobic capacity)	_____
	_____
* Physical Limitation	_____
	_____

Section 5: Safe Lifting Guidelines

The following five general rules should be applied at every opportunity.

* Plan the lift.
* Both squat and stoop lifting is now considered acceptable for jobs requiring repetitive lifting. The term used to describe this is **free form lifting**. No matter what type of lift is used, it is never permissable to exceed the maximum acceptable load of the worker.
* Keep the load as close to the body as possible.
* Lift the load with a smooth body motion. *(Avoid jerking)*
* When turning, do not twist. Turn with the feet rather than twisting of the trunk.

One your own: Describe what, if anything, you see in each of the following pictures.

Worker picking up box: _____

_____

_____

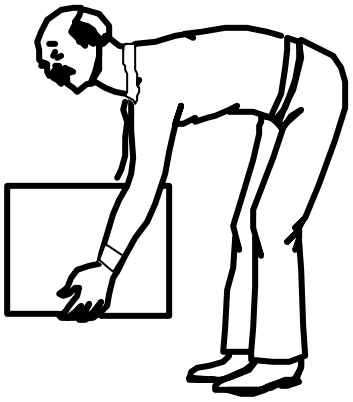
_____

What would you want to see done differently?

_____

_____

_____



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Worker picking up box: _____

_____

_____

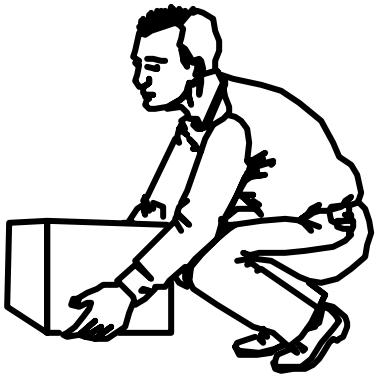
_____

What would you want to see done differently?

_____

_____

_____



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Worker lifting patient from wheelchair:

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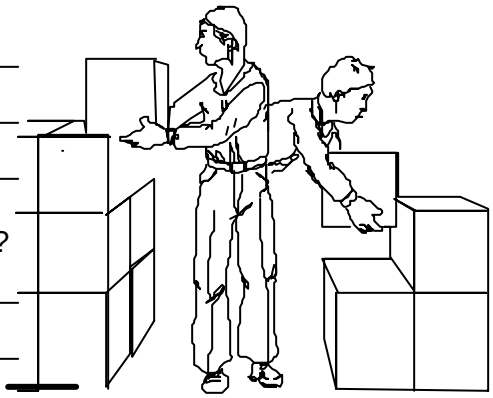
What would you want to see done differently?

Worker lifting and moving boxes:



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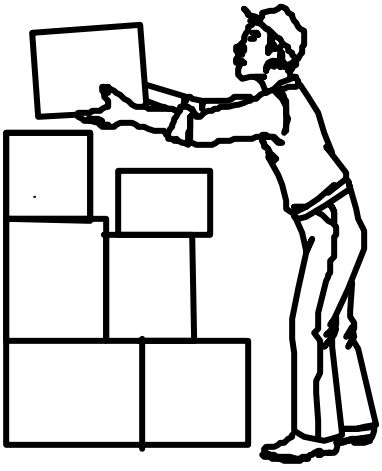
What would you want to see done differently?

Worker stacking boxes:



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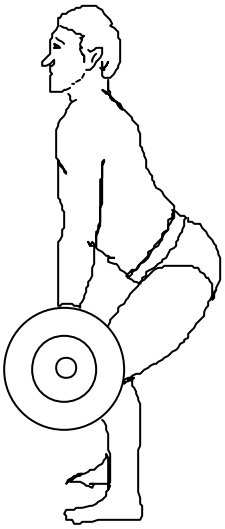
What would you want to see done differently?

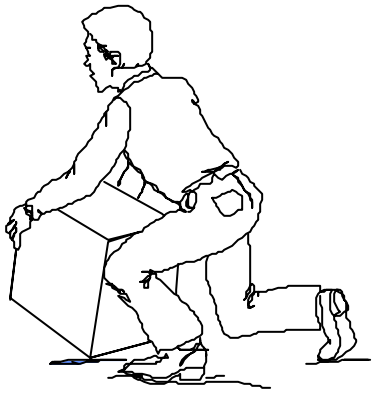
Body Mechanics

All of the problems in the last exercise had something to do with body mechanics. Lifting, carrying and reaching -- remember, it's not how much you lift or carry as much as it is how you do it. Once you have factored in the upper body weight due to posture or the position of the object to be lifted or carried, you can consider the following examples of how you can overcome the lifting hazard by using proper body mechanics.

Remember the five general lifting rules:

* Plan the lift.
* Both squat and stoop lifting is now considered acceptable for jobs requiring repetitive lifting. The term used to describe this is **free form lifting**. No matter what type of lift is used, it is never permissable to exceed the maximum acceptable load of the worker.
* Keep the load as close to the body as possible.
* Lift the load with a smooth body motion. *(Avoid jerking)*
* When turning, do not twist. Turn with the feet rather than twisting of the trunk.





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Keep Back Arched When Lifting
Keep Head and Shoulders Up

What is so special about the way a weight lifter lifts? _____

_____

_____

_____

_____

Plan Ahead, Test The Load
Before Lifting.

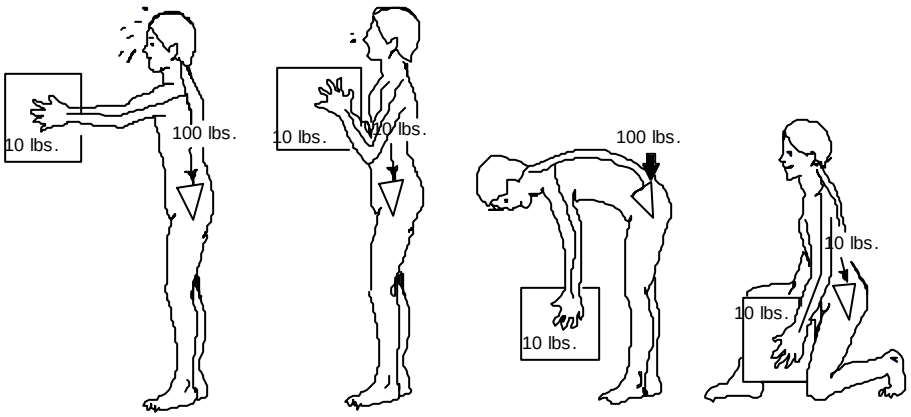
What are your options if the load is too heavy for you to lift alone?

