



Work Area Design

- Definition: the design of the work area to accommodate workers while maximizing human effectiveness
- General Requirements
 - Functional requirements
 - Visibility
 - Displays, controls
 - Present data at right angle to line of sight to minimize visual parallax
 - Hearing requirements
 - Buzzes
 - Alarms
 - Consider clearance
 - Access
 - Egress
 - Comfort and support for grasping and operating equipment controls (e.g., tennis racket)
 - Reach and manipulation
 - Normal (convenient sweep of arm) vs. maximum area (extending arm from shoulder)



Work Area Design

- General Principles
 - Population stereotypes
 - Operator expectancies – ensure they are not violated
 - Psychosocial factors
 - Cleanly and orderliness of work setting
 - Environmental factors
 - Heat
 - Humidity
 - Noise
 - Standardization
 - Savings in training time
 - Design for the total system
 - Design for maintainability
 - Allow various work postures
 - Sitting, standing



Workstation Design

- Adjustability is key
 - Adjustability is a key element of design – adjusting to the user, task allow you to obtain a good fit between the user and task
 - Key: usability will depend on the operator's perception of resulting benefits
- Adjustability approaches
 - Workplace adjustments
 - Cutouts can be used to minimize reach requirements and protrusion of chairs into aisles



Workstation Design

- Adjustability approaches
 - Work surface height and inclination



Workstation Design

- Adjustability approaches
 - Worker position
 - Seat height
 - Chairs with rollers for horizontal adjustment
 - Platforms – help change position in relation to work surface
 - Footrests – resolve unsupported legs – must be adjustable to seat height
 - Work piece and tool adjustment
 - Adjust work piece via clamps, vices, jigs
 - Gravity bins to bring parts to within reach & reduce search time
 - Lift tables
- Work posture
 - Seating – bases – visibility, clearance, less fatigue due to improved blood circulation, reduced static loads
 - Standing – experience greater physiological load, standing still for long periods leads to blood and body fluid accumulation in legs

Swelling, varicose veins



Workstation Design

- Based on: anthropometric data, behavioral patterns of people, and specific work requirements
- Standards often arbitrary, unpractical
 - Developed by committees involving many parties
 - Can be politically motivated
- Working heights
 - Must fit stature and type of work
 - Too high: shoulder lifted, pain in the neck and shoulders
 - Too low: back hunched, backache
 - Standing handwork
 - 50-100 mm below elbow
 - Details: 50-100 mm above elbow/height, support elbows
 - Manual work with tools, containers, and materials: 100-150 mm below elbow
 - If effortful work: 150-400 mm below elbow



Workstation Design

● Working heights

- How to accommodate different statures?
 - Foot supports
 - Tilted table
 - Fully adjustable bench
 - If can't adjust, accommodate tallest and provide platform

● Work heights for sedentary work

- Elbow height is general rule of thumb
 - Fine precision work: above elbow
 - Forceful or large motion: below elbow height
- Conflict with providing adequate knee room
 - Measured from floor to top of seated knee
 - Considerations:
 - Table to accommodate
 - Amount of clearance
 - Table thickness
 - Distance from seat surface to table underside



Workstation Design

● Work heights for sedentary work (con't)

- Office work
 - < 50% have upright posture
 - Common musculoskeletal complaints (% of 246 office workers surveyed)
 - 57% back
 - 29% knee and feet (short people)
 - 24% neck and shoulders (desk height)
 - General recommendations
 - Desk height: 740-780 mm
 - Given seat adjustability and a foot rest
 - Seat below desk: 270-300 mm
 - Regardless of stature
 - Natural trunk posture



Workstation Design

● Work heights for sedentary work (con't)

- General recommendations (con't)
 - Compensate for high work level
 - Lift shoulder (trapezius)
 - Abduct arm (deltoids)
 - Easier to accommodate tallest (desk height)
 - Leg room
 - General rule of thumb: cross legs without difficulty
 - No pressure above legs
 - No desk edge contact
 - Table thickness: < 30 mm
 - Leg space: 680 mm wide by 680 mm high
 - Depth for stretching
 - From 600 mm
 - Post: 800 mm
 - Keyboard table
 - Working height is middle row of keys
 - Work height: elbow height
 - Adjustable from 600-700 mm



Workstation Design

● Sit/Stand Workstations

- Recommended physiologically and orthopaedically
- Alternates stressed and relaxed muscles
- Varies supplies of nutrients to the disc
- Special considerations
 - Horizontal knee room
 - Height of work area from seat and floor
 - Seat adjustability
- Tilted tables
 - Research comparing flat, 12 degree and 24 degree
 - Tilt had more erect posture
 - Tilt less electrical activity
 - Tilt subjectively preferred
 - Tilt for reading
 - Flat for writing
 - Tradeoff of visual & postural advantages vs. ease of use



