Training Center

Ergonomics standards

Formation

ECAM LYON_THAMMASAT UNIVERSITY

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Introduction

The following ergonomic standards refer to those implemented within the schneider company.

In order to implement the 5S method in the continuous improvement strategy of a workshop, operators must be convinced of the usefulness of the 5S, and not only consider this method as verification or checking. In the same way, taking into account ergonomics rules improves our colleagues working conditions and our operating results.

Cycle time calculation

OCOTDAC (Observe, Choose, Observe, Think, Decide, Act, Control)

N°		Steps	Means
1	Observe	1. Basic observations 2. Merge and study of the preliminary analysis	• Pareto • Product analysis • Execution analysis • Proceeding analysis • Process analysis • Instantaneous observations • Circulation diagram • Health & security diagnostic
2	Choose	3. Selection of the workbench according to choose criteria (cost, quality, period)	• Management objectives
3	Observe (workbench study)	4. Detailed observations	• Time • Instantaneous observations • Video • Health & security diagnostic
4	Think & Analyze (now workbench conception)	5. Constructive criticism	• 5 W Questions – rules
		6. Construction or modification project	• Work factors stabilization • Time estimation • STM (Standard Time Method) • MTM (Method Time Mesurement) • Principle and practical solution
5	Decide	7. 1st estimated assessment	• Estimated assessment • Profitability graph
6	Act	8. Practical realization of the new workbench	• Surveillance: new workbench realization • Mastery information • Training of the operator • Production stabilization curve
		9. Times determination	• Chrono census • Theorical times • Work elements determination – elementary times
7	Control	10. Second definitive assessment	• Assessment • Profitability graph
		11. Results control and issues solving	• Operation mode verification • Chrono census • Time confirmation / potential correction

Work time determination

- Direct observation (chrono analyzing or sample measurement)
- Predetermination of the times (MTM or standard data)

Chrono analysis:

1- Select operations and the operator to observe.
2- Divide the work in sub elements.
   - Repetitive task
   - Occasional task
   - Constant task
   - Various task
   - Manual task
   - Machine task
   - Governing task
   - Stranger task
3- Define the necessary number of measures.
   - 10 minimal observations for less than 2 minutes cycle times
   - 5 observations for more than 2 minutes cycle times

Statistic manner to determine the number of measures.

Make a first measurement set.

The total number of measurements depends on 3 factors

- confidence interval
- Data variability
- Wanted precision degree.

$$N = \left(\frac{\sigma \times z}{p \times \bar{x}} \right)^2$$

With

N: the number of measures

p: wanted precision of the estimation (usually 5%)

σ: standard deviation of the first-time measures

x: mean time sample

z: Standard deviation for the wanted confidence interval

4- Measure taking

2 golden rules for direct measure

- Staff must be aware and agreed with the project.
- The timing must be done in normal manufacture conditions.

3 measurement techniques

- Continuous taking

- Sequenced taking (timer back to zero after each section)
- 3 watches system taking (combination of both firsts: the third watch gets back to zero after each sequence)

Measure taking difficulties:

- Missing elements
- Analyst sees elements which are not part of the standard cycle.
- A stranger element appears during the cycle.

5- Observed time calculation To

Three techniques:

- Mean technique (For each phase, calculate the mean time observed)
- Frequency technique (Sort the values and take the one which is the most present)
- Michelin technique (take the 1st value of the 2nd third in the sorted list in ascending order) → Often used in great series.

Stability rate measure:

$$Stability\ rate = \frac{T_{0_{max}} - T_{0_{mini}}}{T_{0_{moyen}}} * 100$$

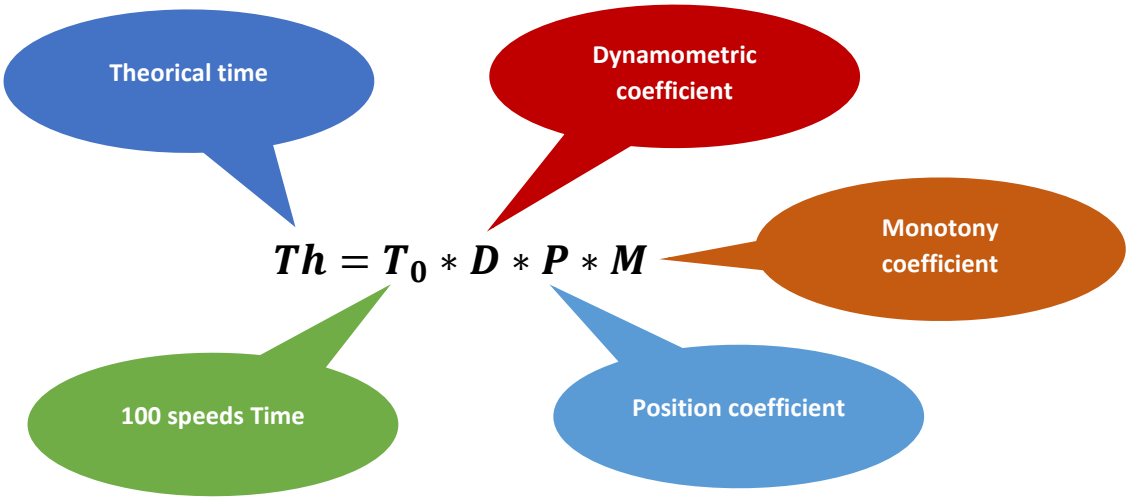
Under 50%, we can consider that the post is stable.

6. Application of the values' appearance and efficiency

Appearance judgment AJ : An experienced operator watch another operator doing his job and judge his speed.

AJ= Speed observed / reference speed

7. Theorical time calculation Th



Dynamometric efforts: movement and dynamic efforts pauses.
Position: unpleasant positions or excessive focus
Monotony: If same muscles or senses are requested; the task lasts more than 8min, and efforts are different from the dominant one.

Atmosphere: Temperature, hygrometric degree

Recapitulative tables

Timing analysis	
Advantages	Disadvantages
• Permits the analyst to see the whole cycle and identify progress sources. • The only method to measure the real actual time to realize a task. • Fast to identify a first-time base. • Relatively simple to implement and explain. • Provides values quickly for machine operations	• Requires a performance rate depending on operator skills and effort. • Requires many observations on different operators. • Not so useful on non-repetitive operations • Requires a person per operator to perform the analysis

Sample measurement	
Advantages	Disadvantages
• No timing • No need of a permanent presence near the operator • Exclude the issue of constant observation on a long time. • Represents the mean time whatever the conditions • Ideally appropriated for machine operations studies • Can be used with a performance rate	• Based on the hypothesis that the operator uses an acceptable and standard work method without behavior modification • Requires an analysis on many work categories • Not profitable if used on an unique post

Time predetermination

Time predetermination thanks to movement analysis (practicable for manual operations)

5 steps:

1.Separation of each task's movements

2.Determination of each movements' variables

3.Codification of each movement

4.Reconstitution of movement's needed times thanks to tables

5.Détermination of operation's times

Time predetermination	
Advantages	Disadvantages
• Force to be precise in analysis. • Permits to compare several methods to perform a new task. • Stimulate movement simplification. • Exclude performance rate need. • Permits to establish times before the production. • Safe and reliable method • Permits to easily update time data depending on methods' changes. • Permits to measure the time of little movements. • Define a standard language for every operation	• Depends on the task description's precision. • Requires formation time. • Harder to explain to workers. • Requires chrono-analysis or time standards for "machine" times

Standard data	
Advantages	Disadvantages
• Supplies a mean performance rate • Permits to establish times before the production • Safe and reliable method • Permits to quickly and cheaply establish standards • Permits to easily update time data depending on methods' changes.	• Requires important funding to establish the first version • Not reliable for little variations in method changings • Requires good competences from the analyst to understand complex formulas • Hard to explain to workers

Other times exist:

- Technologic time (time only depending on material actions)
- Technic & human time (time depending on actions which need both material and human resources)
- Frequential time (time of an action which periodically modify the cycle proceedings)
- Planned time (calculated from technologic and frequential times)
- Allocate time (planned time + backup time
- Provisional time (planned time to consider factors like disruption
- Human time (Physical or mental work time: only linked to the executant)
- Hidden time (time of a work done during another work)
- Residual time (inactivity time = technologic time – sum of hidden times)
- Balanced time (complementary times to synchronize cycles)
- Preparation time (time to launch a set)

Workbenches ergonomics

22 rules for movement ergonomics

- Movement simultaneity

1. Both hands must start and finish their movements at the same time

2. Both hands must not stay inactive at the same time, unless it's break times

3. Arms movement must be symmetrical and simultaneous

- Minimal energy spent

4. Work related movement must include the smallest muscular masses possible.

5. Continous movements are preferable to « zig zag » movements or movements in broken lines with acute angles.

- Living force

6. The living force must be used whenever it's possible to help the operator's movements. It must be reduced to the minimum if the movement is controled.

7. The ballistic movements are faster, easier and more precise than constrained or controled movements.

- Rythm

8. Rythm acquisition is essential to an eased and automatised work execution.

- Order in the equiped work area.

9. There must be a defined area for each material or component.

10. Tools, materials and checker must be placed as close as possible and right in front of the operator.

11. Materials, components and tools must be displayec to allow the best possible movement sequence.

- Use of the seriousness.

