Ergonomic Considerations for Workstation Design

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Liberty Mutual Loss Control Advisory Services

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Session Objectives

By the conclusion of this session, participants should be able to:

– Link workstation design principles to reduced fatigue, greater efficiency & higher performance
– Apply anthropometry concepts to recognize variability among your workforce
– Use design concepts and data to establish correct ranges for performing tasks
– Apply principles of workstation design to sitting and standing workstations
Preliminary Design Considerations

- Characteristics of users vs. job demands
- Materials and tools handled
- Visual and tactile requirements
- Precision tolerances needed
- Methods to operate machines/ tools
Anthropometry

The study of human (anthrop) physical dimensions and measurements (metrics)

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Male Height Distribution

69.13 in.

-3 -2 -1 +1 +2 +3

68% 95% 97.5%
Female Height Distribution

64.15 in.

-3 -2 -1 +1 +2 +3

68% 95% 97.5%
Male and Female Distribution Combined

66.64 in.

95%
Anthropometric Design Principle

• GOAL- To accommodate 90- 95% of your working population
**Anthropometric Principles**

- Clearance specifications should be based on larger users (stature, profile, frame, etc.)
- Ergo reach envelopes should be based on smaller users, but need to accommodate others-
  - Machine safety vs. ergo factors (movement efficiency)
- Critical points should consider extremes
- Adjustability should be incorporated when possible
Anthropometry

• Whole body dimensions
• Body landmark dimensions
• Body segment dimensions
• Functional dimensions
Anthropometric Data

Whole body dimensions

Height
Weight
Anthropometric Data

Body landmark dimensions

(e.g., note body segment dimensions – wrist to elbow)
Anthropometric Data

Functional dimensions

(Job demands vs. capability of employees)
Anthropometry Process

• WHO? Define your work/user population
• WHAT? Determine proportion for design; acquire anthropometric data
• WHAT? Determine applicable dimensions
• HOW? Modify data with allowances
Steps for order picking:

1. Design for 95\textsuperscript{th} to 5\textsuperscript{th} percentile
2. Determine acceptable range for workforce
   - Determine difference between fingertip vs. power grip reach.
   - Determine 5\textsuperscript{th} tile female shoulder height + 1" for shoes.
   - Determine 95\textsuperscript{th} tile male knuckle height + 1" for shoes.
Emergency Stop Features

Determine Range for Emergency Stop

Alternatives ‘may’ include-
- Buttons
- Trip cables
- Kick plates
- Body bars

Bear in mind-
- Reach, height, sight, mobility, language, noise, etc.
What Must be Seen?
Degree of Precision

- Characteristics of the object
- Characteristics of the tools
- Sit - Stand - or both?
**Sit or Stand?**

<table>
<thead>
<tr>
<th>Sitting</th>
<th>Standing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less fatiguing</td>
<td>More fatiguing</td>
</tr>
<tr>
<td>Less mobility</td>
<td>More mobility</td>
</tr>
<tr>
<td>More stability</td>
<td>Less stability</td>
</tr>
<tr>
<td>Lower exertable forces</td>
<td>Higher exertable forces</td>
</tr>
<tr>
<td>Foot or hand controls</td>
<td>Hand controls</td>
</tr>
</tbody>
</table>
Guidelines For Standing Workstations

• Often-accessed materials to reach-
  –Within 15”, other materials within 25”
• When reaching overhead, down/behind the body is not required (controls, tools, materials)
  –task can be performed with either hand
  –hands at appropriate height for precision/exertion
• Work-piece can be made ‘height adjustable’
Work Surface Height

Precision work - 2” - 4” above elbow height

Normal light hand work - 2 -4” below elbow height

Heavy work (large downward forces) - 4” - 8” below elbow height
Guidelines For Standing Workstations (cont)

• Equipment, parts, bins, tool boxes, etc. are
  – designed to access with neutral upper extremities
  – no accumulation of foreign materials on the floor
  – not something that requires significant balance

• Provide means of back support with -
  – Cushioned floor mat
  – Footwear insoles designed/fit for the user’s shoe
  – Foot rest (up to 8“)

