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**335 211609**

# **INDUSTRIAL PLANTS 2**

## **Chapter four È part 1**

### **Study of work**

### **Ergonomy**

**DOUBLE DEGREE MASTER IN**  
**Í PRODUCTION ENGINEERING AND MANAGEMENTÎ**

**CAMPUS OF PORDENONE**  
**UNIVERSITY OF TRIESTE**

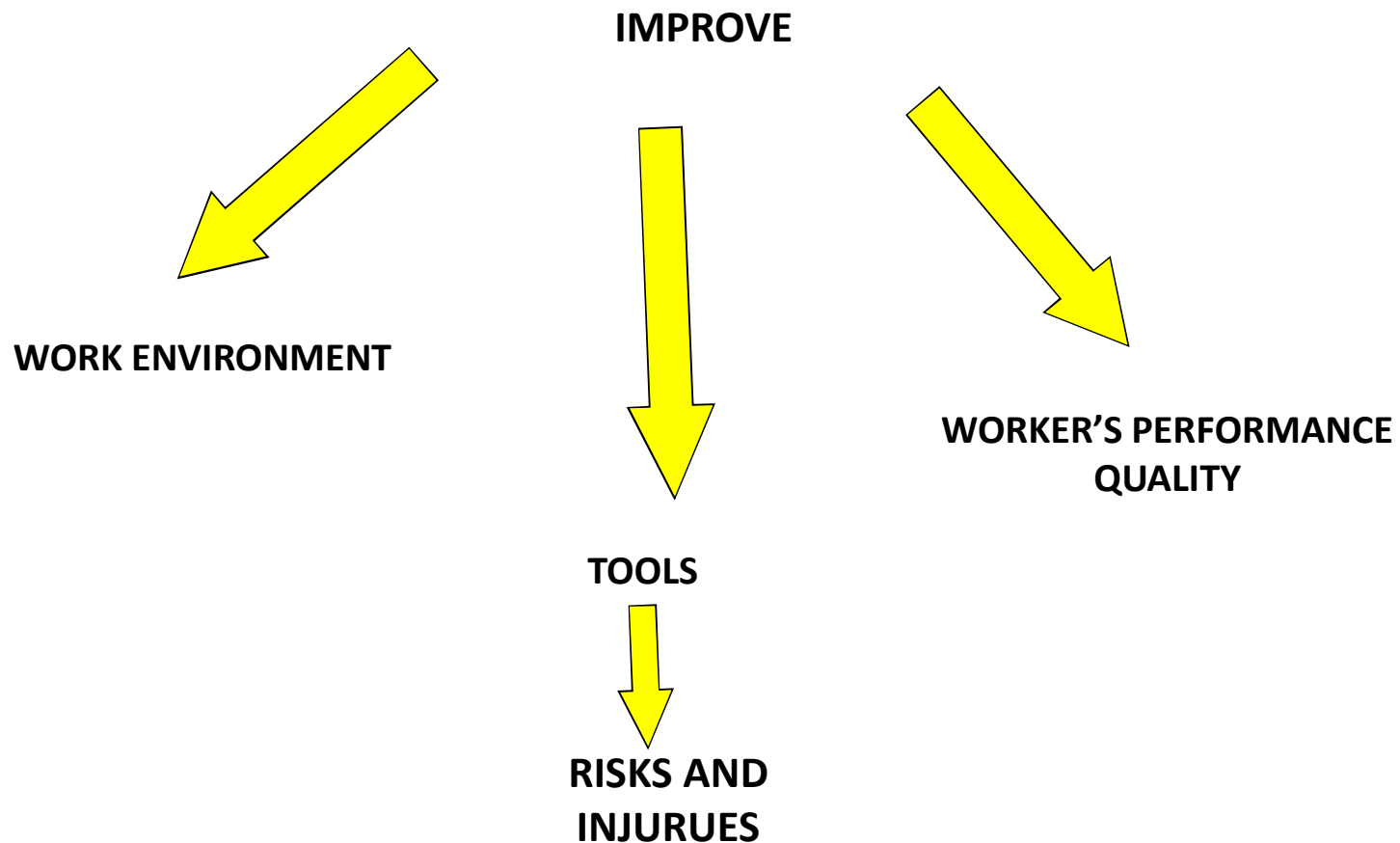
# **THE STUDY OF THE WORK**

## **ERGONOMICS**

**Analysis and prevention of risks due to  
repeated movements**

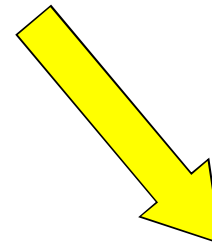
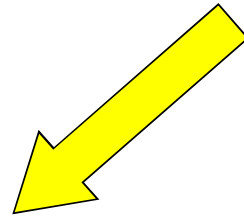
# ERGONOMICS

Ergonomics is a branch of science that study the human abilities and limitations, and then apply this learning to improve people's interaction with products, systems and environments, minimising risk of injury or harm.



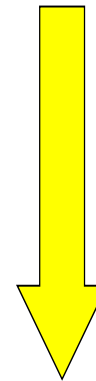
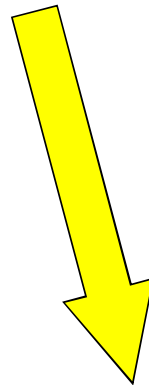
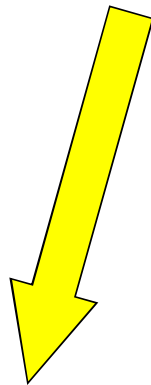
# ERGONOMICS

SCOPE



PREVENT

PROMOTE



INJURIES

PROFESSIONAL  
DISEASES

PSYCHO-PHYSICAL WELLBEING

# ERGONOMICS

## FUNDAMENTAL PRINCIPLES

### GLOBAL INTERVENTION

1. WORK PLACE
2. WORK ENVIRONMENT
3. WORK PROCESSES

### WORKERSEINVOLVEMENT

1. INTERVENTION IDENTIFICATION
2. APPLICATION SUSTAINABILITY

### INTERDISCIPLINARY APPROACH

1. ENGINEERING
2. MEDICINE
3. PSYCHOLOGY/SOCIOLOGY

# THE STUDY OF THE WORK

## PRINCIPLES OF MOVEMENTS SAVINGS

(in relation with the human body)

1. the two hands must start and finish their movements at the same time
2. the two hands must not be idle at the same time (except during the rest phases)
3. the movements of the arms must be symmetrical, in opposite directions and done simultaneously
4. momentum must be used when possible, but it must be reduced to a minimum when it is then necessary to stop it by means of muscular effort
5. sudden movements or movements requiring sudden and rapid changes of direction must be avoided
6. free rotation movements are preferable to constrained ones because they are faster, easier and more precise
7. the pace of work must be such that the operator can follow it naturally
8. whenever an operation can be performed with parts of the body other than the hands, it is good to take advantage of this opportunity (eg. the pedals)

# THE STUDY OF THE WORK

## PRINCIPLES OF MOVEMENTS SAVINGS

(in relation with the work place)

1. every tool and material must have a precise and studied location
2. Tools, materials and jigs must be placed close to the worker and possibly in front, in any case within the work area
3. Tools and materials must be arranged in such a way as to allow the best sequence of movements
4. The feeding of materials should be facilitated as much as possible
5. The force of gravity must be used whenever possible, especially for materials movements
6. The workplace lighting must be adequate
7. The height of the work top and the seat must be such as to allow working both seated and standing
8. The colors of the workplace must make the piece clearly visible without stressing the sight

# THE STUDY OF THE WORK

## PRINCIPLES OF MOVEMENTS SAVINGS (in relation with the tools and jigs)

1. Do not use the hands to position or hold the pieces during processing, when this can be done with simple tools
2. the number of tools must be limited to a minimum
3. when the fingers perform some specific movement, the load must be distributed according to the relative mobility of the various fingers
4. the handles of the tools must be such as to allow the greatest possible surface of the hand to come into contact with them, especially when a certain level of effort must be exerted
5. any levers, crossbars or flyers must be placed in such a way that the operator can use them with the least possible change in body position and maximum performance



## LIMBS UTILIZATION

“ Scribes  
“ Telegraphers  
“ Pianists  
“ Shoemakers  
“ Tailors  
“ Nurses  
“ .....  
“ **Workers**



- **WMSD** Work Musculo-Skeletal Disorder
- **WRULD** Work Rel. Upper Limbs Disorder
- **CTD** Cumulative Trauma Disorder
- **RSI** Ripetitive Strain Injuries
- **RMI** Ripetitive Motion Injuries
- **OCD** Occupational Cervico-brachial Disorder
- **OOS** Occupational Overuse Disorder