12.Boxes and alimentation receptacle for seriousness have to supply the executants near their work space.

13.It is important to use the seriousness for evacuation : channels, transporters, tilted roller...

- Workbench comfort and lighting

14 It is necessary to arrange the lights for each operator to have the best working conditions

15. The workbench and seat height must be adjustable to permit stand or seated work

16.A seat giving a good posture must be provided to each operator

- Hands liberty

17.Hands must be relieved from every work which can be done in an easier way by an assembly

- Combine / Put in place

18. Tools must be combined whenever it's possible.

19. Tools and devices must be put back in place whenever it's possible.

- Finger load

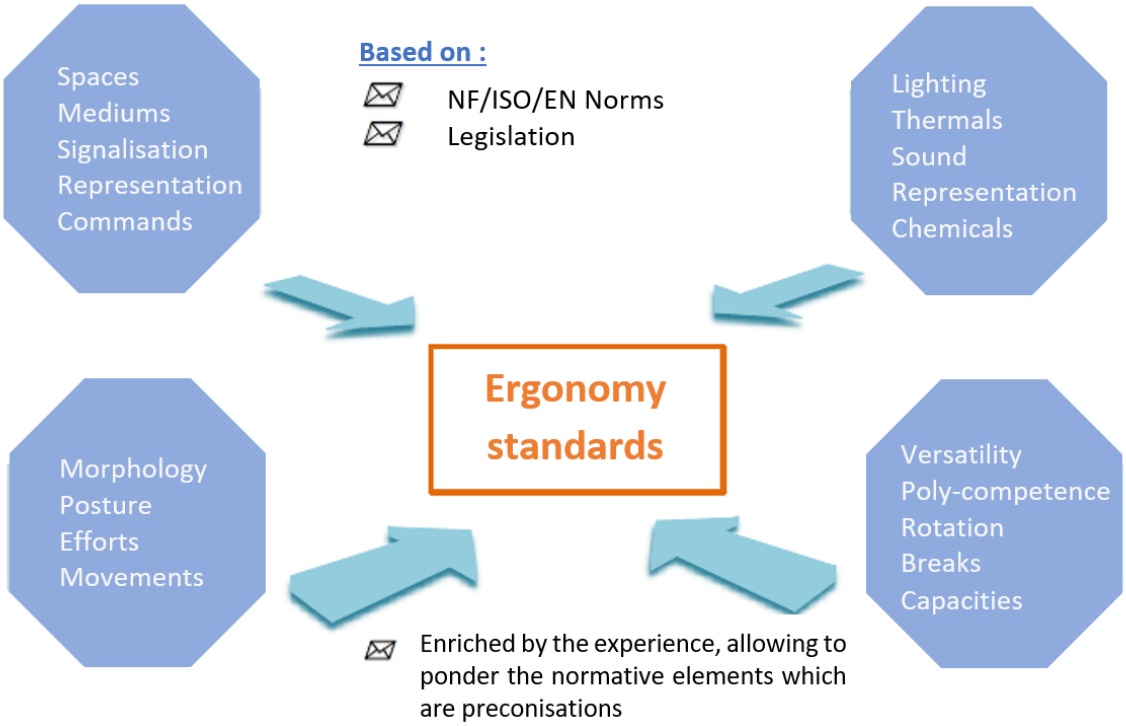
20. When each finger has a different movement, the load on each finger must be distributed according to their capacities.

- Control units

21. Handles must allow the largest possible contact

22. Levers, capstans, wheels, must allow their maneuver with th least posture change with the highest efficiency.

Ergonomics standards

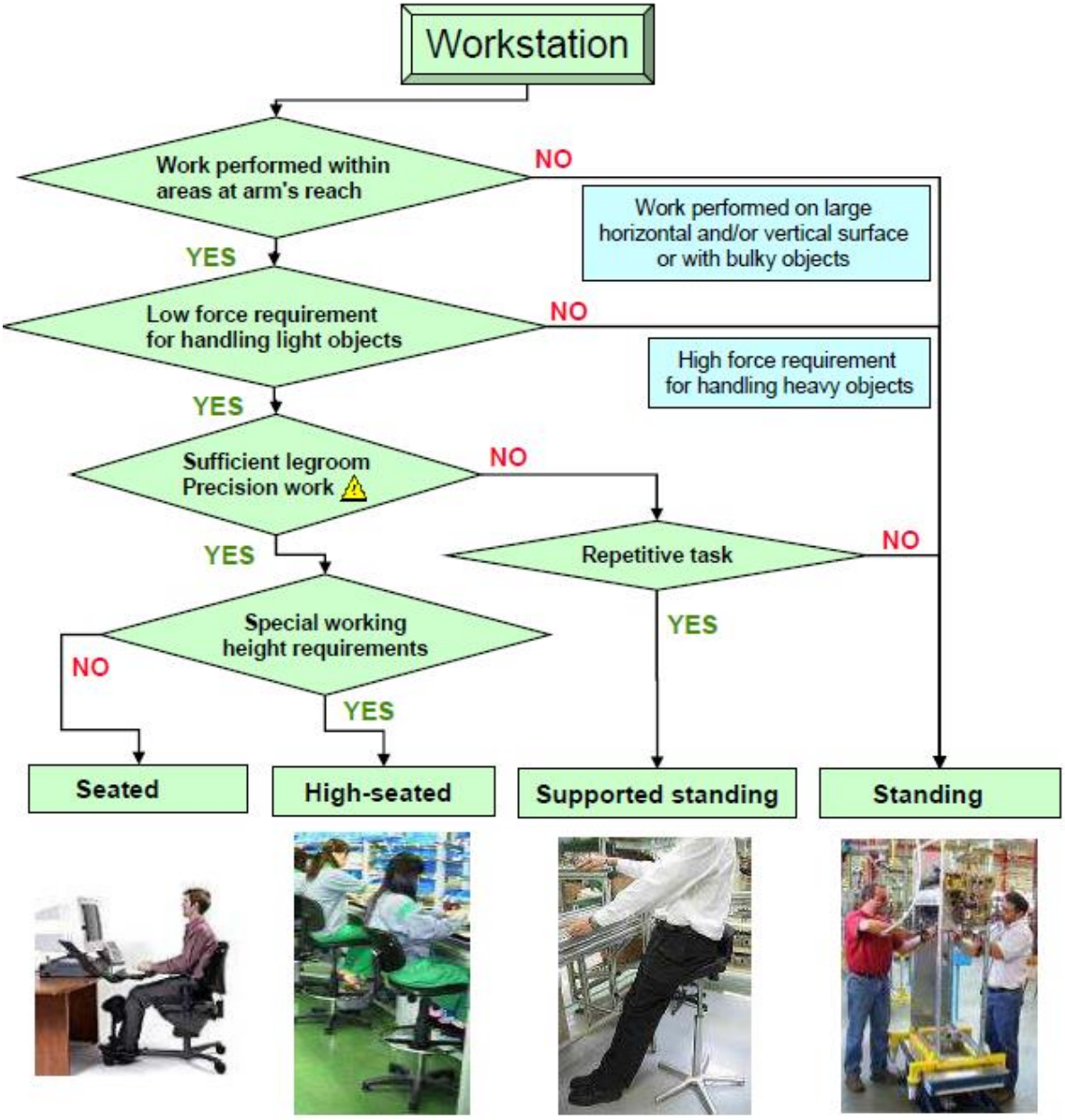


Numerous norms linked to ergonomics

Choice of working posture

Posture is the first thing to define. The workbench and each of its elements must be organized depending on this posture.

The most frequent strain factor is the working posture set according to the workstation design.



Choice of a seat

The choice of the seat will depend on:

- task constraints
- posture flexibility
- ease to sit and stand
- seat stability required
- material covering
- ease to be adjusted

Seat lightness and compactness facilitate application of Lean Manufacturing principles (workstation changing and mutual assistance)

Seated and high-seated positions

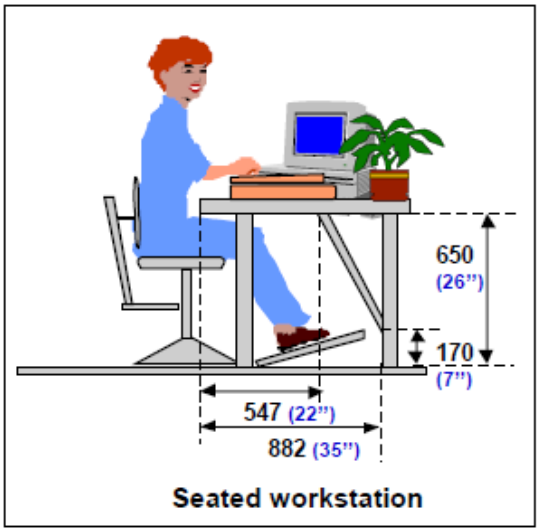
Recommendations :

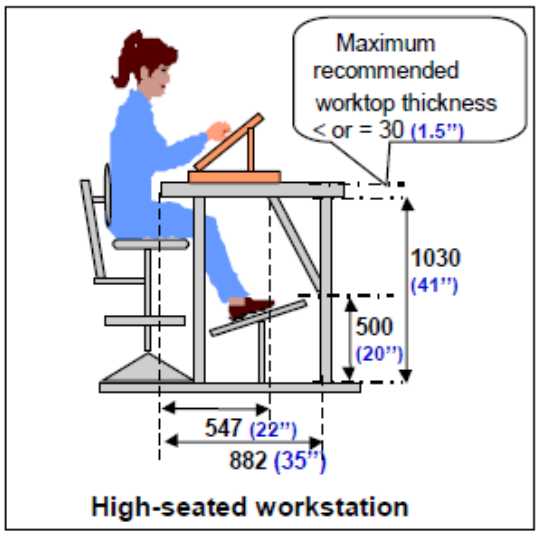
- Working seat should be easily adaptable to each user's specific needs.
- Seat section should provide support and avoid discomfort due to seat pressure on the rear side of the leg.
- Material used should prevent sweat accumulation and electrostatic discharge production.
- Back rest, adjustable in height and inclination, should allow back muscles to relax.
- Base should have 5 bearing points to ensure stability. Use of castors is not recommended for high-seated position. They can cause a risk when the seat is moved.