• Sitting down possible option if no continuous standing
  – Latest studies (OSU) show some movement is good!
    • http://www.workforce.com/article/20120809/NEWS02/120809933/ohio-state-university-takes-a-stand-against-sitting-for-too-long#
Example 1; Range for Control Location

Steps:
1. Determine for whom you will design
   - 5%-95% vs. all users?
2. Determine acceptable range for access
   - Reach of shortest female & fingertip height of tallest male
3. Determine preferred range for access
   - Determine height of 5%tile female and add 1" for shoes
   - Determine elbow height for 95%tile male and add 1" for shoes

* Safety distance criteria will be an essential component involved with your calculation; refer to ANSI B11.19-2010 for more detail.
Example 2; Machine Feeding Position

Steps:
1. For seated tasks, need adequate leg space
   - Determine 95%tile male popliteal height
   - Add thigh and heel height
2. Determine chair height range
   - Determine from above
   - Add heel heights for lower level chair heights
   - Subtract 5%tile female thigh height from 95%tile male thigh height
   - Add thigh difference to lower level for upper level chair heights.
3. Other design considerations;
   - Height of point of operation
     - Determine 5%tile female elbow height
     - Add to upper chair height
   - Determine maximum table height thickness (include tub, bolster, etc.)
Example 3; Common Palletizing Tasks

Risk Factors Observed-
- Highly repetitive, pace determined by production flow
- Very manual, no mechanical assists
- Full range of movement from floor to above shoulder height

Solutions and Ideas-
- SOP to avoid manual stacking over shortest female worker and lower than tallest male knee height
- Examine product weight and limit sizes and re-packed content where possible
- Introduce workflow design concepts
- Test drive auto palletizer or OH lift system
Individual Differences:
Most Important Are Age and Gender

- We get shorter as we age
- We get weaker as we age
- Women have <50% isometric strength as men
- Female heart rates are higher
- Females recover faster from exertions
- 8% of males are color deficient
- Response time, vision, hearing deteriorate with age
- 10% of population is left handed
Guidelines For Seated Workstations

• Chairs (dependent on setting, demands, env.  
  – Backrest, lumbar support, cushioned seat pan, waterfall front edge, 5 leg base

• Other desirable features include-
  – Height is adjustable
  – Allows for some movement
  – Often-accessed materials within 15" reach distance, others within 25”
  – Reaching overhead or down and behind the body is not required to access controls, tools materials or equipment
Workstation Layout
• The task can be performed with either hand
• There is room for knees/feet below the work surface
• Hands are at elbow height
• Height of the work surface is adjustable
• Equipment, parts, bins, tool boxes, etc. are designed to allow access and operation with the upper extremities in neutral postures
• Opportunities to stand are designed into the work
General Guidelines (cont)

• Keep elbows down
• Shoulder abduction <30°
• Avoid long reaches (>16”)
• Head tilt <15°
Tasks That Require Physical Bending

• Keep work at the mid-range level (knuckle height to shoulder height)

• Use lift tables, work dispensers, or other aids to raise the work-level
  – Design to use gravity where possible (e.g. conveyors, chutes, ball transfer, etc.)

• Provide material at multi work-levels
  – Carousels, elevated surfaces, tilted bins, etc.

• Keep material off the floor if the material must be raised later
  – Consider storage arrangements, how it gets there and how it gets moved
Tasks That Require Twisting

• Position all materials/tools in front of the worker
• Use conveyors, chutes, slides or turntables to change the direction of material flow
• Provide adjustable swivel chairs for seated workers
• Provide sufficient work area for whole body to turn
  – Change in foot position is vital, but avoid carries
• Improve workstation layout to eliminate need to twist
Workstation Design Summary

• Proper design of workstations can minimize fatigue and enhance performance and output

• Ergonomic design will minimize MSD risk factors

• Know who you are designing for and accommodate them

• Consider the big picture (how one task design affects others)

• Adjustability is critical!
Resources and Guidance

- Thomas Bernard (University of South FL)
  - Data from Kodak's Ergonomic Design for People at Work, 2nd Ed. Table 1.5, pp 48 – 49

- Task lighting standards or Lighting Industrial Environments

- ANSI/HFES 1000

- Liberty Mutual Research Center data