# UL WMSDs

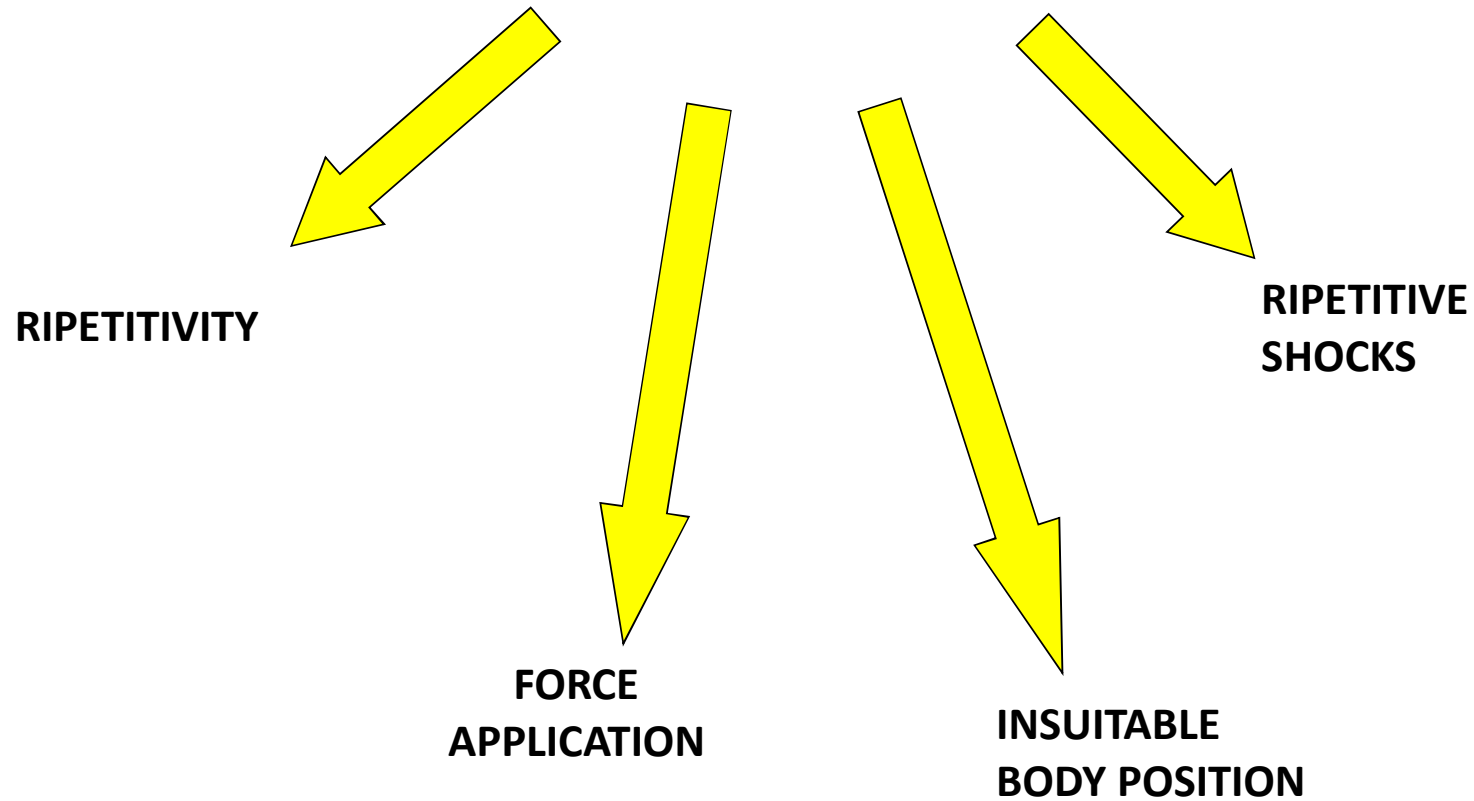
## Upper Limbs Work Muscolo-Skeletal Disorders

### POTENTIAL NEW PROFESSIONAL DESEASES

- **HAND**
- **WRIST**
- **ELBOW**
- **SHOULDER**

COUNTRY	1ST CAUSE	2ND CAUSE	3RD CAUSE
Austria	HYPOACUSIA	SKIN DESEASE	ASTHMA
Belgium	WMSD	SKIN DESEASE	SILICOSIS
Denmark	SKIN DESEASE	WMSD	HYPOACUSIA
Finland	WMSD	SKIN DESEASE	RESPIRATORY
France	WMSD	SILICOSIS	HYPOACUSIA
Germany	HYPOACUSIA	SILICOSIS	SILICOSIS
Greece	SKIN DESEASE	ASTHMA	SILICOSIS
Italy	HYPOACUSIA	SKIN DESEASE	SILICOSIS
Spain	WMSD	SKIN DESEASE	HYPOACUSIA
Sweden	WMSD	RESPIRATORY	SKIN DESEASE

## UL WMSDs CAUSES



# UL WMSDs INDEX FOR ASSESSMENT

**RULA (Rapid Upper-Limb Assessment):** It is an agile and quick tool to get an estimation of biomechanical and postural overload that, with only a page, identifies the critical areas to be submitted to a more careful exam.

**OSHA (Occupational and Safety Administration):** This check list presents the same positive point of RULA because easy and quick to be applied

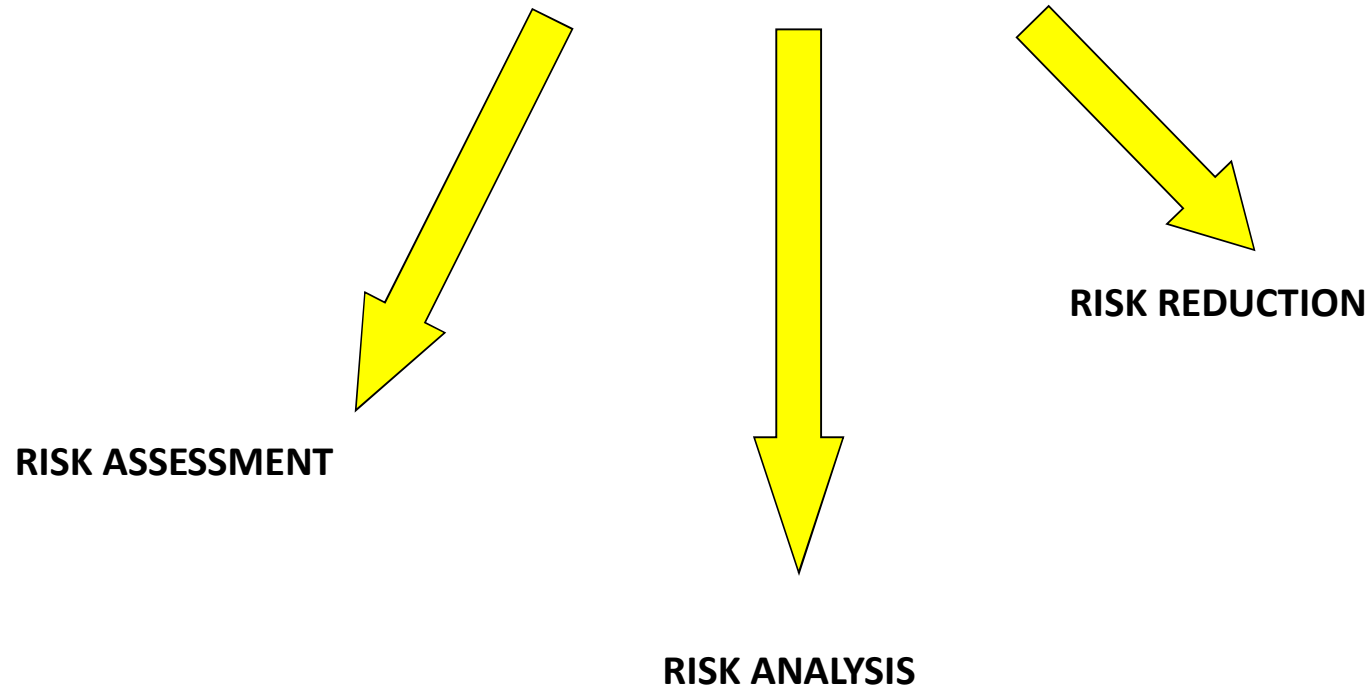
**CTD (Cumulative Trauma Disorder):** it was introduced to get assessment on Incidence Rate of pathology due to biomechanical overload of upper limbs.

**STRAIN INDEX:** it is a semi-quantitative method used to analyse a single task from the pathology of hands, wrists, elbows and carpal tunnel.