Adjustment devices, enabling seat to be adapted to work situation, should be easy to manipulate and reliable.
Correct seat adjustment requires operator to be informed and made aware of risks.

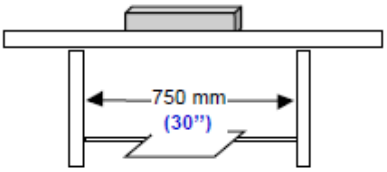
Workstation Dimensioning Product assembly

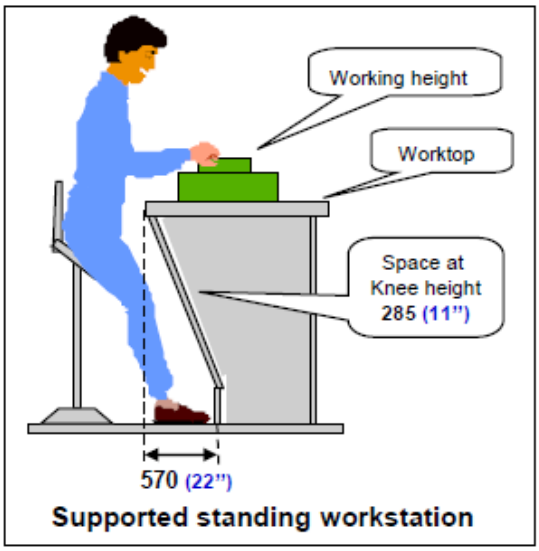
Clearance for passing legs and feet beneath.

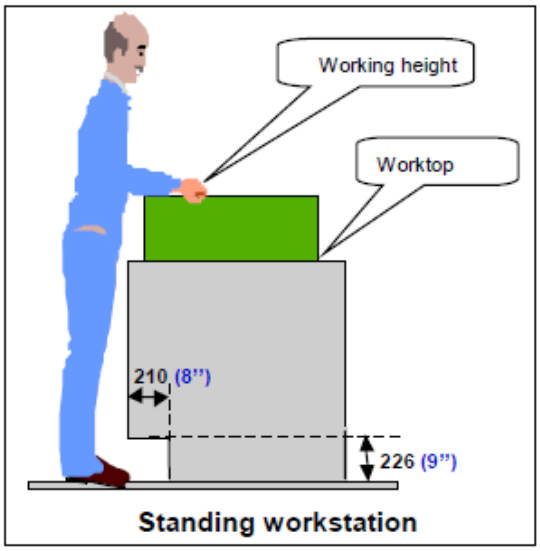




Lateral clearance width
for passing legs beneath
seated workstation
*should be **750 mm minimum***
30 inches

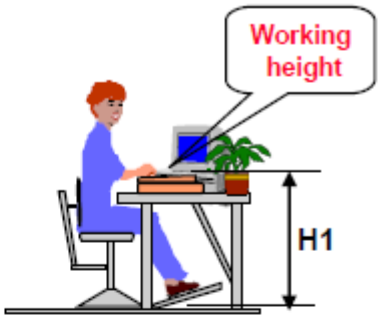
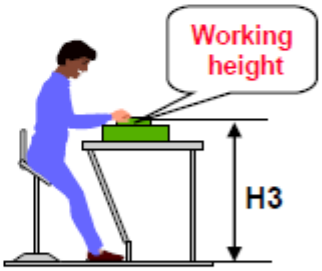
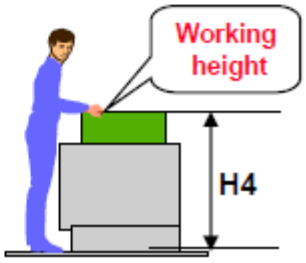






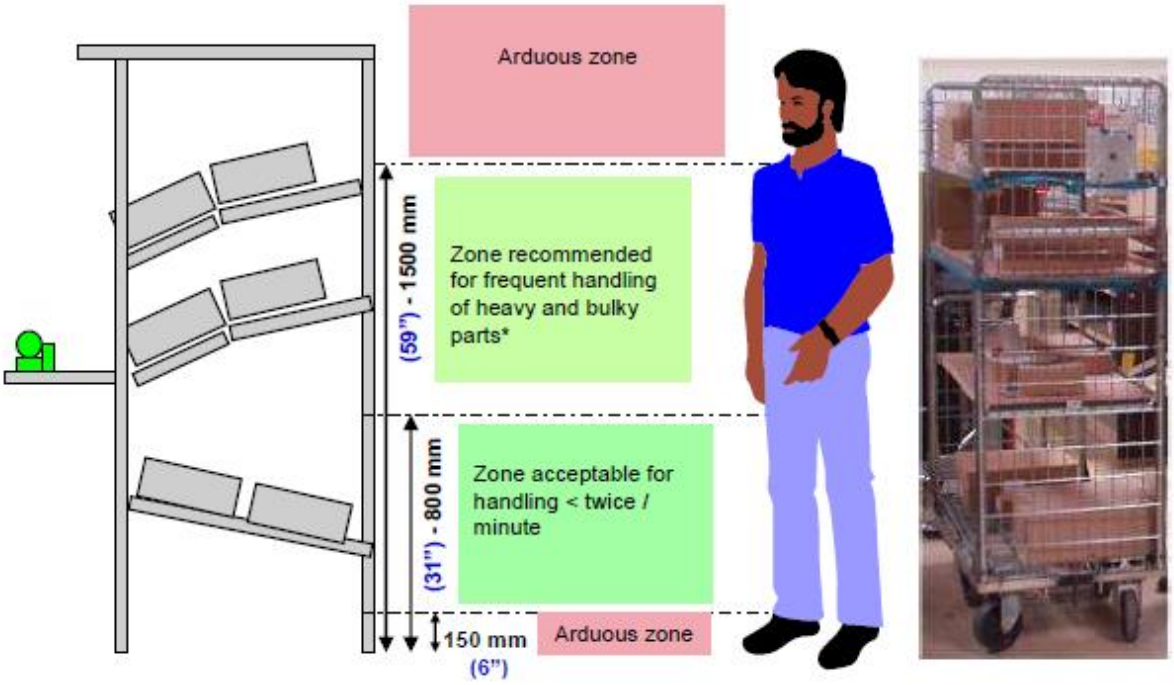
Working height and Worktop

The height of these equipment must be adapted to each operator and to each task.

Task requirement	Position	Working height	Worktop height
Office work		H1 = 700 à 750 mm 28'' to 30''	Worktop at elbow height
Manual work (arm support) coordination associated with visual surveillance in same working area		H2 = 1100 à 1200 mm 43'' to 47''	Worktop above elbow height
Active arm or small object movements		H3 = 1000 à 1100 mm 39'' to 43''	Worktop at elbow height
Handling of objects that are large but not too bulky or heavy		H4 = 800 à 1000 mm 31'' to 39''	Worktop below elbow height

Workstation material replenishment

METTRE DU TEXTE ??



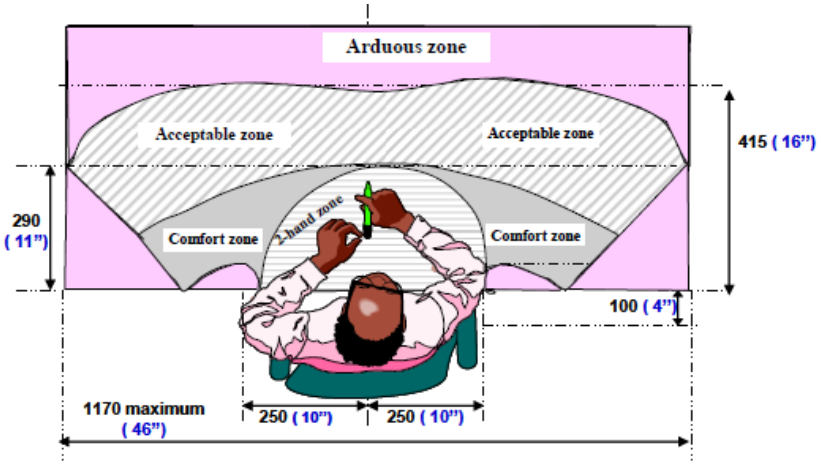
Picking et manutention

Recommandations :

- Objets volumineux et lourds > 12kg :
  - Les pièces sont préférablement stockées au niveau bas sur une palette ou un chariot
  - Une aide à la manutention est mise à disposition
  - Un espace de manœuvre au minimum du double du volume de la pièce est à prévoir
- Cartons, contenants unitaires < 12 kg :
  - Prévoir l'accès des mains pour saisir le contenant
- Prise de pièces dans des contenants < 12 kg :
  - Prévoir le passage des mains, éviter les hyper flexions du poignet
  - Prévenir des coupures occasionnées par des bords coupants du carton
  - Éviter les couvercles en permanence sur les contenants
- Utiliser des convoyeurs à rouleau évitant aux produits ou aux cartons de se mettre de travers, de s'accrocher et de fait de rendre la manipulation difficile.