Workstation Design

● Neck and head posture

- Hard to define since 7 joints
 - Estimate line along neck relative to vertical, horizontal, trunk
 - Carveys line (CCL): line from earhole to eyeball
 - Used to describe posture
 - Used to reference line of sight
 - Approximately 15 degree (to vertical) ok
 - Qualifies as angle between upper to lower
 - Should not be greater than 20 degrees for any time
- Line of sight
 - Represented by line from pupil to visual target
 - If head upright
 - Distal targets along horizontal with eye
 - Closer targets more declined
 - Reading: 10 degrees below 90°
- General rule: preferred line of sight 10-15 degrees below horizontal
 - Defines regular viewing cone of 30 degrees around preferred line of sight (15 degrees above, 15 degrees below)
 - CCL should be less than or equal to 15 degrees relative to horizon
 - Results apply to VDT work, also



Workstation Design

● Room to Grasp and Reach (see overheads)

- Grasp/Reach envelope: sweep radius of arms with hand in grasping or reaching posture
 - Location of shoulder joint
 - 5th percentile measurements
- Vertical Grasp - vertical plane in which you can take hold of things and move them around
 - Based on shoulder height of 5th %ile (closed hand arm length)
 - Can occasionally extend by stretching shoulder, feet, and legs
- Horizontal Grasp - horizontal plane in which you can take a hold of things and move over table top
- Reach Height: vertical height reached with extended hand
 - Shelves, storage (consider shelf depth)



Workstation Design

● Sitting at Work

- Improves well-being, efficiency, reduces fatigue
- Standing is poor physiologically (static work)
- % of worker in industrial countries are sedentary

● Advantages

- Take weight off legs
- Increase stability of upper body posture
- Reduce energy consumption
- Reduces demands on circulatory system

● Disadvantages

- Slackening of abdominal muscles
- Spine curvature impedes digestion and breathing
- Weakens spine and back muscles, increases disc pressure



Seat Design

● Comfortable chair

- Seat pan tilt $\leq 24^\circ$
- Backrest tilt $105-110^\circ$ to seat pan
- Lumbar pad 100-180 mm with apex between 3^{rd} and 5^{th} lumbar vertebrae

● Office chairs

- General recommendation: high back-rest with back contour – better to support weight of trunk
- Specific features
 - Adaptable to traditional and computer work
 - Accommodate forward and reclined seating
 - Adjustable angle backrest
 - Backrest height ≥ 500 mm from seat surface
 - Backrest should have well formed lumbar pad from L3 to sacrum
 - Seat pan: 400-490 mm across, 380-420 mm deep, cavity in seat, lightpad, non-slip, permeable material
 - Footrests
 - Adjustable height, swivel, rounded front edge, 5 arm base, user-friendly controls



Seat Design

- Promote lumbar support



(a) Standing

(b) Sitting

- Minimize disc pressure
 - Discs between vertebrae and spine can be damaged due to excessive pressure
 - Unsupported seating (i.e., no backrest) increased pressure
- Minimize static loading of back muscles
 - Slumping will reduce but causes other problems
- Reduce postural rigidity
 - Sitting in one position
 - Reduces blood flow to discs
 - Chair design can allow user to rock and reduce problems



Computer Workstations

● VDT operator tied to workstation

- Attention on screen
- Hands on keyboard

● Problems:

- Constrained posture
- Repetitive activities
- Poor photometric display characteristics
- Inadequate lighting

● Discomforts

- Visual strain
- Physical discomfort in back, neck/shoulder, forearm, wrist, hand

● Reported problems highest among data-entry and full-time typists



Computer Workstations

● Workstation characteristics linked to discomforts

- Keyboard height
- No forearm/wrist support
- Key tops too high above table
- Wrist deviation (keyboard design)
- Head inclination (visual field placement)
- Insufficient leg room

● Should provide adjustability

- Keyboard height
- Screen height, distance, inclination
- Document holder inclination



Guidelines

● Furniture as flexible as possible

- Keyboard height 700-850 mm
- Screen center height 800-1100 mm fro floor
- Screen inclination from horizontal 105 degrees
- Screen distance to table edge 500-750 mm

● If not adjustable, not for continuous use

● Adjustable controls should be easy to use

● Provide ample knee and foot space

● Promote easy body movement but minimize excessive motions