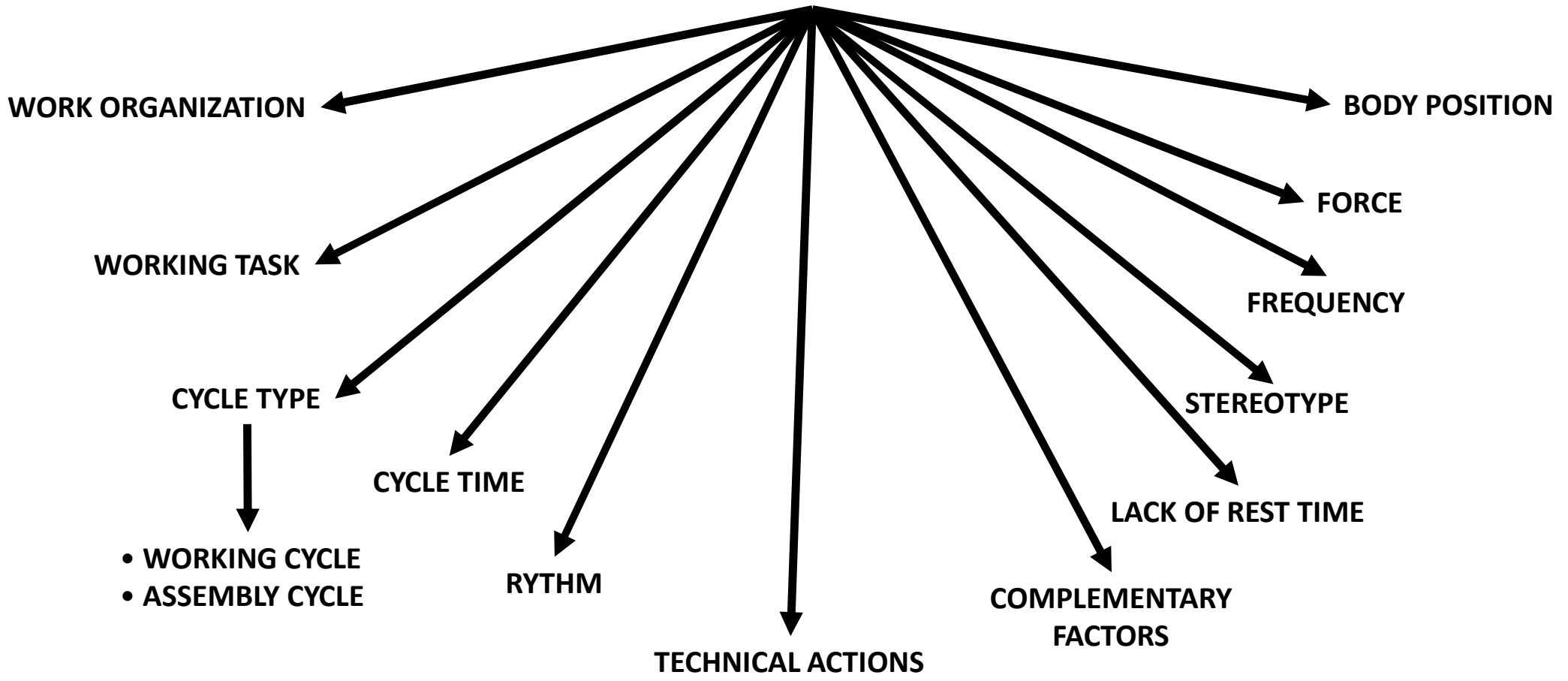
**ACGIH (American Conference of Governmental Industrial Hygienists)** have identified some Threshold Limit Values (TLV), based on epidemiologic, psychophysics and biomechanical studies for the task repeated for 4 hours relating to hands, wrist and forearm.

**OCRA (Occupational Repetitive Actions)** interdisciplinary method that provides quantitative data on exposure level as a consequence of the analysis of the task and the work place.

# **OCCUPATIONAL RIPETITIVE ACTIONS** **OCRA**



# OCCUPATIONAL RIPETITIVE ACTIONS OCRA



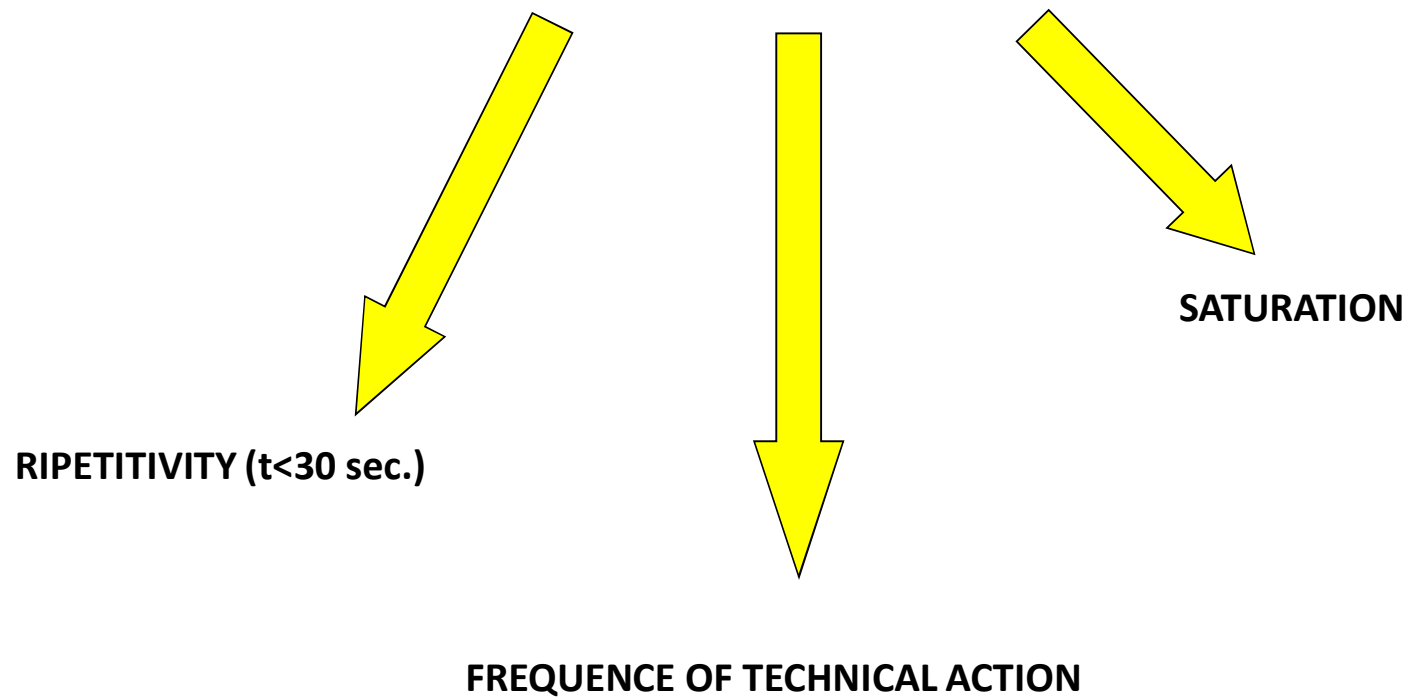
# **OCCUPATIONAL RIPETITIVE ACTIONS**

## **OCRA**

### **TECHNICAL ACTIONS:**

- REACH
- MOVE
- GRAB / TAKE
- GRAB WITH HAND / GRAB WITH ANOTHER HAND
- PLACE / POSITION
- INSERT / PULL OUT
- PUSH / PULL
- RELEASE
- ACTIVATE
- SPECIFIC ACTIONS DURING PROCESSING
- WALK
- CHECK VISUAL
- TRANSPORT (3 KG> 1 METER)

# OCCUPATIONAL RIPETITIVE ACTIONS OCRA





# **OCCUPATIONAL RIPETITIVE ACTIONS** **OCRA**

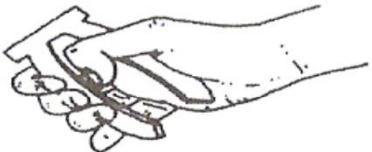
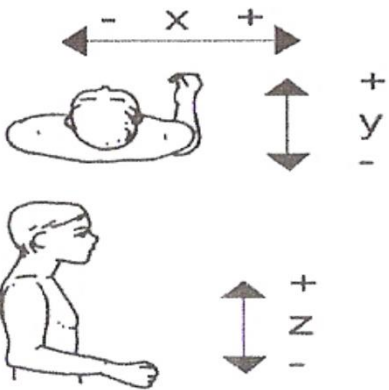
## **MTM-OCRA comparison**

**Es. Pag.: 83, 84, 85**

# OCCUPATIONAL RIPETITIVE ACTIONS

## OCRA

### FORCES ANALYSIS

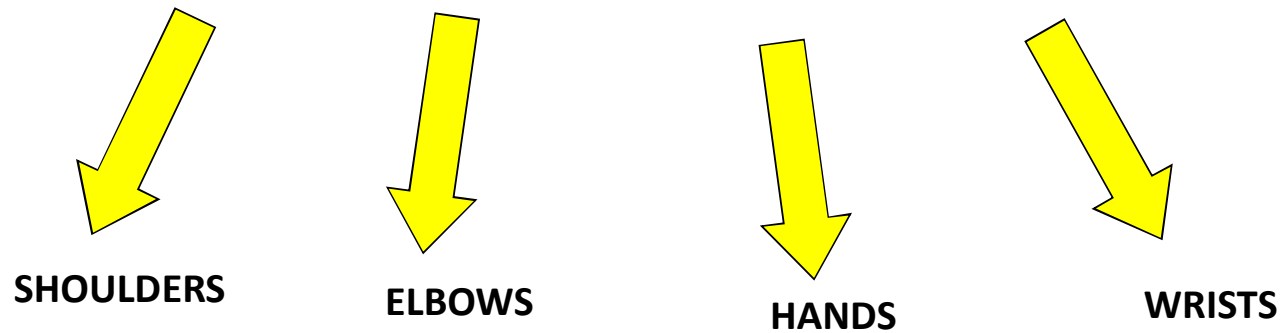
Type	Action	Professional Use (Force Newton)
	<b>Work of the hand (grip)</b>	250
<div style="text-align: center;">  </div>	<b>Work of the arm/seated position, one arm:</b> Above (z +) 50 Down (z -) 75 Out (x +) 55 In (x -) 75 <b>Push (y +)</b> With backrest 275 Without backrest 62 <b>Pull (y -)</b> With support 225 Without support 55	