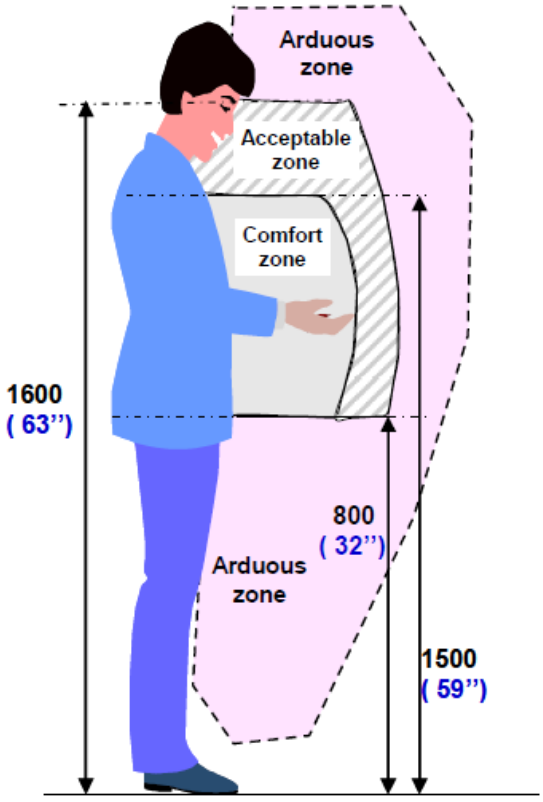
Working zones

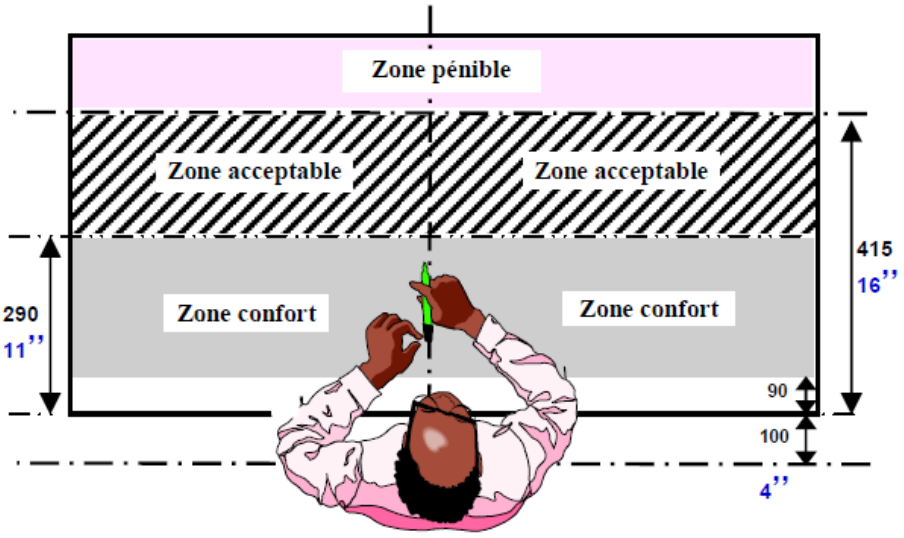
Seated



When undertaking assembly requiring **body movement precision**, it is recommended that the 2-hand zone be centered at an average distance of 200 mm (8") from the table edge (150 to 250 mm – **6" to 10"**)

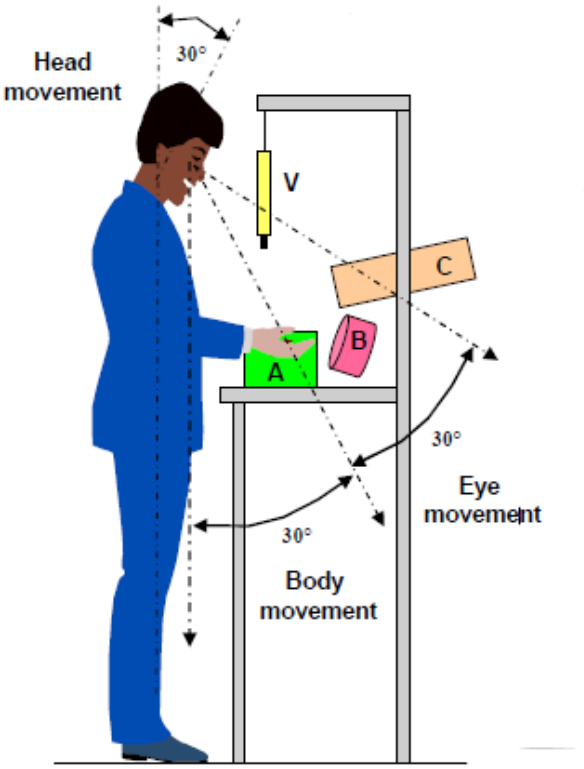
Standed

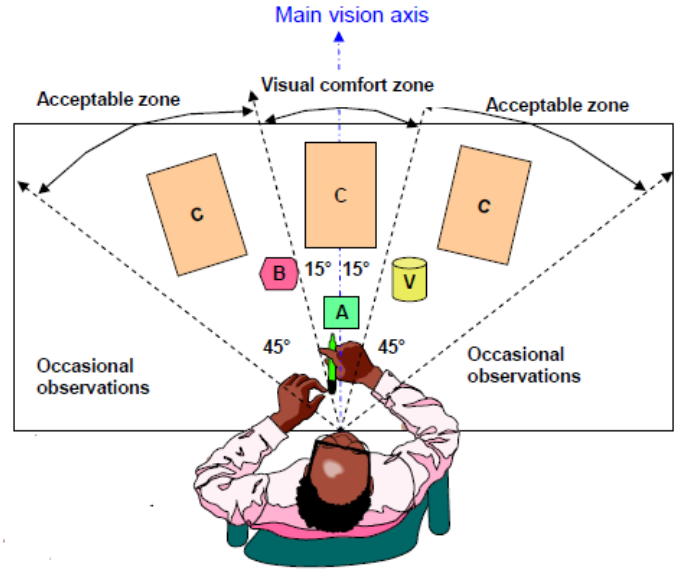




Zones determined as semicircular for "seated" or "high-seated" workstations become linear for "standing" workstations, the operator being able to move in front of the workstation.

Zones of vision





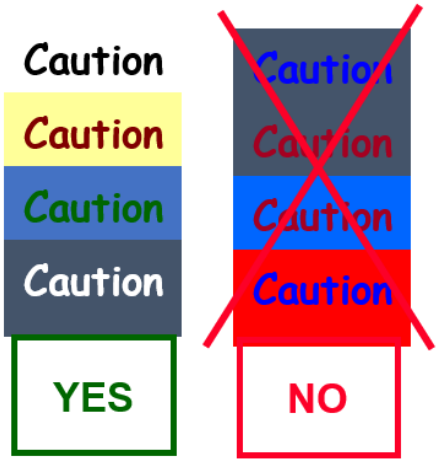
A → Product being assembled
B → Visual indicator to be viewed at each cycle
C → Cyclic feeding of parts required for product assembly
V → Power screwdriver

Visual range

D (mm)	Between → And →	0 500	500 800	800 1250	1250 2000	2000 3150	3150 5000	5000 8000
H (mm)		3	3.5	4.5	6	9	14	23
W (mm)	Between → And →	2 3	2 3.5	2.5 4.5	3.5 6	5 9	8 14	12 23
t (mm)	Dark on light Light on dark	0.3 0.25	0.35 0.3	0.45 0.4	0.6 0.5	0.9 0.75	1.4 1.2	2.3 2

D = eye distance to the character
H = height of the character
W = width of the character
t = line thickness