_____

_____

_____

_____



Keep The Weight Close To The Body

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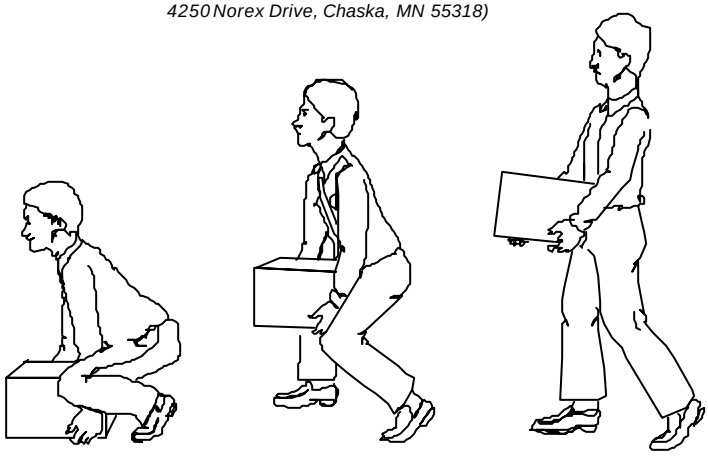

The Diagonal Lift

Squat, Head Up, Back Arched, Feet Spread One Foot Ahead As You Lift

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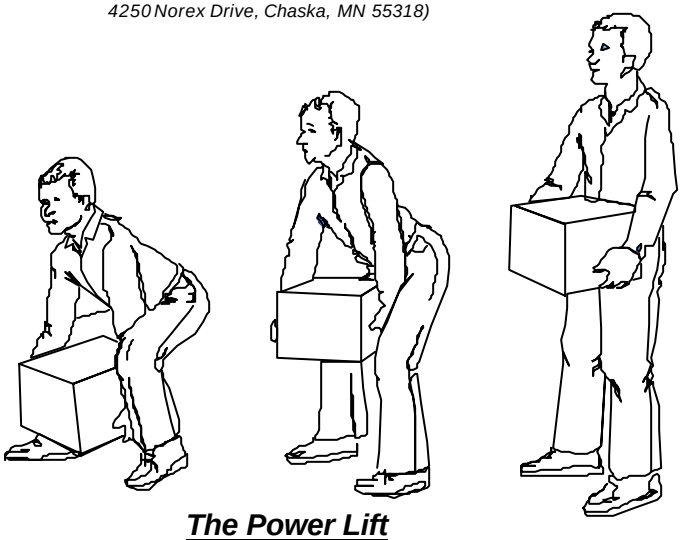

The Power Lift

Partial Squat, Head Up, Back Arched, Feet Spread One Foot Ahead As You Lift

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Section 6: The MMH Survey

Surveys are tools that can remind us of conditions and practices that, when present in the workplace, can lead to injury or illness. Surveys should ask critical questions about the operation. The answers, if the questions are properly designed, will lead the inspector to general conclusions with regards to the degree of risk. A Manual Materials Handling survey should include, at the minimum, questions similar to the following:

Costs

	Yes	No
Are we experiencing costly accidents relative to this task?	❒	❒

Activities

Are any of the following activities required in this task?

Lifting / Lowering	❒	❒
Pushing / Pulling	❒	❒
Twisting	❒	❒
Carrying	❒	❒
Holding	❒	❒

Models

Do any of the following models apply to this task?

Biomechanical (compression forces at L5)	❒	❒
Physiological (frequency vs. weight)	❒	❒
Aerobic Capacity (conditioning)	❒	❒
Effective Use of Muscles	❒	❒
NIOSH Lifting Guidelines	❒	❒

Factors

Are any of the following influencing the task?

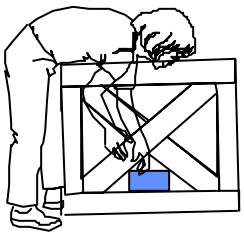
Worker Characteristics	❒	❒
Task Characteristics	❒	❒
Material / Container Characteristics	❒	❒

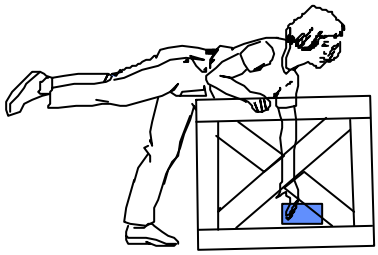
Training

Is the employee in need of training in safe lifting guidelines?	❒	❒
Is the employee in need of training in body mechanics?	❒	❒

Note: Any one “Yes” answer can be serious enough to cause serious injury or illness. The more “Yes” answers the higher the risk even when the single condition is determined to be minor. This is due to the cumulative effect of multiple negative factors.

MMH Survey Exercise: Complete the survey for the following seven tasks.





The Golfer's Lift

(*Adapted from: The Saunders Group inc., 4250 Norex Drive, Chaska, MN 55318)*

Costs

	Yes	No
Are we experiencing costly accidents relative to this task?	❒	❒

Activities

Are any of the following activities required in this task?

Lifting / Lowering	❒	❒
Pushing / Pulling	❒	❒
Twisting	❒	❒
Carrying	❒	❒
Holding	❒	❒

Models

Do any of the following models apply to this task?

Biomechanical (compression forces at L5)	❒	❒
Physiological (frequency vs. weight)	❒	❒
Aerobic Capacity (conditioning)	❒	❒
Effective Use of Muscles	❒	❒
NIOSH Lifting Guidelines	❒	❒

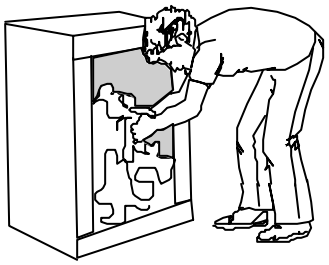
Factors

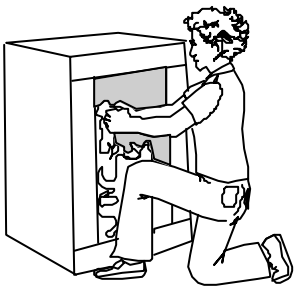
Are any of the following influencing the task?