# **OCCUPATIONAL REPETITIVE ACTIONS**

## **OCRA**

**ANALYSIS AND ASSESSMENT OF BODY POSITION**

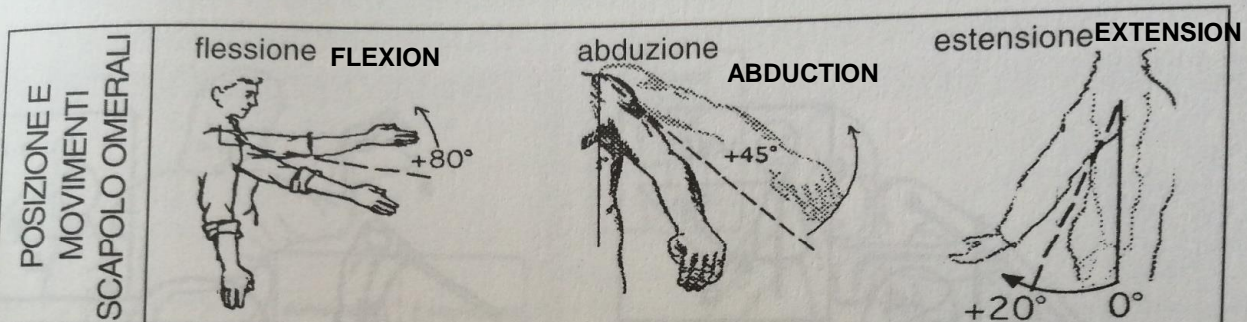
- **MOVIMENTS/EXTREME BODY POSITIONS**
- **MOVIMENTS/LONG KEPT BODY POSITIONS**
- **HIGHLY REPETITIVE MOVIMENTS**



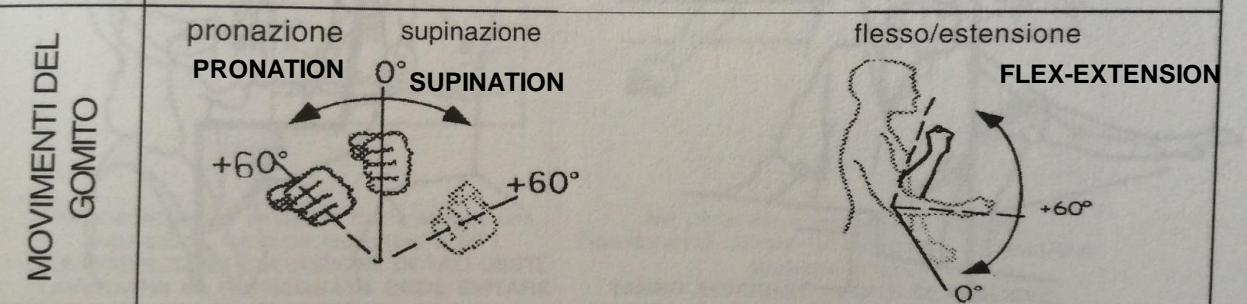
# OCCUPATIONAL RIPETITIVE ACTIONS OCRA

Fig. 19.1 - Movimenti e posizioni del braccio, del gomito e del polso: valori critici (> 50%) del range articolare

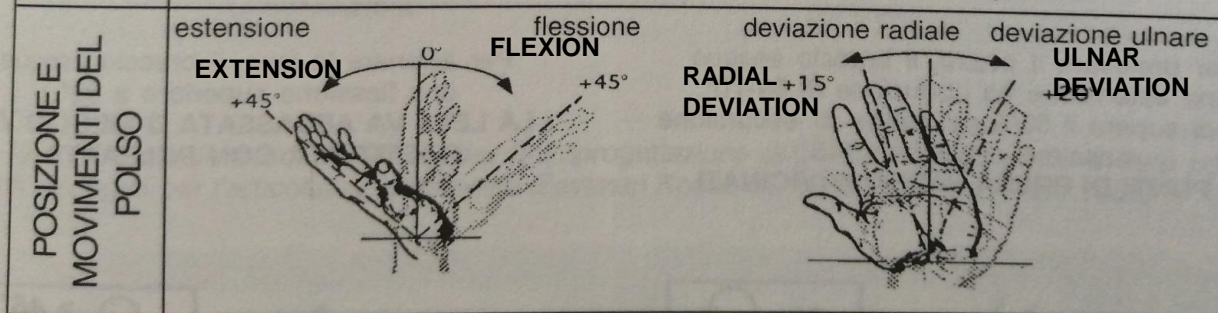
POSITION AND  
MOVEMENTS OF  
SHOULDER AND ARM



ELBOW MOVEMENTS



WRIST POSITION AND  
MOVEMENTS



# OCCUPATIONAL RIPETITIVE ACTIONS

## OCRA

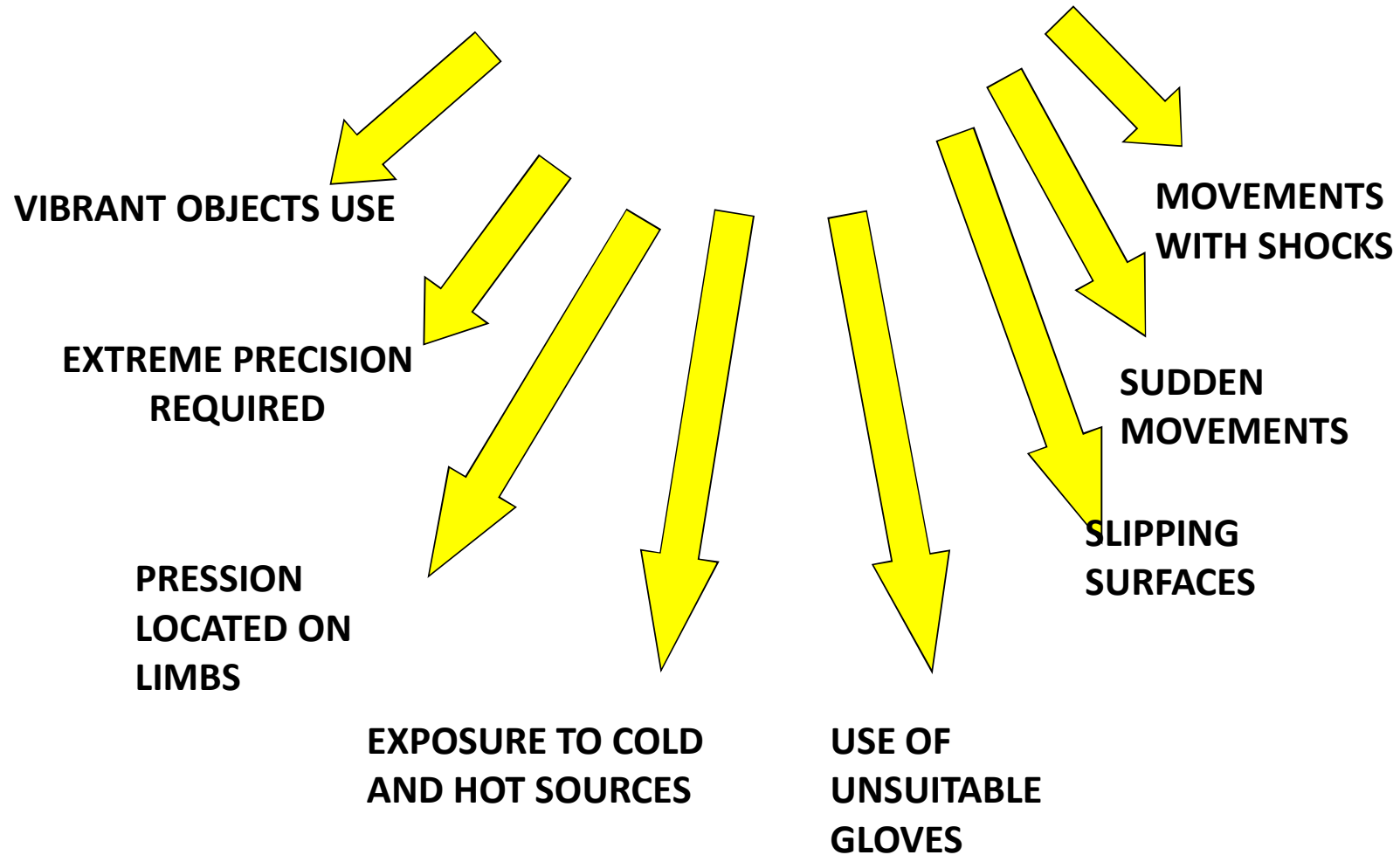
### LIMB JOINTS ANALYSIS

JOINT	MOVEMENT	AMPLITUDE	SCORE
SHOULDER JOINT	ABDUCTION	45° - 80°	4
	FLEXION	80°	4
	EXTENSION	20°	4
ELBOW JOINT	SUPINATION	60°	4
	PRONATION	60°	2
	FLEX-EXTENSION	60°	2
WRIST JOINT	FLEXION	45°	3
	RADIAL DEVIATION	15°	2
	ULNAR DEVIATION	20°	2
	EXTENSION	45°	4

# OCCUPATIONAL RIPETITIVE ACTIONS OCRA LIMB JOINTS ANALYSIS

TYPE OF GRIP	SCORE
( WIDE GRIP ) (4-5-CM)	1
( NARROW GRIP ) (1,5 CM)	2
F FINGERS PRECISE MOVEMENTS	3
PINCH	3
PALM GRIP	4
HOOK GRIP	4