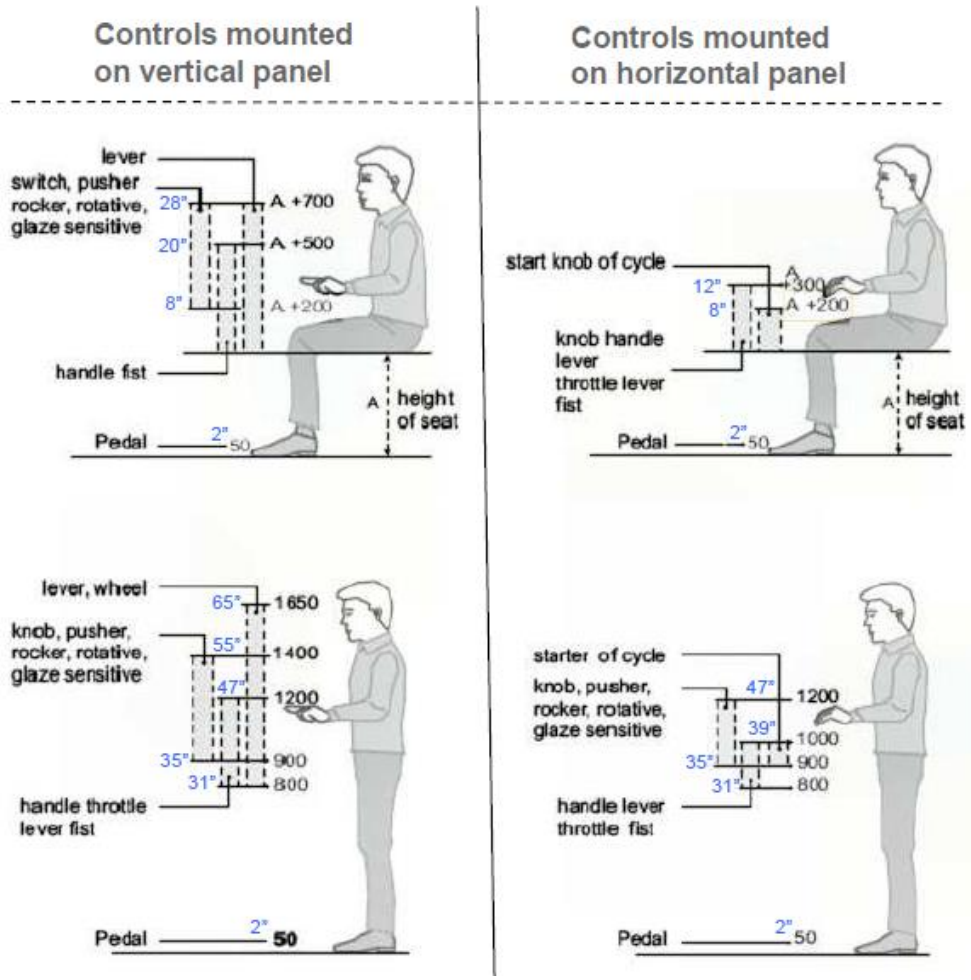
Examples of which policy use or not



Positioning of controls

Recommendations:

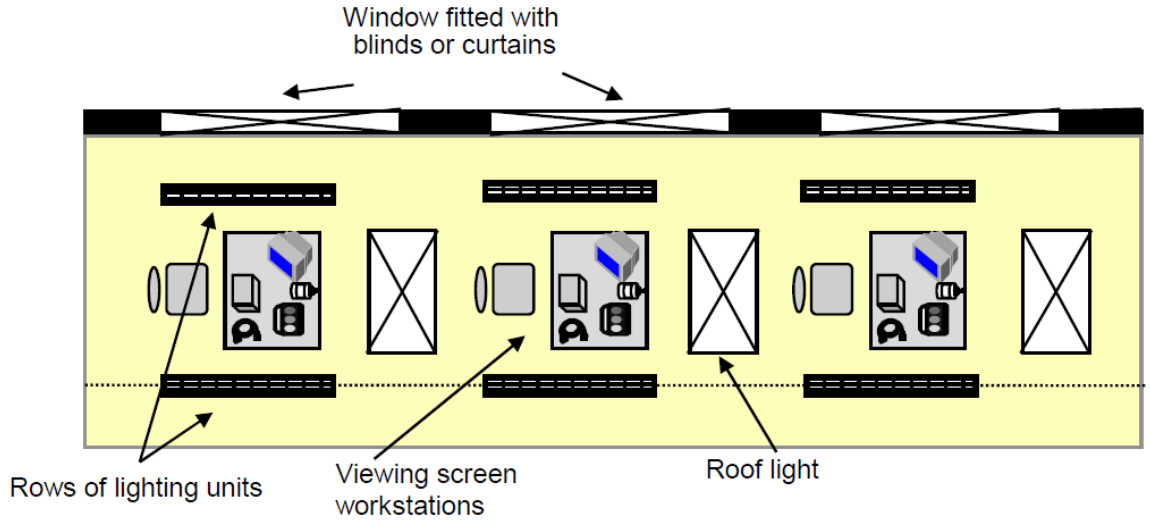
- Manual controls used at each cycle should be located in acceptable gripping zones.
- The degree of force to be applied should be considered, when determining the position of controls requiring application of force (e.g. press lever).
- Controls used frequently should always be located near the visual task.
- A control used for emergency operation should be capable of actuation in a very short time.
- When a control requires only a single hand, position it on the side of the limb required. Provide means of adjustability to satisfy right-handed / left-handed operation if possible.
- Controls should have a low probability of being actuated accidentally. Ensure body movements (amplitude and direction) are compatible with required arm movements.
- Controls should located according to:
    - expected operator response time
    - potential of emergency reaction (activate E-stop)
    - operator learning curve
    - handling constraints



Arrangement of controls can minimize postural constraints but, in some cases, can increase the risk of identification errors.
Controls must be protected if they could be accidentally activated.

Screen and keyboard

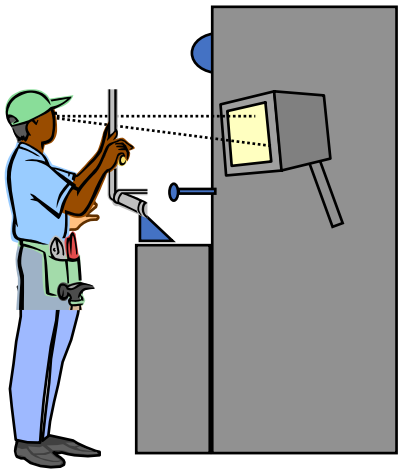
Workshop computer terminals should not be automated office terminals. The former is used to view data at each cycle or possibly to receive status information and/or enter nominal data during testing or maintenance operations.



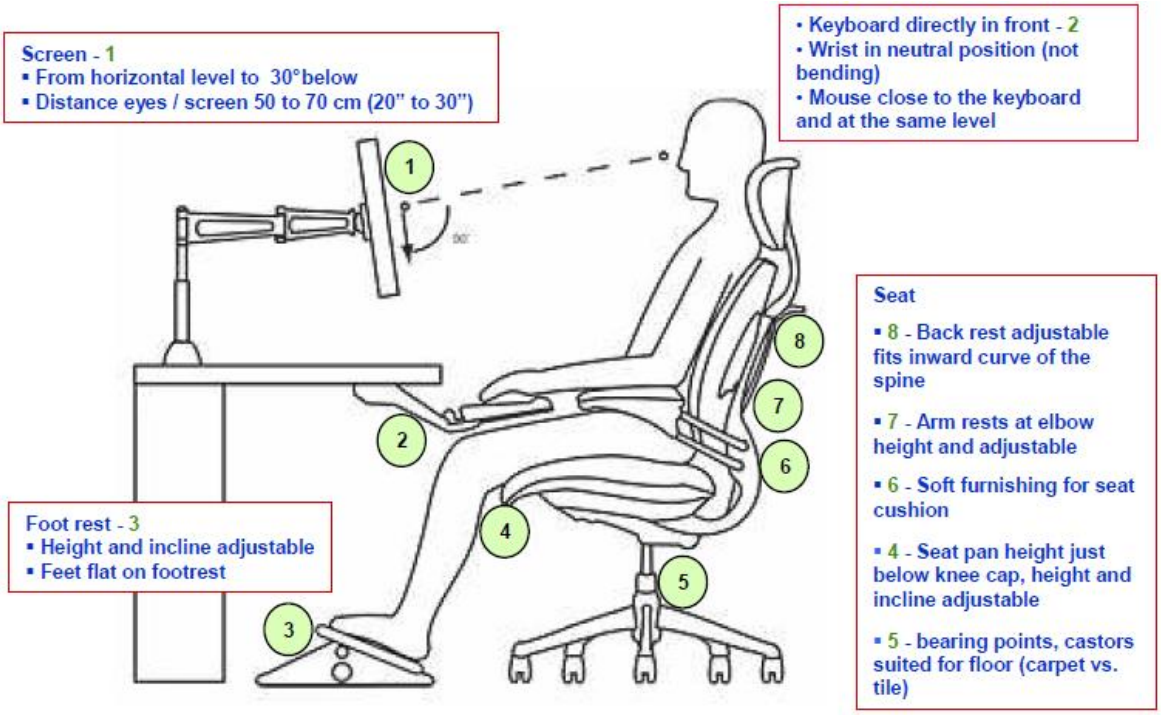
Position screens such that they are not subjected to direct light from lighting units or external openings (roof lights, windows, etc.)