Worker Characteristics	❒	❒
Task Characteristics	❒	❒
Material / Container Characteristics	❒	❒

Training

Is the employee in need of training in safe lifting guidelines?	❒	❒
Is the employee in need of training in body mechanics?	❒	❒





Kneel When Working In A Low Position

(*Adapted from: The Saunders Group inc., 4250 Norex Drive, Chaska, MN 55318)*

Costs

	Yes	No
Are we experiencing costly accidents relative to this task?	❒	❒

Activities

Are any of the following activities required in this task?

Lifting / Lowering	❒	❒
Pushing / Pulling	❒	❒
Twisting	❒	❒
Carrying	❒	❒
Holding	❒	❒

Models

Do any of the following models apply to this task?

Biomechanical (compression forces at L5)	❒	❒
Physiological (frequency vs. weight)	❒	❒
Aerobic Capacity (conditioning)	❒	❒
Effective Use of Muscles	❒	❒
NIOSH Lifting Guidelines	❒	❒

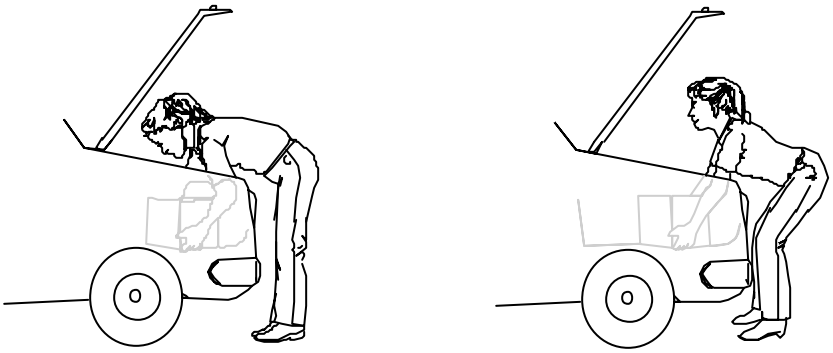
Factors

Are any of the following influencing the task?

Worker Characteristics	❒	❒
Task Characteristics	❒	❒
Material / Container Characteristics	❒	❒

Training

Is the employee in need of training in safe lifting guidelines?	❒	❒
Is the employee in need of training in body mechanics?	❒	❒



Straight Leg Lift, Bend At The Hips, Not The Back

(Adapted from: The Saunders Group inc., 4250 Norex Drive, Chaska, MN 55318)

Costs

	Yes	No
Are we experiencing costly accidents relative to this task?	❒	❒

Activities

Are any of the following activities required in this task?

Lifting / Lowering	❒	❒
Pushing / Pulling	❒	❒
Twisting	❒	❒
Carrying	❒	❒
Holding	❒	❒

Models

Do any of the following models apply to this task?

Biomechanical (compression forces at L5)	❒	❒
Physiological (frequency vs. weight)	❒	❒
Aerobic Capacity (conditioning)	❒	❒
Effective Use of Muscles	❒	❒
NIOSH Lifting Guidelines	❒	❒

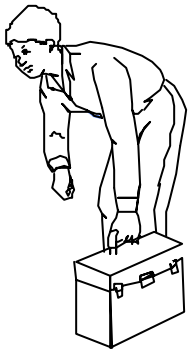
Factors

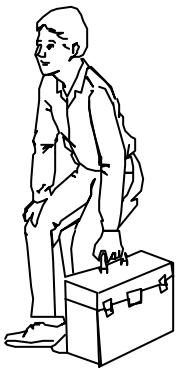
Are any of the following influencing the task?

Worker Characteristics	❒	❒
Task Characteristics	❒	❒
Material / Container Characteristics	❒	❒

Training

Is the employee in need of training in safe lifting guidelines?	❒	❒
Is the employee in need of training in body mechanics?	❒	❒





Partial Squat Lift

(Adapted from: The Saunders Group inc., 4250 Norex Drive, Chaska, MN 55318)

Costs

	Yes	No
Are we experiencing costly accidents relative to this task?	❒	❒

Activities

Are any of the following activities required in this task?

Lifting / Lowering	❒	❒
Pushing / Pulling	❒	❒
Twisting	❒	❒
Carrying	❒	❒
Holding	❒	❒

Models

Do any of the following models apply to this task?

Biomechanical (compression forces at L5)	❒	❒
Physiological (frequency vs. weight)	❒	❒
Aerobic Capacity (conditioning)	❒	❒
Effective Use of Muscles	❒	❒
NIOSH Lifting Guidelines	❒	❒

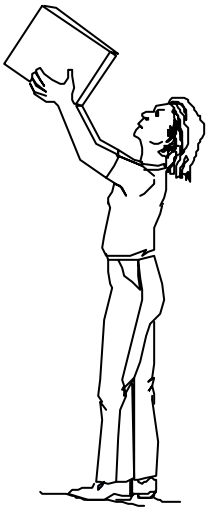
Factors

Are any of the following influencing the task?

Worker Characteristics	❒	❒
Task Characteristics	❒	❒
Material / Container Characteristics	❒	❒

Training

Is the employee in need of training in safe lifting guidelines?	❒	❒
Is the employee in need of training in body mechanics?	❒	❒



Reaching With a Heavy Load

(*Adapted from: The Saunders Group inc., 4250 Norex Drive, Chaska, MN 55318)*

Costs

	Yes	No
Are we experiencing costly accidents relative to this task?	❒	❒

Activities

Are any of the following activities required in this task?

Lifting / Lowering	❒	❒
Pushing / Pulling	❒	❒
Twisting	❒	❒
Carrying	❒	❒
Holding	❒	❒

Models

Do any of the following models apply to this task?

Biomechanical (compression forces at L5)	❒	❒
Physiological (frequency vs. weight)	❒	❒
Aerobic Capacity (conditioning)	❒	❒
Effective Use of Muscles	❒	❒
NIOSH Lifting Guidelines	❒	❒

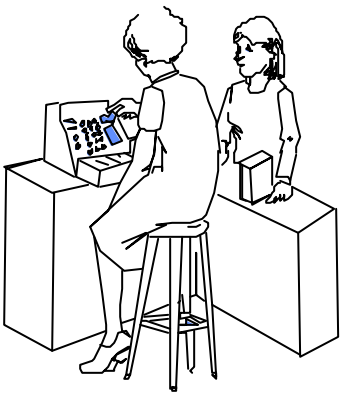
Factors

Are any of the following influencing the task?