## COMPLEMENTARY RISK FACTORS



# **OCCUPATIONAL RIPETITIVE ACTIONS OCRA INDEX**

$$\text{OCRA} = \frac{\text{ATA}}{\text{RTA}}$$

**ATA = Actual technical Actions**

**RTA = Raccomended technical Actions**



# OCCUPATIONAL RIPETITIVE ACTIONS OCRA INDEX

**ATA = Actual technical Actions =  $(F_i \times D_i)$**

**$F_i$  = Average Frequency of the technical actions per minute related to the task  $T_i$**

**$D_i$  = Average Duration (min) of the task  $T_i$**

**RTA = Raccomended technical Actions =**

**=  $[CF_i \times (Fo_{Mi} \times Po_{Mi} \times Re_{Mi} \times Ad_{Mi}) \times D_i] \times (Rc_M \times Du_M)$**

**$CF_i$  = K (30) of frequency of the tech. action/min. raccomandated**

**$Fo_{Mi} \times Po_{Mi} \times Re_{Mi} \times Ad_{Mi}$  = coeff. Multipl. For risk, force, body position and repetitivity**

**$D_i$  = duration (min) of each task**

**$Rc_M$  = factor for lack of rest time**

**$Du_M$  = factor keeping into account the overall net duration of repetitive tasks**

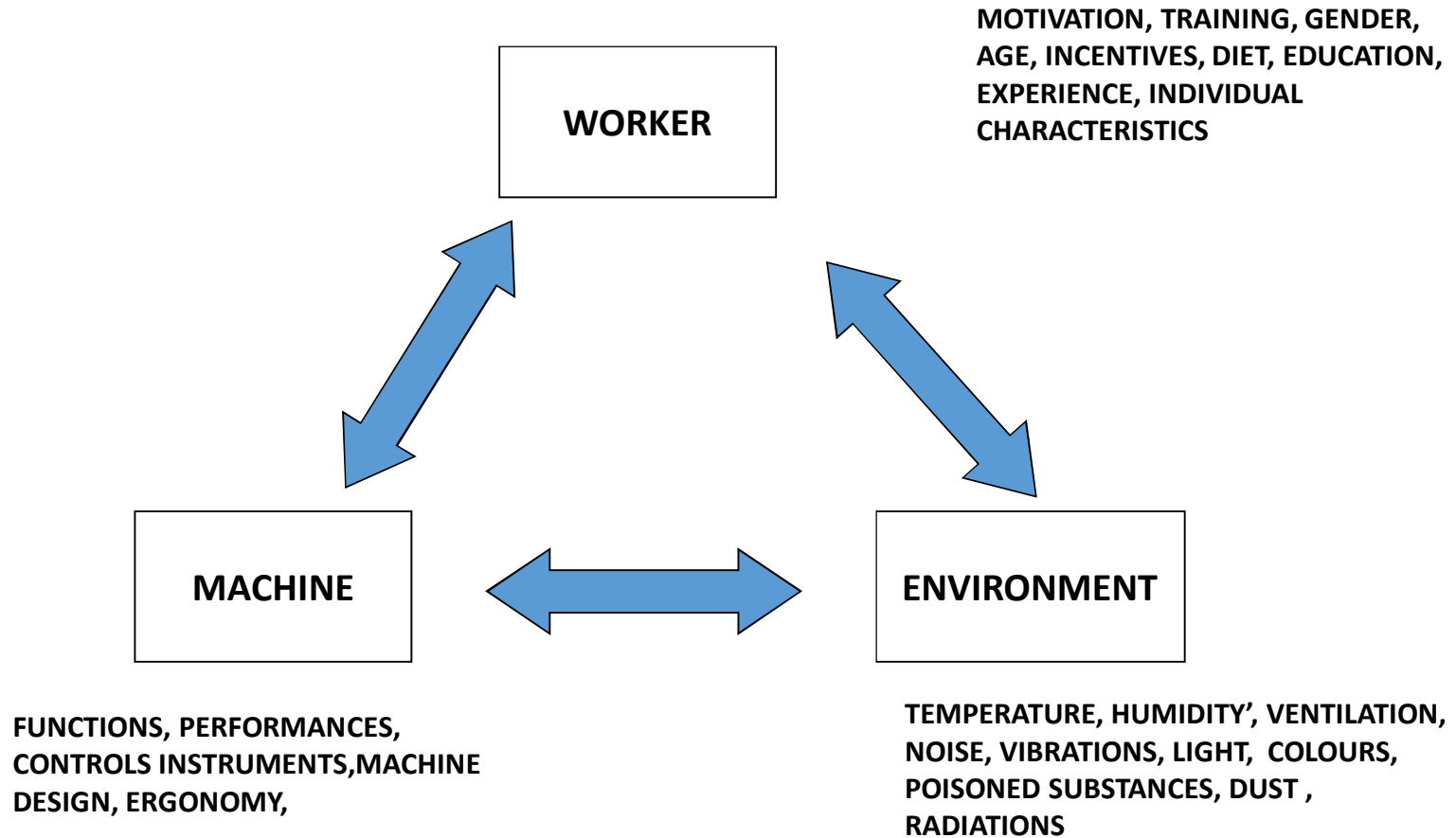
**$I$  = generic repetitive task**



## OCCUPATIONAL RIPETITIVE ACTIONS ANALISI DEL RISCHIO

Area	OCRA Values	Risk	Action
<b>GREEN</b>	$< 2,3$	<b>Acceptable</b>	<b>None</b>
<b>YELLOW</b>	$2,3 < x < 3,5$	<b>light</b>	<b>verify</b>
<b>RED</b>	$> 3,6$	<b>present</b>	<b>risk reduction</b>