Terminal remote from machine

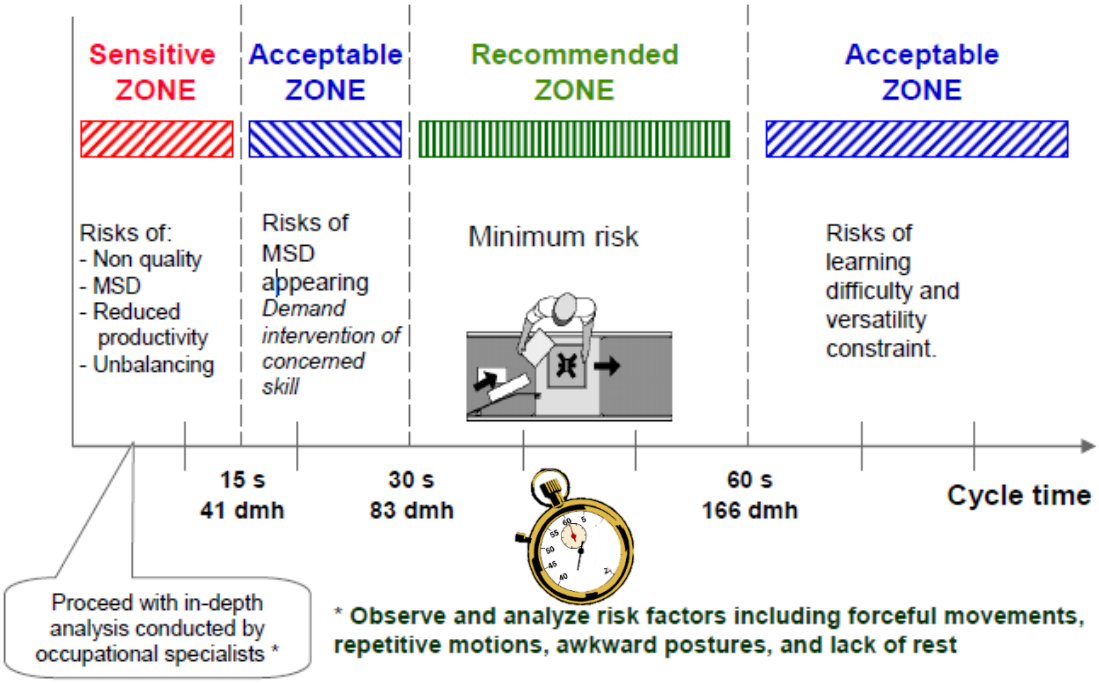
- Top and bottom tiltable screen.
- Eye-screen distance suited to character vertical dimension.
- If Plexiglas protection is required, it should be concave to prevent reflection.



Office Work

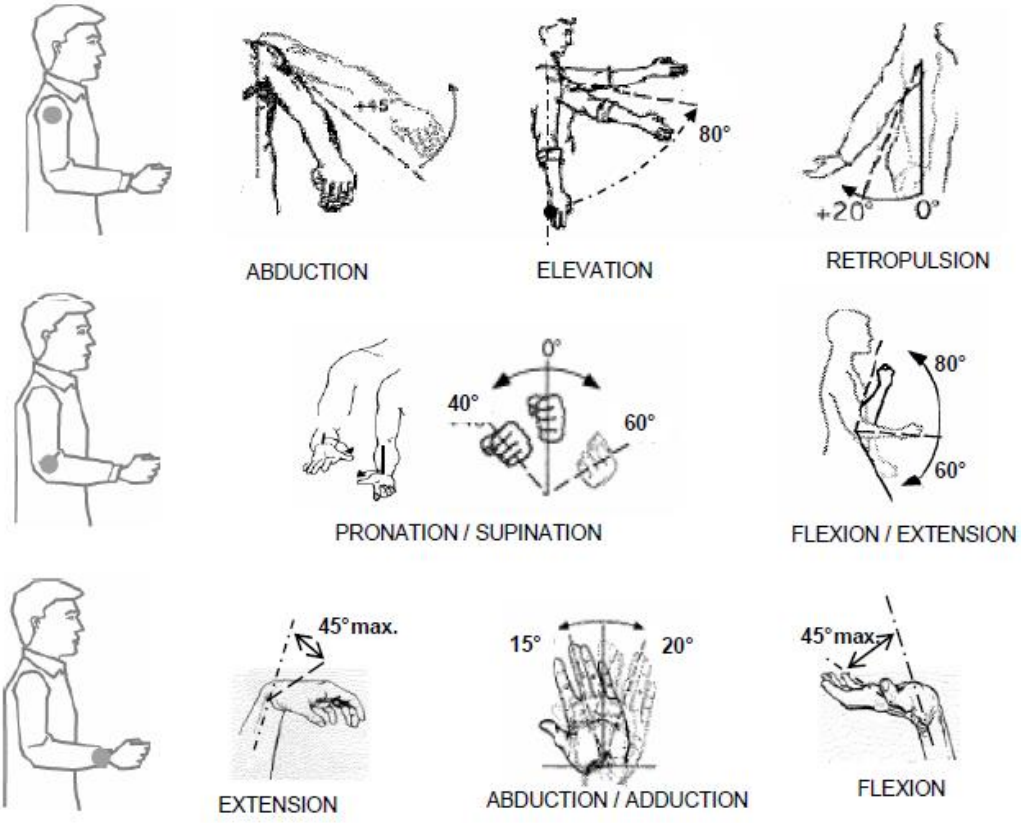

Screen - 1
▪ From horizontal level to 30°below
▪ Distance eyes / screen 50 to 70 cm (20" to 30")
• Keyboard directly in front - 2
• Wrist in neutral position (not bending)
• Mouse close to the keyboard and at the same level
Seat
▪ 8 - Back rest adjustable fits inward curve of the spine
▪ 7 - Arm rests at elbow height and adjustable
▪ 6 - Soft furnishing for seat cushion
▪ 4 - Seat pan height just below knee cap, height and incline adjustable
▪ 5 - bearing points, castors suited for floor (carpet vs. tile)
Foot rest - 3
▪ Height and incline adjustable
▪ Feet flat on footrest
1
2
3
4
5
6
7
8

Cycle time

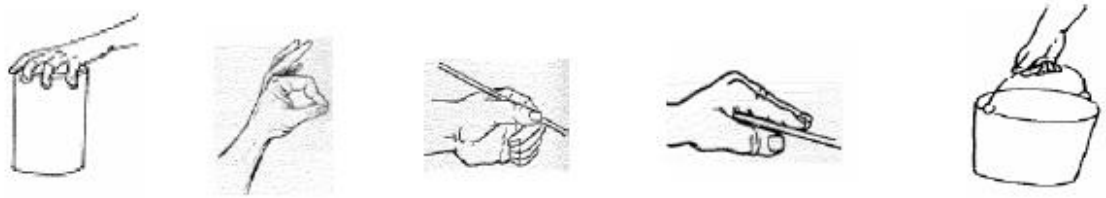

Sensitive ZONE
Acceptable ZONE
Recommended ZONE
Acceptable ZONE
Risks of:
- Non quality
- MSD
- Reduced productivity
- Unbalancing
Risks of MSD appearing
Demand intervention of concerned skill
Minimum risk
Risks of learning difficulty and versatility constraint.
15 s
41 dmh
30 s
83 dmh
60 s
166 dmh
Cycle time
Proceed with in-depth analysis conducted by occupational specialists *
* Observe and analyze risk factors including forceful movements, repetitive motions, awkward postures, and lack of rest

Body movement recommendations

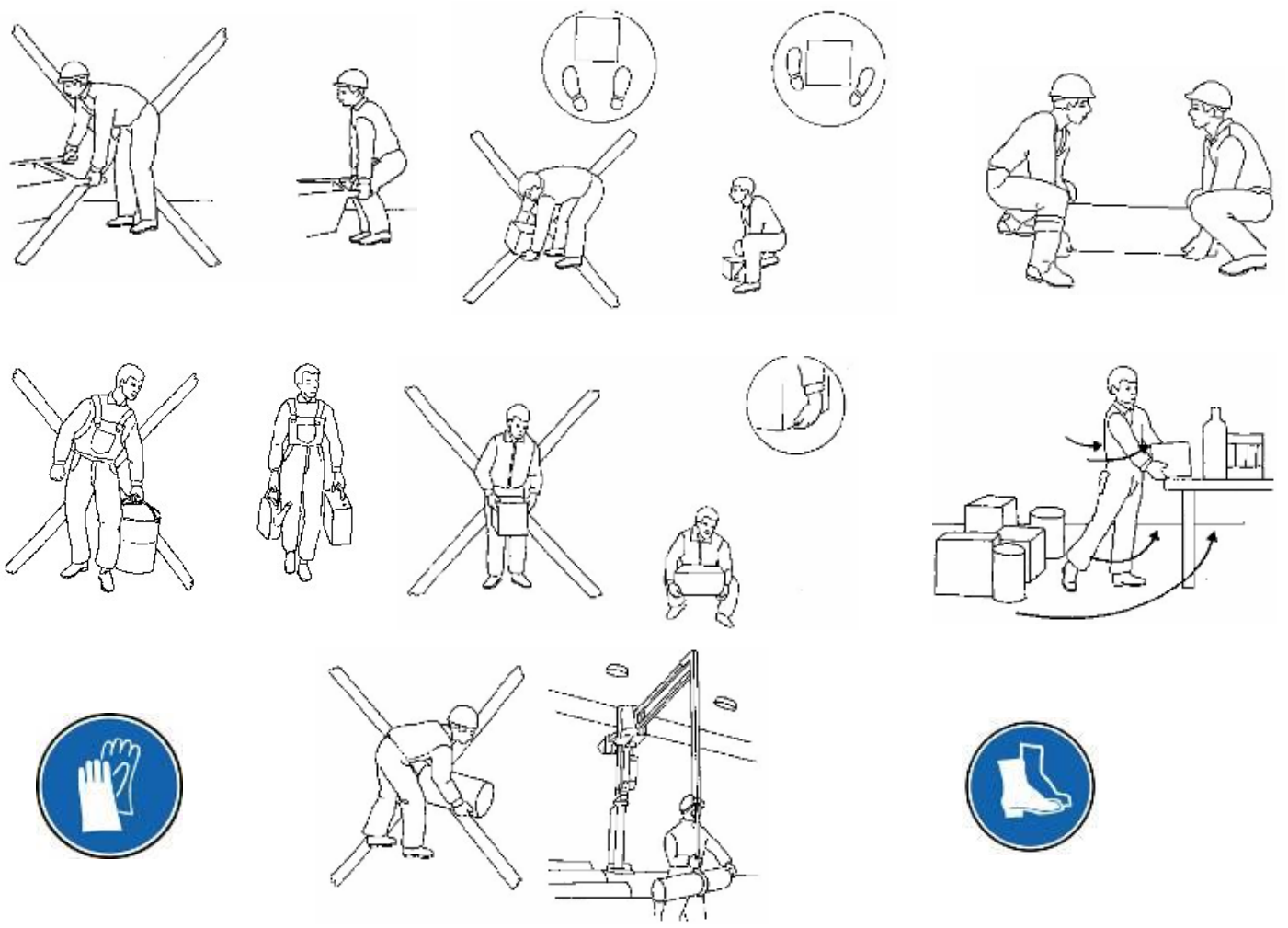
When defining operating procedures, try to limit extreme postures and repetitive movements. Consider exerted forces, movement combinations and their combined effect on the worker.