Worker Characteristics	❒	❒
Task Characteristics	❒	❒
Material / Container Characteristics	❒	❒

Training

Is the employee in need of training in safe lifting guidelines?	❒	❒
Is the employee in need of training in body mechanics?	❒	❒



Back Unsupported

(*Adapted from: The Saunders Group inc., 4250 Norex Drive, Chaska, MN 55318)*

Costs

	Yes	No
Are we experiencing costly accidents relative to this task?	❒	❒

Activities

Are any of the following activities required in this task?

Lifting / Lowering	❒	❒
Pushing / Pulling	❒	❒
Twisting	❒	❒
Carrying	❒	❒
Holding	❒	❒

Models

Do any of the following models apply to this task?

Biomechanical (compression forces at L5)	❒	❒
Physiological (frequency vs. weight)	❒	❒
Aerobic Capacity (conditioning)	❒	❒
Effective Use of Muscles	❒	❒
NIOSH Lifting Guidelines	❒	❒

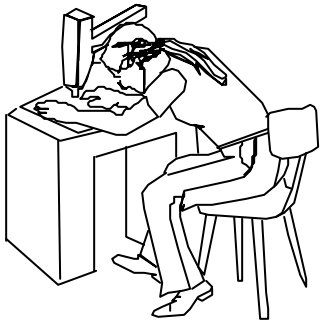
Factors

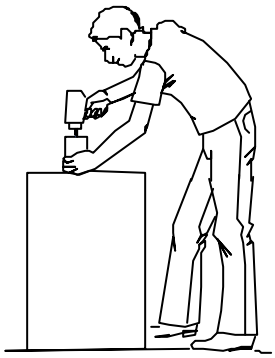
Are any of the following influencing the task?

Worker Characteristics	❒	❒
Task Characteristics	❒	❒
Material / Container Characteristics	❒	❒

Training

Is the employee in need of training in safe lifting guidelines?	❒	❒
Is the employee in need of training in body mechanics?	❒	❒





Working Surface Too Low and Far Away

(*Adapted from: The Saunders Group inc., 4250 Norex Drive, Chaska, MN 55318)*

Costs

	Yes	No
Are we experiencing costly accidents relative to this task?	❒	❒

Activities

Are any of the following activities required in this task?

Lifting / Lowering	❒	❒
Pushing / Pulling	❒	❒
Twisting	❒	❒
Carrying	❒	❒
Holding	❒	❒

Models

Do any of the following models apply to this task?

Biomechanical (compression forces at L5)	❒	❒
Physiological (frequency vs. weight)	❒	❒
Aerobic Capacity (conditioning)	❒	❒
Effective Use of Muscles	❒	❒
NIOSH Lifting Guidelines	❒	❒

Factors

Are any of the following influencing the task?

Worker Characteristics	❒	❒
Task Characteristics	❒	❒
Material / Container Characteristics	❒	❒

Training

Is the employee in need of training in safe lifting guidelines?	❒	❒
Is the employee in need of training in body mechanics?	❒	❒

Quiz

1. What percent of all Oregon accepted disabling claims in 1993 were **soft tissue?**

   a.) 10% b.) 23% c.) 40% d.) 55%

2. What were the single most frequent disabling injuries? _____

3. What five activities are involved in Manual Materials Handling?

   _____ _____ _____

   _____ _____

4. What are two types of models used in MMH risk evaluation?

   _____ _____ _____

   Bonus

5. What three factors can influence MMH?

   _____ characteristics _____ characteristics

   _____ characteristics

6. What are the five general rules for Safe Lifting?

   _____

   _____

   _____

   _____

   _____

7. What is the purpose of a MMH Survey?

   _____

   _____

   _____

Appendices

* **Definitions**
* **Equipment, Materials, Container Characteristics**
* **Biomechanical Model**
* **NIOSH Lifting Summary**
* **Manual Materials Handling Survey (Master for reproduction)**
* **Manual Materials Handling Task Evaluation Guide**
* **Action Plan Flow Diagram**

Definitions

*** Ergonomics:** The laws or principles governing work design. The study of the design of work in relation to the physiological and psychological capabilities of people. This science addresses worker performance and well-being in relation to their job tasks, tools, equipment, and physical and social environment.

*** Manual Materials Handling (MMH):** The use of human power to move loads by lifting, lowering, pushing, pulling, and/or carrying.

*** Dynamic Effort:** The muscle acts as a local pump in the circulatory system. Compression squeezes blood out of the muscle and the subsequent relaxation releases a fresh flow of blood into it several times greater than normal. In fact, the muscle may receive between 10 and 20 times as much blood as when it is resting. *(A muscle performing dynamic work is therefore constantly flushed out with blood and returns the energy-rich sugar and oxygen balance contained in it, while at the same time waste products are removed.)*

*** Static Effort:** During static effort the muscle is not allowed to extend, but remains in a state of heightened tension, with force exerted over an extended period. *(During static effort the blood vessels are compressed by the internal pressure of the muscle tissue, so that blood no longer flows through the muscle.)*

*** Waste Product Accumulation:** A muscle that is performing heavy static work is receiving virtually no sugar or oxygen from the blood and must depend upon its own reserves. Moreover - and this is by far the most serious disadvantage - waste products are not being excreted. Quite the reverse, the waste products are accumulating and produce the acute pain of muscular fatigue.

*** Muscle Nourishment:** Oxygen deficiency, which is unavoidable during static muscular effort, inevitably lowers the effective working level of the muscle (general fatigue). Periodic stretching and dynamic muscular effort relieves this condition. *(The substances that are so important for energy production - glucose and oxygen - are stored only in small amounts in the muscles themselves. Both of them must therefore be continuously transported to the muscles by the blood.)*

*** Biomechanics:** The science which investigates the effect of internal and external forces on the human body in movement and at rest.

**** Force:** a: strength or energy exerted or brought to bear: cause of motion or change: active power.

**** Load: n** 2 a: a mass or weight supported by something.

**** Load: vt** 3 a: to increase the weight of by adding something heavy.

* Adapted from Principles & Applications of Ergonomics,
"The Joyce Institute", 1313 Plaza 600 Bldg.., Seattle, Wa, 98101
** Adapted from Webster's Ninth New Collegiate Dictionary

Equipment, Materials, Container Characteristics

Hand Carts and Trucks for pushing or pulling by an operator without mechanical assistance.