# WORKER-MACHINE-ENVIRONMENT SYSTEM



## OPERATIONAL AREA OF A STANDING WORKER

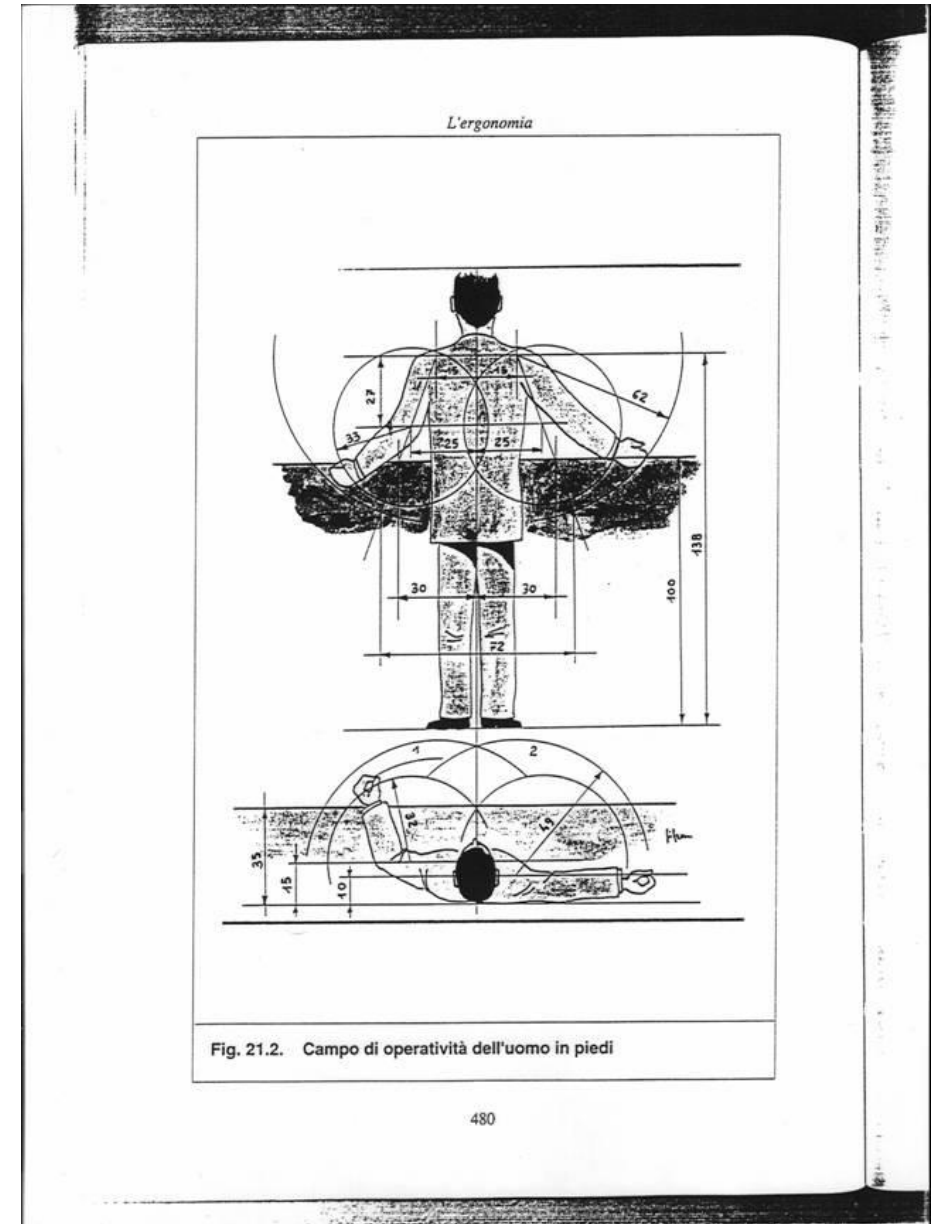
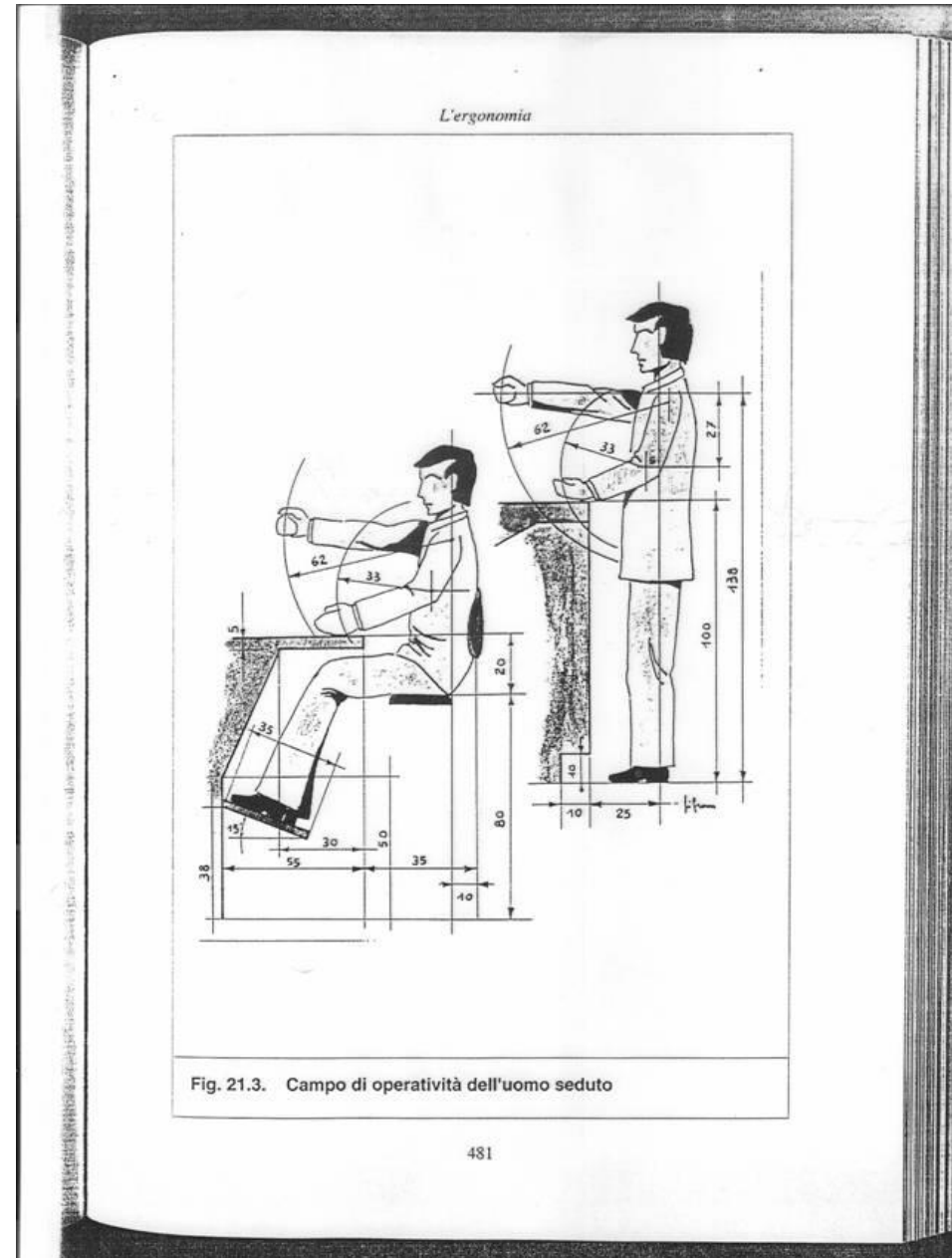
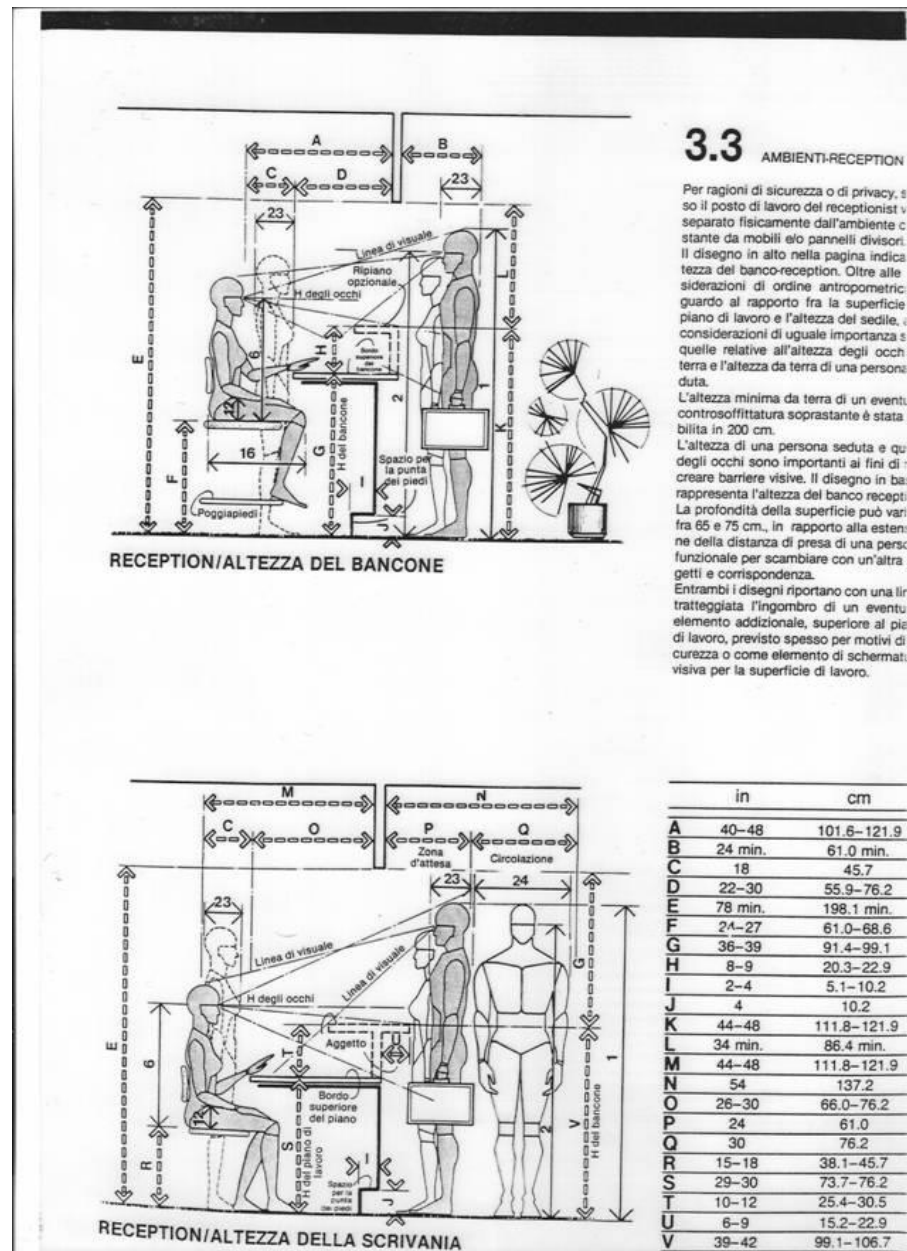