Avoid using the hand as a hammer (blows), pliers (forces), press (prolonged bearing).
Avoid the use of prolonged static forces and forces applied by wrist rotation or extreme angular positions.



Manutention gestures recommendations

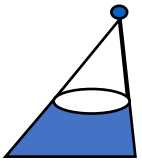


Illumination

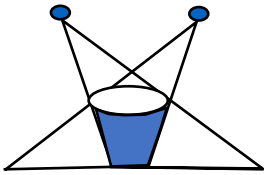
Comply with the following recommendations to ensure a good illumination level.

Illumination level: corridors and stairs	**E = 100 - 200 lux**	E1 = ceiling illumination E3 = sidewalk illumination E4 = effective plane illumination
Illumination level: packing area, warehouses	**E = 200 - 400 lux**	
Illumination level: assembly of medium-size parts	**E = 500 - 750 lux**	
Illumination level: assembly of small parts, inspection	**E = 750 - 1000 lux**	
Illumination level: assembly of very small parts	**E = 1000 - 2000 lux**	
Illumination level: routine office work	**E = 400 - 600 lux**	
General / local lighting ration	Eg > El / 3	
Luminance contrast in central part of visual field	0.3 < E1 / E4 < 0.9	
Luminance contrast between peripheral and central part of visual field	0.5 < E3 / E4 < 0.8	

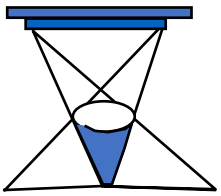
Lighting homogeneity



One light generates a large overhead shade

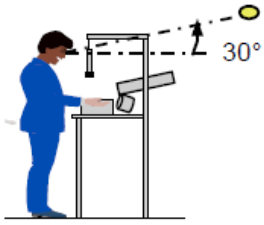


Two lights soften the shadow



A large lighting equipment minimize the shadow

Dazzle elimination

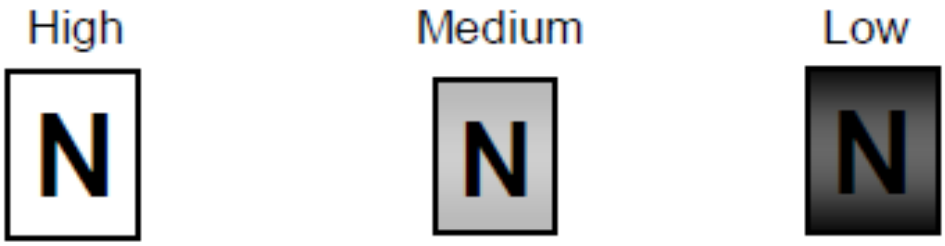


The operator can see the light if he raises the sight by more than 30°

Good placement of lights to suppress reflection and minimize shadow

Risk of direct light reflection

Contrasts between objects and immediate background



Too much light can generate uncomfortable glares and unbalanced illumination.

Noise

Recommended exposure values in workshops:
$L_{EX,8h}$ < 80 dB(A) and/or Lpc < 135 dB(C)

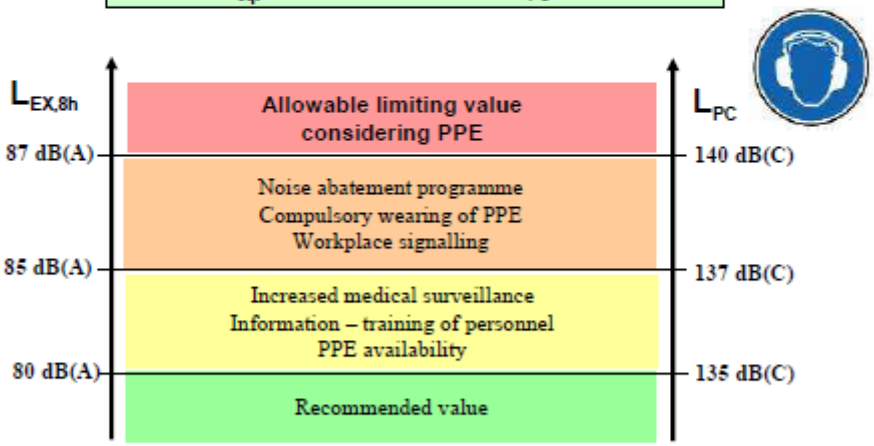
Thresholds not to be exceeded:
$L_{EX,8h}$: 85 dB(A) and/or Lpc : 137 dB(C).

Recommended noise level in offices:

Daily noise exposure
L_{EXd} < 55 dB(A)

Recommended noise level during acceptance inspection at machine-tool supplier:

Equivalent sound pressure	Peak acoustic pressure
L_{eqt} < 70 dB(A)	L_{PC} < 120 dB(C)



Ambient noise levels (dB A) allowing conversation depending on distance between speakers.

Dist. between Speakers	0.35 m / 1.2 ft	1 m / 3.3 ft	2 m / 6.5 ft	3 m / 9.8 ft
Very loud voice	80	70	65	60
Normal voice	70	60	55	50

Noise level should allow for verbal communication requirement and task complexity.

Thermal environment

Thermal environment should be adapted to human physiological characteristics.

Definition

Thermal comfort results from environmental characteristics and individual's physiological condition.

Recommendations

Ventilation

- *Generally, an air renewal rate of 2 volumes/hour minimum is sufficient for rooms with a known atmosphere.*

Air-conditioning

The following parameters should be especially taken into account:

- *air renewal (consider air movement)*
- *maintaining temperature by heating or cooling*
- *maintaining atmospheric composition by filtering solid pollutants*
- *humidity atmospheric composition to preserve moisture content*
- *air-conditioner maintenance*

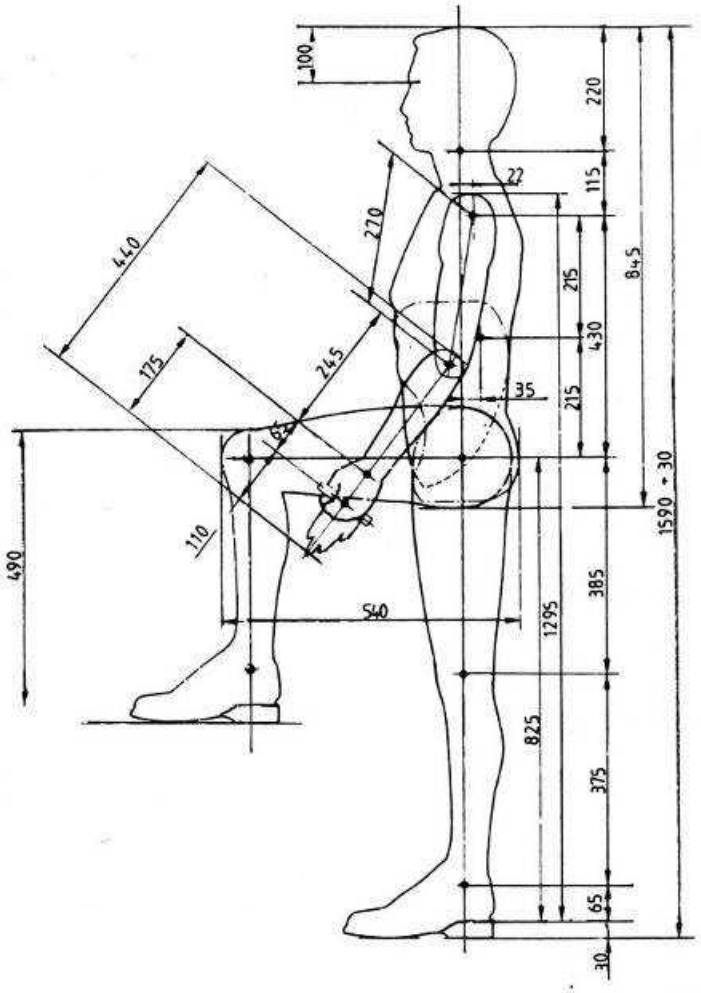
	Winter conditions	Summer conditions
Operating T°	**>19°C**	**<25°C**
Air relative humidity	**30-70%**	**30-70%**
Air velocity	**<0.15m/s**	**<0.25m/s**
Vertical gradient	**<3°C (feet-head)**	**<3°C (feet-head)**