* Trucks	* Pallet or skid trucks	* Drum trucks	* Mail carts
* Hand lift trucks	* Tea wagons	* 2, 3, or 4 wheel vehicles	

Guidelines:

Do not load two, three, and four wheel carts with more than 500 pounds of material. Use hand pallet trucks for heavier loads.

Use of truck and hand cart for tasks occurring less than 200 times a day is suitable. Higher frequency needs power trucks.

When materials are transported more than 100 feet, power trucks should be used.

When pushing a cart maintain a clear view ahead and to both sides.

Selection and Design Factors

* Wheels and Casters: Diameter, Composition, Tread, Maintenance, Swivel caster (limited)

* Handle type and location: Place handles on swivel end only.

* Trucks for pushing (hand carts)
  - Handle should be located so that it straddles the load's center of gravity
  - Determine the handle type based on the cart dimensions and the task.
  - Maneuverability is determined by the truck's width and length and the distance between the handles.
  - 36" and 44" is the recommended handle height. The higher the center of gravity the higher the handle height.

* Trucks for pulling (hand carts): A T-bar handle is recommended. For fixed handle, locate the handle at least 8 inches in front of the truck and at least 36 inches above the floor.

* Truck and cart dimensions: Trucks wider than 3 feet or longer than 4 feet are not easily turned in most factory aisles. Do not put the worker in conditions that force awkward postures. Push trucks should not exceed 55" in height. Warning devices and braking systems should be included with the load exceeds 1100 pounds (due to stopping force and distance).

Equipment, Materials, Container Characteristics (cont.)

Handling factors

Start - Sustain - Maneuver - Stop

* Average size loads can be handled at a pace of up to 2.5 miles per hour or 200 ft min Heavier loads require slower speeds.

* A handling truck should start with 50 pounds of force. 40 pounds of force for less than ten feet should maintain the load. 25 pounds of force should not be exceeded for maintaining the load for one minute continuously. It should not require more than 80 pounds of force to complete an emergency stop of less than 3 feet.

Note: Anytime the forces are found to be in excess of these limits, powered equipment should be used.

Surface Characteristics: Most difficulties can be overcome with larger diameter wheels. Avoid friction between cart wheels and floor. Special consideration must be given when ramps are to be used.

Trays

Trays are containers that are rectangular in shape and are normally less than 6 inches deep.

When selecting trays, consider the following:

- How the tray is to be used.
- The amount of product in the tray.
- The size, shape, and nature of the product in the tray.
- The kind of handling (manual or powered).
- The kind of product protection required (when applicable).
- Any environmental issues.
- Storage/ stacking requirements.
- Tray maintenance.
- Desired life cycle of the tray.
- The weight of the tray: Not to exceed 30 lbs.
- The size of the tray: Recommended width is 14" not to exceed 20", and not to exceed the length.
- Stability of the tray: Center of load below the handles, with dividers to prevent shifting of load.
- Grasping characteristics/handles: Handles at both ends, upper surface at least 1/2 " wide, non-slip surface for finger contact.

Equipment, Materials, Container Characteristics (cont.)

Conveyors

The way a person works can be influenced by the type, location, height, width, and speed of conveyors that are used to link workplaces.

Guidelines

Avoid overexertion by providing a space where produce can temporarily accumulate to allow for short rest periods.

Keep conveyor speed at below 32 ft min to minimize conveyor sickness.

Use anthropometric tables when designing size and location of conveyors.

Consider the size of the items handled, the location of the handles, and hand locations when determining conveyor width and height.

Provide crossovers and/or gates for workers.

Allow room on both sides of the conveyor for easy access.

Leveling devices

Lift tables and elevators provide an adjustable work surface height.

Hoists

Heavy objects can best be handled with a hoist.

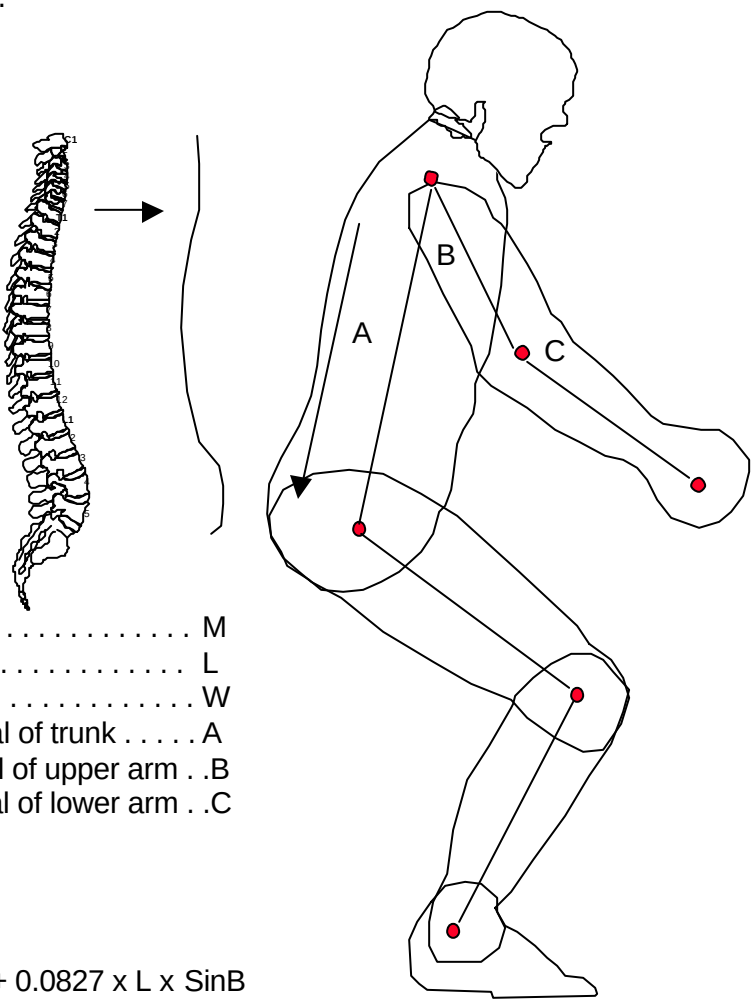
Guidelines

Powered hoist controls must be clearly labeled and designed to accommodate the hand size of 90 % of the working population. Ensure that safe operating procedures are written and used.