Fig. 21.2. Campo di operatività dell'uomo in piedi

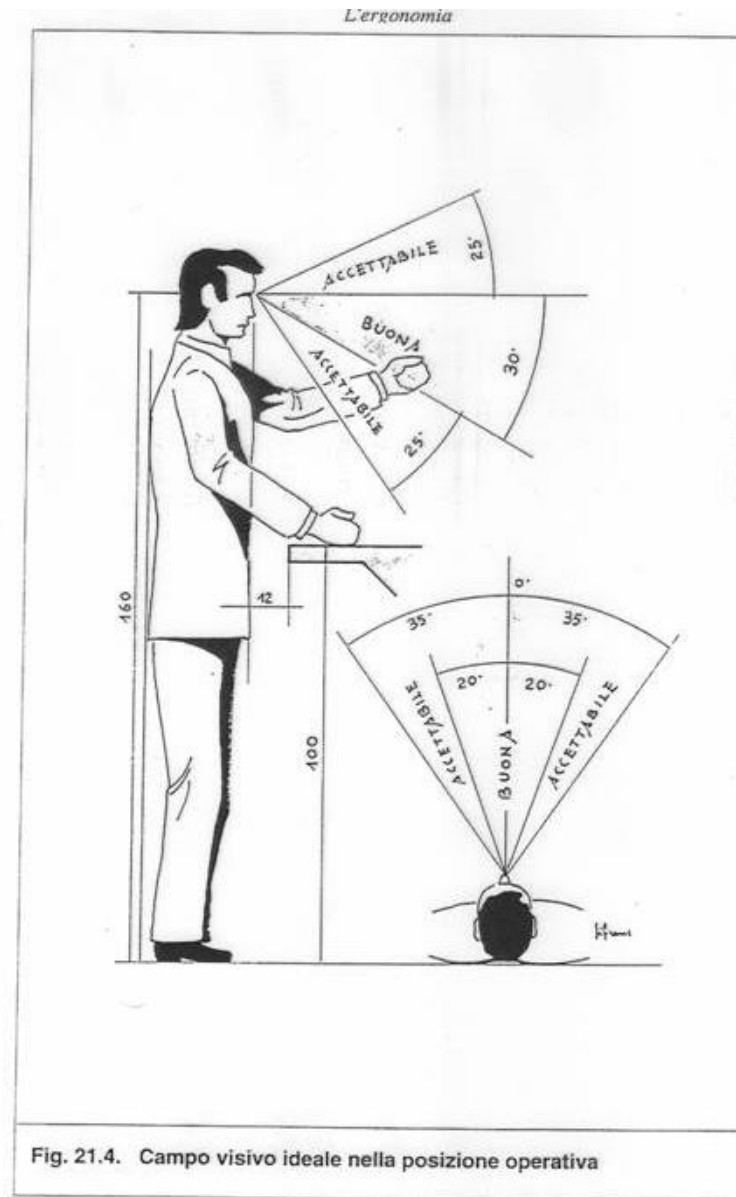
## OPERATIONAL AREA OF A SEATED WORKER



## RECEPTION COUNTER HEIGHT DESK HEIGHT



## IDEAL VISUAL FIELD

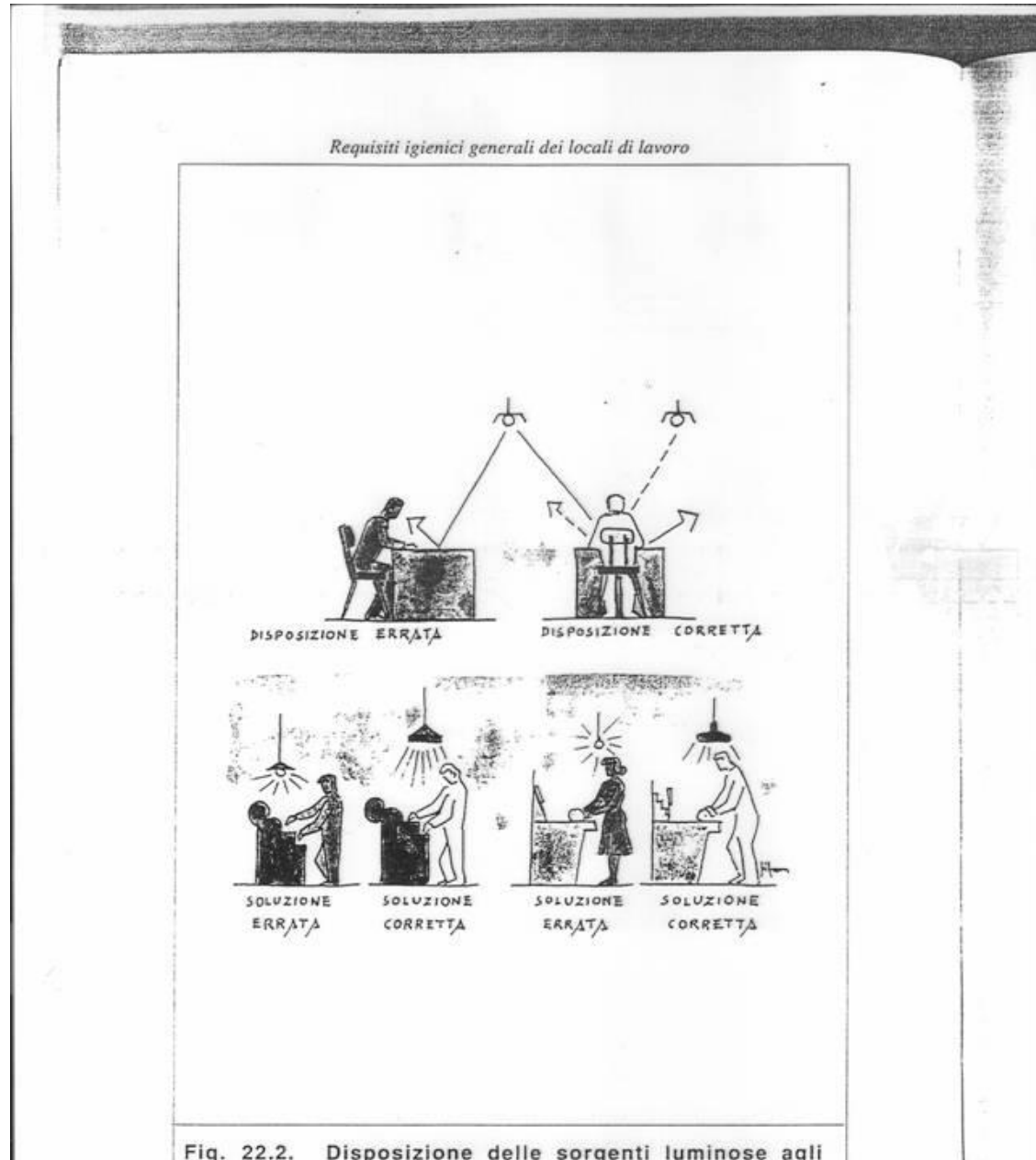


## LIGHTING LEVELS (DIN NORM 5035)

	LUX
UNMANNED WAREHOUSES	15
OCCASIONAL PASSAGES	30
LIGHT VISUAL COMMITMENT (LARGE SIZE DETAILS WITH STRONG CONTRAST)	120
NORMAL VISUAL COMMITMENT (MEDIUM SIZE DETAILS WITH MEDIUM CONTRAST)	500
DIFFICULT VISUAL COMMITMENT (SMALL DETAILS WITH WEAK CONTRAST)	1000
VERY DIFFICULT VISUAL COMMITMENT (VERY SMALL DETAILS WITH MIN. CONTRAST)	2000
SPECIAL CASES (SURGERY ROOM)	5000



## LIGHTING SOURCES SET-UP



## KRUIHOFF DIAGRAM

Requisiti igienici generali dei locali di lavoro

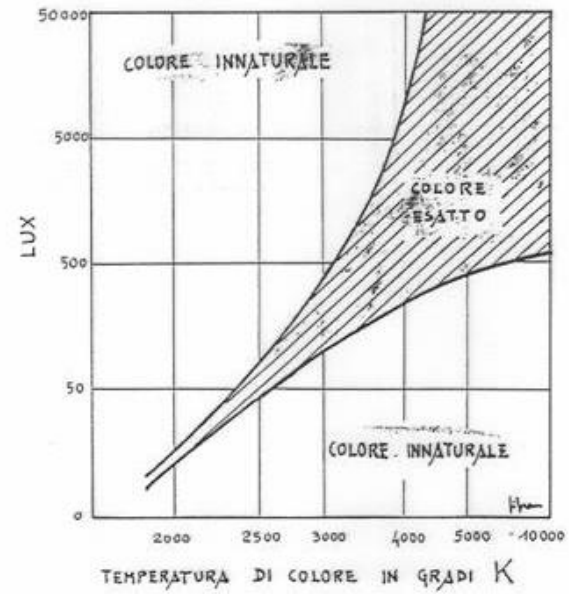
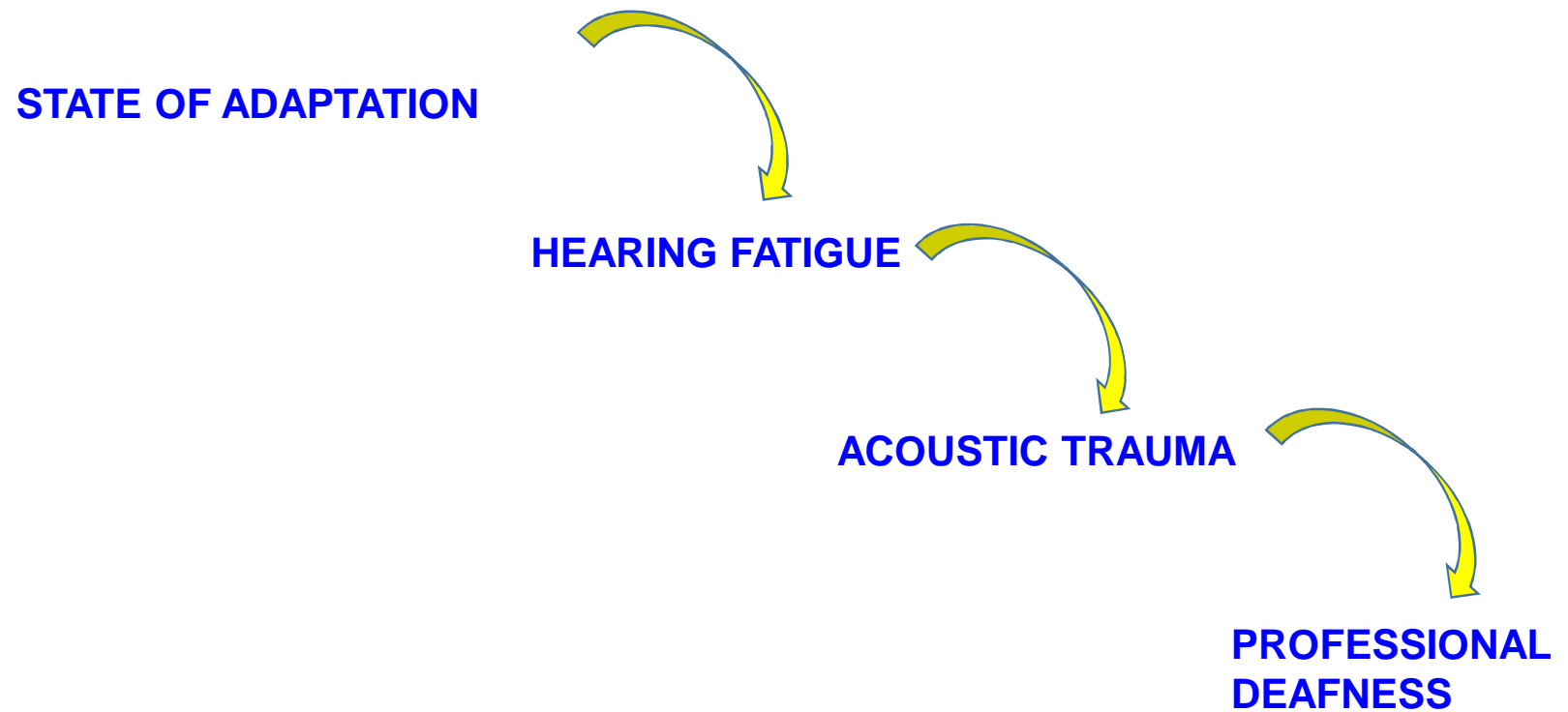