Anthropometric Models OF MASCULINE AND FEMININE POPULATION

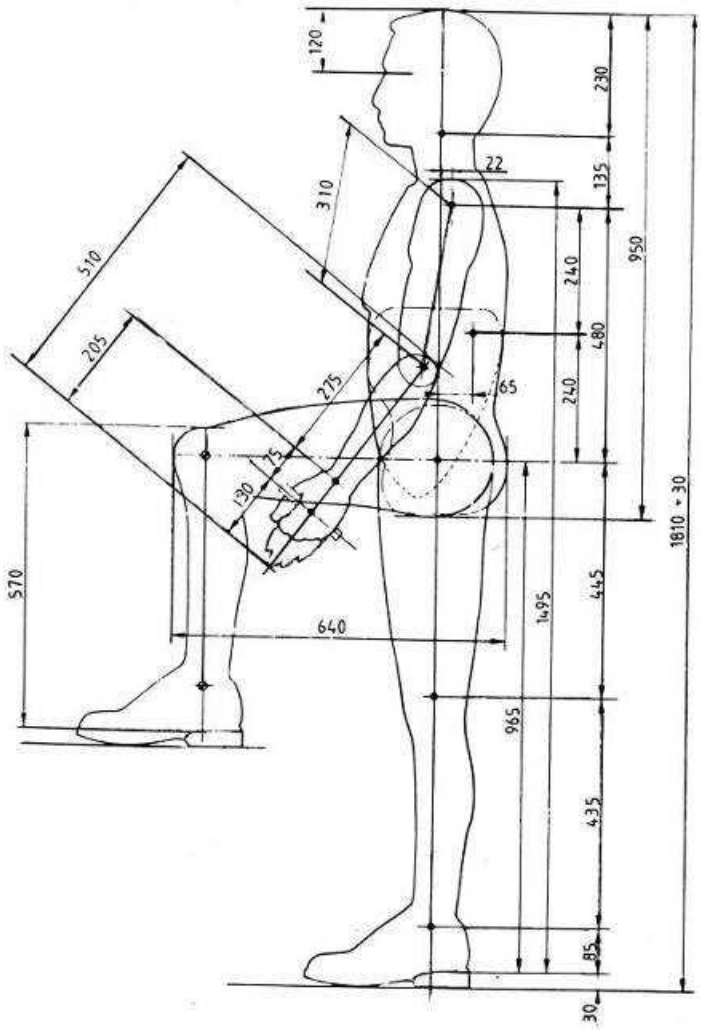
- These figures are intended to facilitate an elementary approach to problems of congestion, reach, posture and comfort, when designing equipment.
- These figures are simply a model based on the physical body size of most of the population.
- Suggested dimensions are derived from known measurements for the fit adult population.
- More specific and accurate measurements should be used for in-depth ergonomic design.
- Working zones should be adjusted for 90% of the population.
- The frequency of the distribution for the stature will depend on the population and it can vary from one country to another.

The anthropometric values considered for a particular country or region may not be suitable for other countries or regions depending on the local physical characteristics.

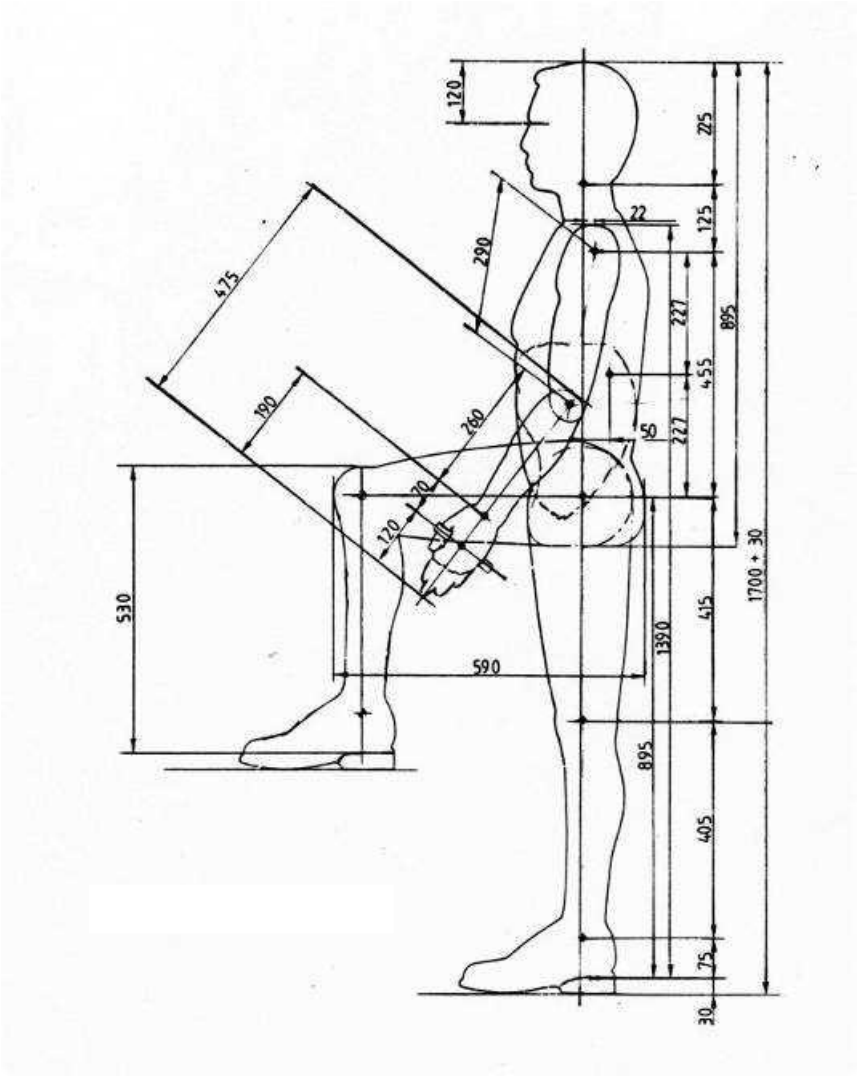
Short man – Average woman



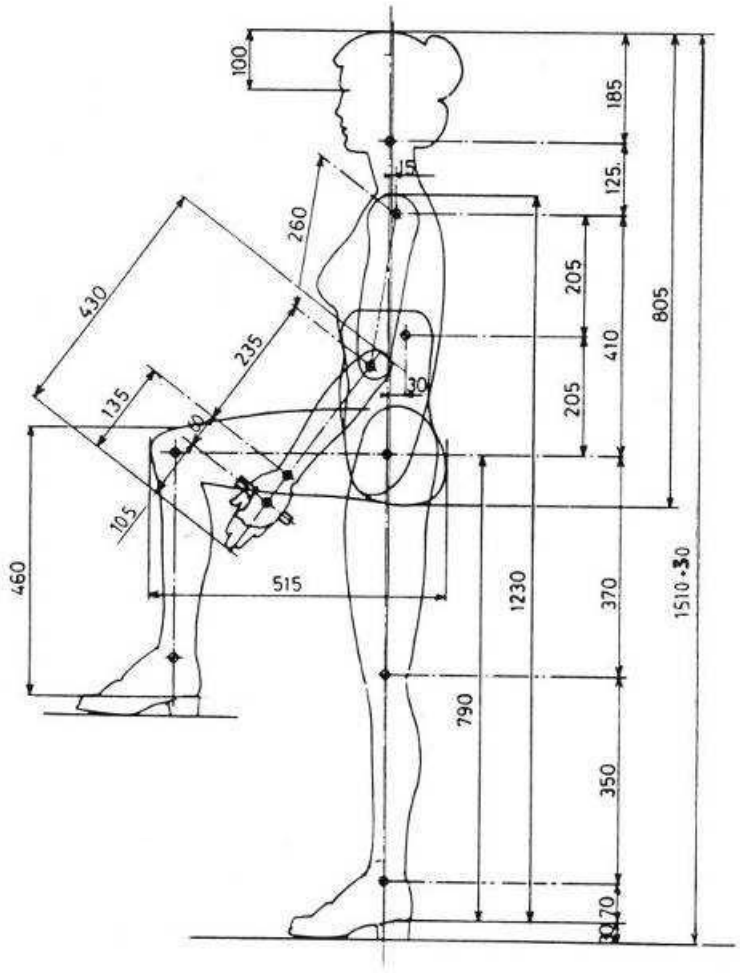
Tall man


120
230
22
135
310
510
205
275
240
480
65
240
950
75
130
1810 + 30
570
640
1495
445
965
435
85
30

Average man – Tall woman



Short woman


100
185
15
125
260
205
805
430
410
235
30
205
135
40
105
460
515
1230
370
1510 ± 30
790
350
70