Manually operated hoist must not cause the worker to have to use forces that exceed safe limits to move the hoist and load in any direction (up, down, side to side, forward, or backward).

Biomechanical Model

The following model shows the sources of force on L5 / S1 disc. It must be noted that it does not help us to visualize the added forces during twist/bend lifting and backward bending situations.



Biomechanical Model

Subject's Weight . . . . . M
Subject's Height L
Object's Weight . . . . . W
Angle from upper vertical of trunk . . . . . A
Angle from lower vertical of upper arm . .B
Angle from upper vertical of lower arm . .C

Formula

X1 = 0.1010 x L x SinA
X2 = 0.2337 x L x SinA + 0.0827 x L x SinB
X3 = 0.2337 x L x SinA + 0.1896 x L x SinB + 0.0820 x L x SinC
X4 = 0.2337 x L x SinA + 0.1896 x L x SinB + 0.1907 x L x SinC

FES = 20 (0.363 x M x X1 + .062 x M x X2 + 0.050 x M x X3 + W x X4
E = (FES x SinA)/(FES x COS A + 0.475 x M + W)
D = TAN-1 E
R = (FEW x SinA)/SinD
R = Disc compressive force on L5 / S1

Factors to consider :

- **Factor 1 = Subject weight, subject height, and Angle A**
- **Factor 2 = Subject weight, subject height, Angle A, and Angle B**
- **Factor 3 = Subject weight, subject height, Angle A, Angle B, and Angle C**
- **Factor 4 = Object weight, subject height, Angle A, Angle B, and Angle C**

NIOSH Lifting Summary

NIOSH Lifting Guidelines (based on 1982 NIOSH Guidelines)

This summary of the NIOSH Lifting Guidelines is adapted from the NIOSH Work Practices Guide for Manual Lifting 1982.

The NIOSH guidelines determine what the maximum load should be, given the following characteristics:

* Weight of the object lifted.

* Position of load with respect to the body; starting and ending point of horizontal and vertical distances.

* Frequency of lift.

* Duration of lift.

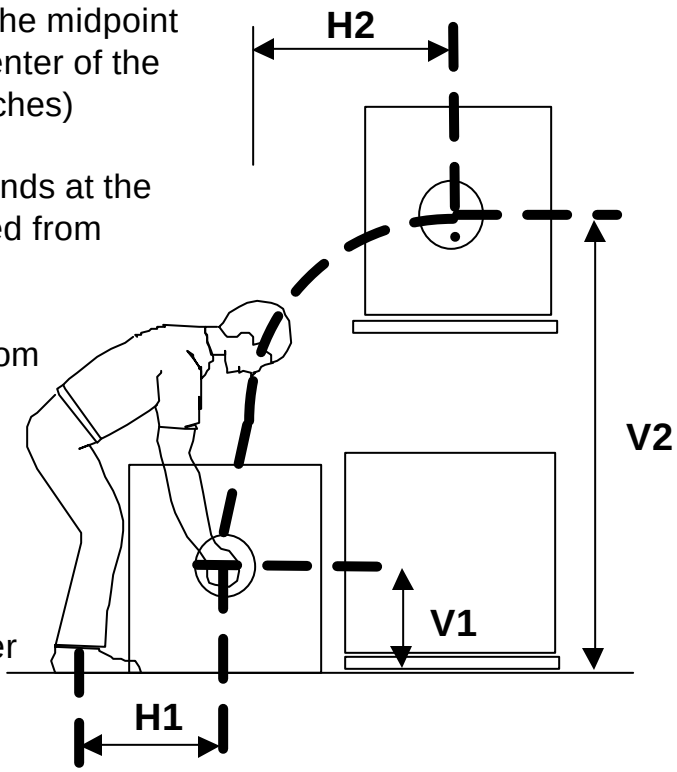
H = horizontal location from the midpoint between ankles to the center of the load at origin of lift (in inches)

V = vertical location of the hands at the beginning of lift measured from floor to hands (inches)

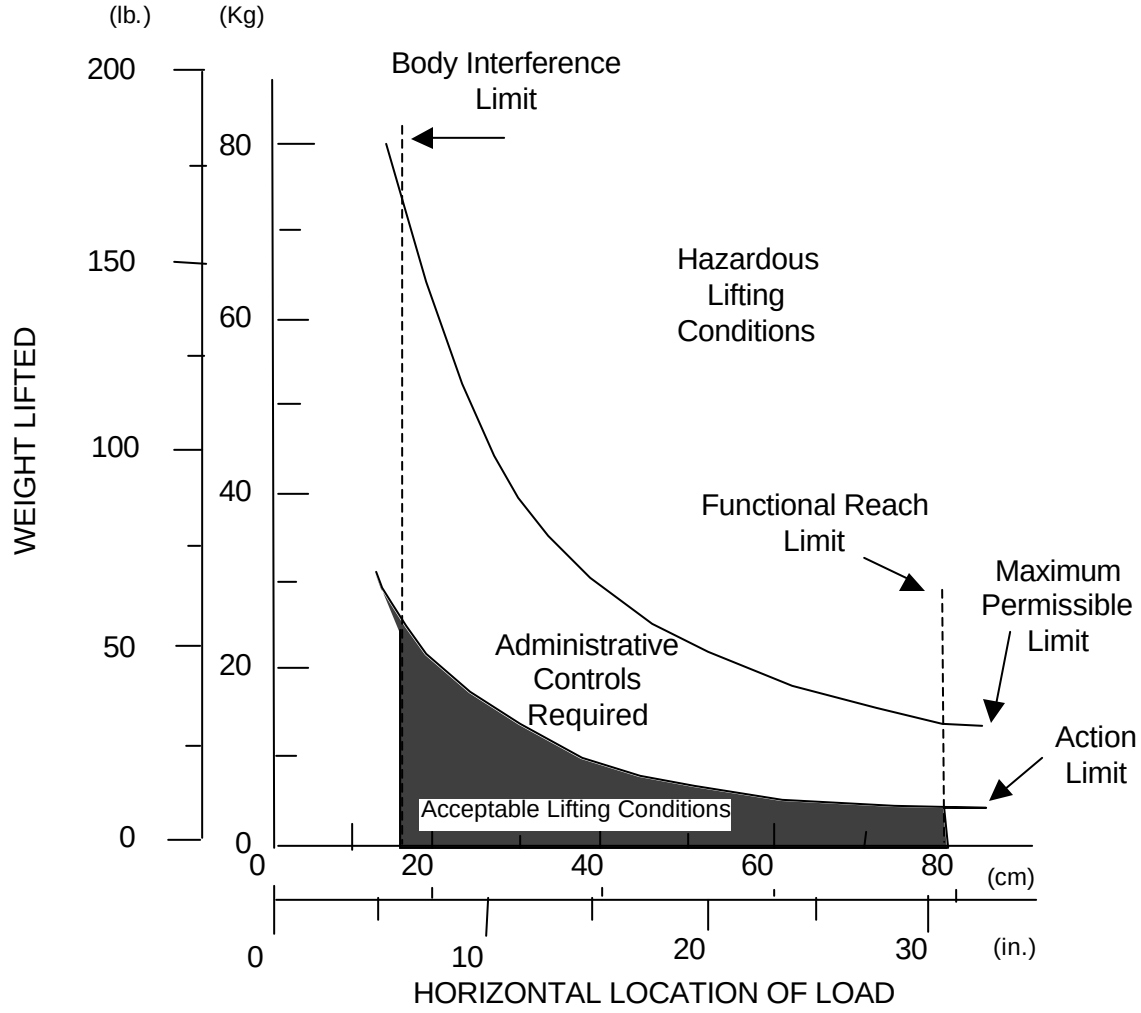
D = vertical travel distance from origin to destination of load (in inches)

F = average frequency of lift (lifts / minute)

Fmax = the maximum number of lifts (lifts / minute)



NIOSH guidelines apply to loads which are symmetrically balanced in from of the body.



AL = (Action Limit) the amount of load that can be lifted with minor risk.

AL = 90 (6/H) (1-0.01[V-30]) (0.07 + 3/D) (1- F/F max)
= 90 (HF) (VF) (DF) (FF)

MPL = (Maximum Permissible Limit) the amount of load that poses substantial risk to most people.

HF = Discounting factor due to the horizontal location of load at beginning of lift

VF = Discounting factor due to vertical location of load at beginning of lift

DF = Discounting factor due to the distance load is lifted

FF = Discounting factor due to the frequency of lifts

F max Table

AVERAGE VERTICAL LOCATION (cm) (in)

V1 > 75 V1 ≤ 75
V1 > 30" V1 ≤ 30

DURATION	V1 > 75	V1 ≤ 75
Infrequent/ Occasional Lifting	18	15
Continual Lifting	15	12

The following parameters will result in the maximum acceptable weight of lift according to NIOSH guidelines.

* Design the horizontal distance to be as close to 7 inches as possible.

* Design the vertical location of the origin of the lift V1 to be at least 30 inches from floor.

* The vertical travel distance (D) should be no greater than 10 inches.

For purposes of this Guide, these variables are assumed to have the following limits:

* H is between 6 inches and 32 inches. Objects cannot, in general, be closer than 6 inches without interference with the body. Objects further than 32 inches cannot be reached by many people.

* V is assumed between 0 inches and 70 inches representing the span of reach for most people.

* D is assumed between 10 inches and (80-V) inches. For travel less than 10 inches, set D = 10.

* F is assumed between .2 (one lift every 5 minutes) and F max. For lifting less frequently than once per 5 minutes, set F = 0

Note: NIOSH has developed a "Revised NIOSH equation for the design and evaluation of manual lifting tasks (1991) For information contact: National Institute for Occupational Safety and Health, 4676 Columbia Parkway, Cincinnati, OH 45226.

Manual Materials Handling Survey

Date: _____ Location: _____

Task Description: _____

Survey Conducted by: _____

Costs

	Yes	No
Are we experiences costly accidents relative to this task?.....	❒	❒

Activities

Are any of the following activities required in this task?

Lifting / Lowering		
Pushing / Pulling	❒	❒
Twisting	❒	❒
Carrying	❒	❒
Holding	❒	❒
	❒	❒

Models

Do any of the following models apply to this task?

Biomechanical (compression forces at L5)		
Physiological (frequency vs. weight)	❒	❒
Aerobic Capacity (conditioning)	❒	❒
Effective Use of Muscles	❒	❒
NIOSH Lifting Guidelines	❒	❒
	❒	❒

Factors

Are any of the following influencing the task?

Worker Characteristics		
Task Characteristics	❒	❒
Material / Container Characteristics	❒	❒
	❒	❒

Training

Is the employee in need of training in safe lifting guidelines?		
Is the employee in need of training in body mechanics?	❒	❒
	❒	❒

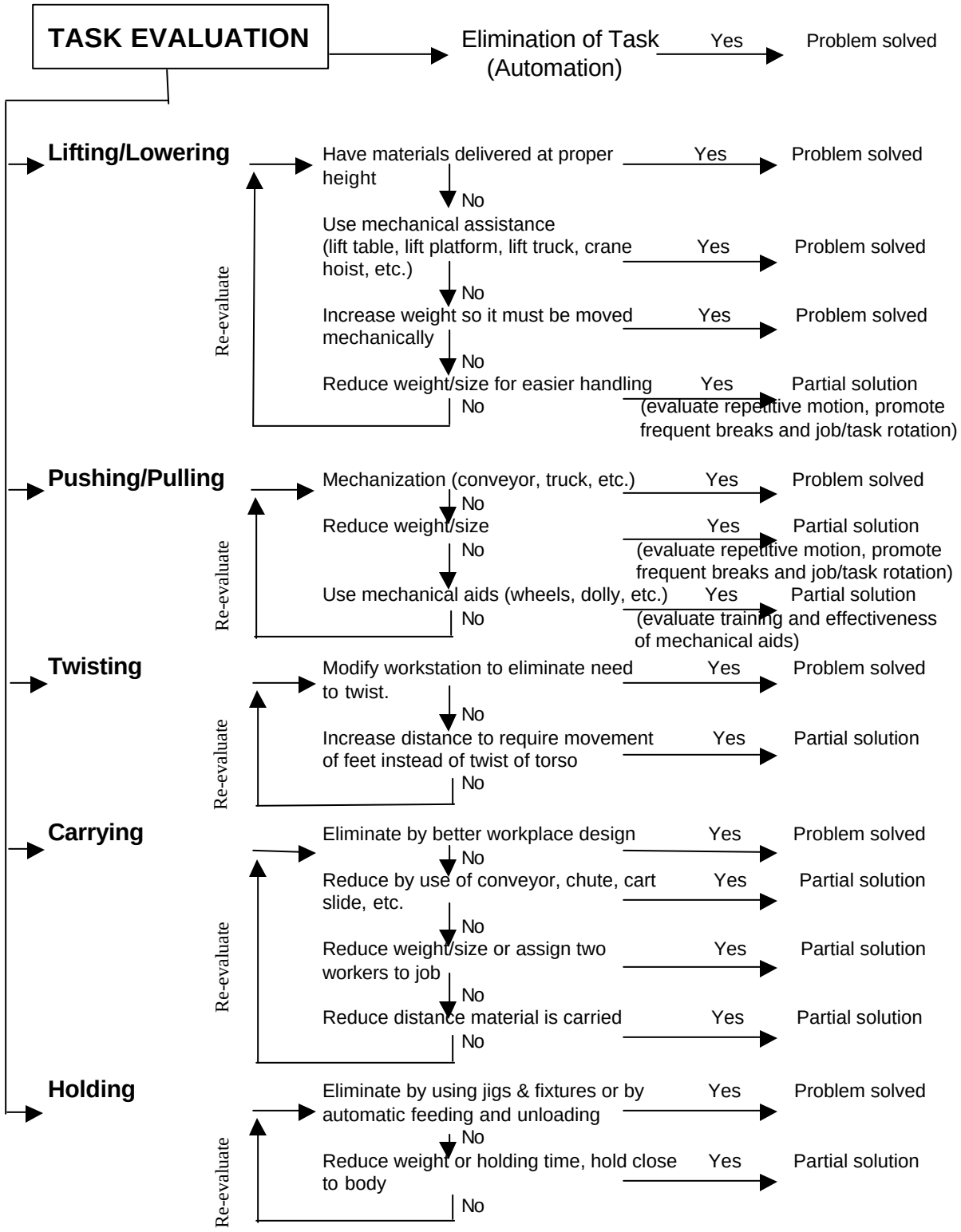
Further action / analysis is recommended as follows: _____

_____

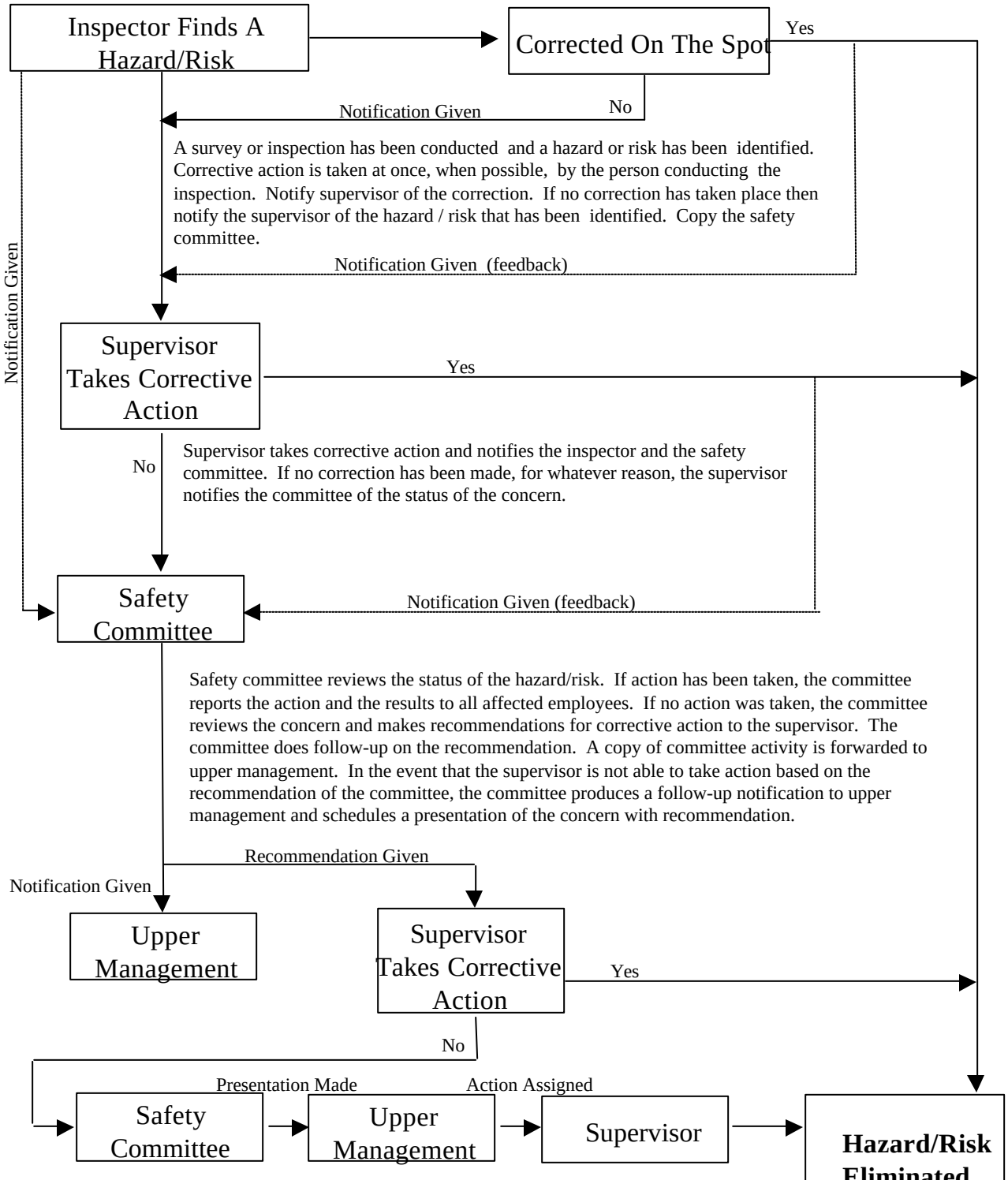
_____

_____

Manual Materials Handling Task Evaluation Guide



Action Plan Flow Diagram



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