Fig. 22.3. Diagramma di KRUIHOFF

# NOISE

## CONSEQUENCES ON HEARING:

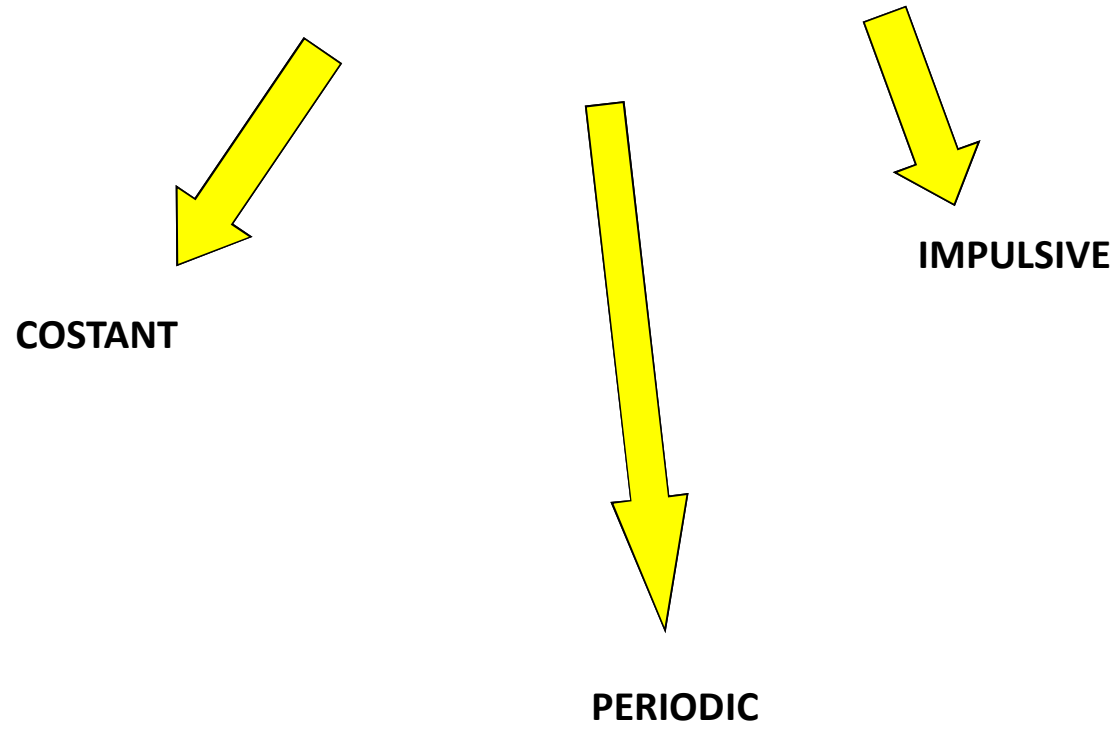


# NOISE

## CONSEQUENCES ON OTHER PARTS OF THE BODY AND FUNCTIONS:

- ” ON THE SENSE OF EQUILIBRIUM
- ” ON THE ATTENTION, CONCENTRATION
- ” ON THE SIGHT
- ” ON THE NERVOUS SYSTEM
- ” ON THE DIGESTIVE APPARATUS
- ” ON THE ENDOCRINE SYSTEM
- ” ON THE RESPIRATORY SYSTEM
- ” ON THE VASCULAR SYSTEM
- ” ON CHARACTER,
- ” ON BEHAVIOR
- ” ON THE IMMUNE SYSTEM

# NOISE



## NOISE CHARACTERISTICS



### FREQUENCY

Number of oscillations, generated by a sound source, which occur in one second.

16 Hz - 20,000 Hz



### AMPLITUDE

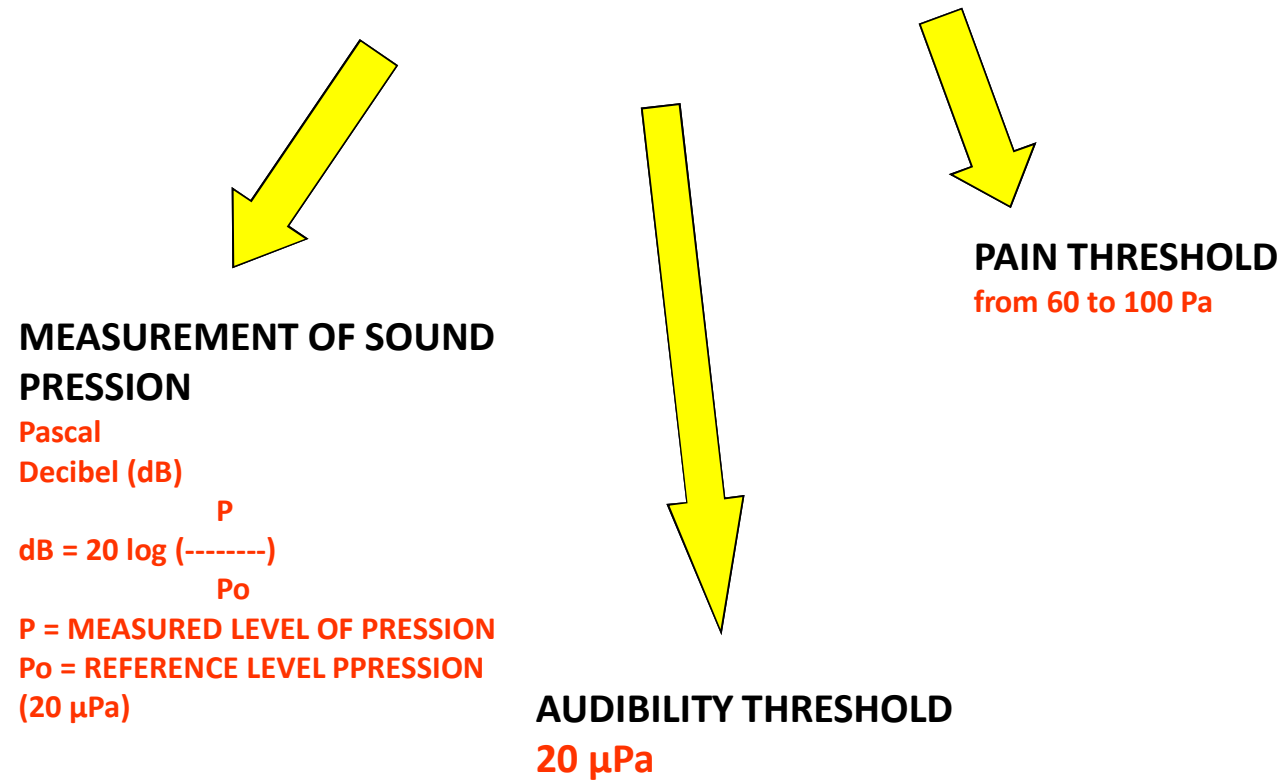
It is the deviation caused by the movement of the air molecules



### SPEED OF PROPAGATION

It is the transfer of molecular energy that has a propagation speed depending on the medium within which it occurs. In air it is 344 m / sec, in water it is 1500 m / sec, in solids it varies from 3000 to 5000 m / sec.

# NOISE MEASUREMENT



## NOISE LEVELS

Pressione sonora		Livello Sonoro in dB (A)	Sorgenti sonore
		170	
1000	Pa	160	Fucile d'assalto
		150	pistola 9 mm
100	Pa	140	pistola sparachiodi
		130	Soglia del dolore
10	Pa	120	motore a reazione
		110	Trivellatrice
1	Pa	100	martello pneumatico
		90	Discoteca
100	mPa	80	Lavorazioni meccaniche
		70	Traffico stradale
10	mPa	60	Conversazione
		50	Ufficio
1	mPa	40	Abitazione
		30	Sala di lettura
100	μPa	20	Camera da letto
		10	Studio radio
20	μPa	0	Soglia di udibilita'

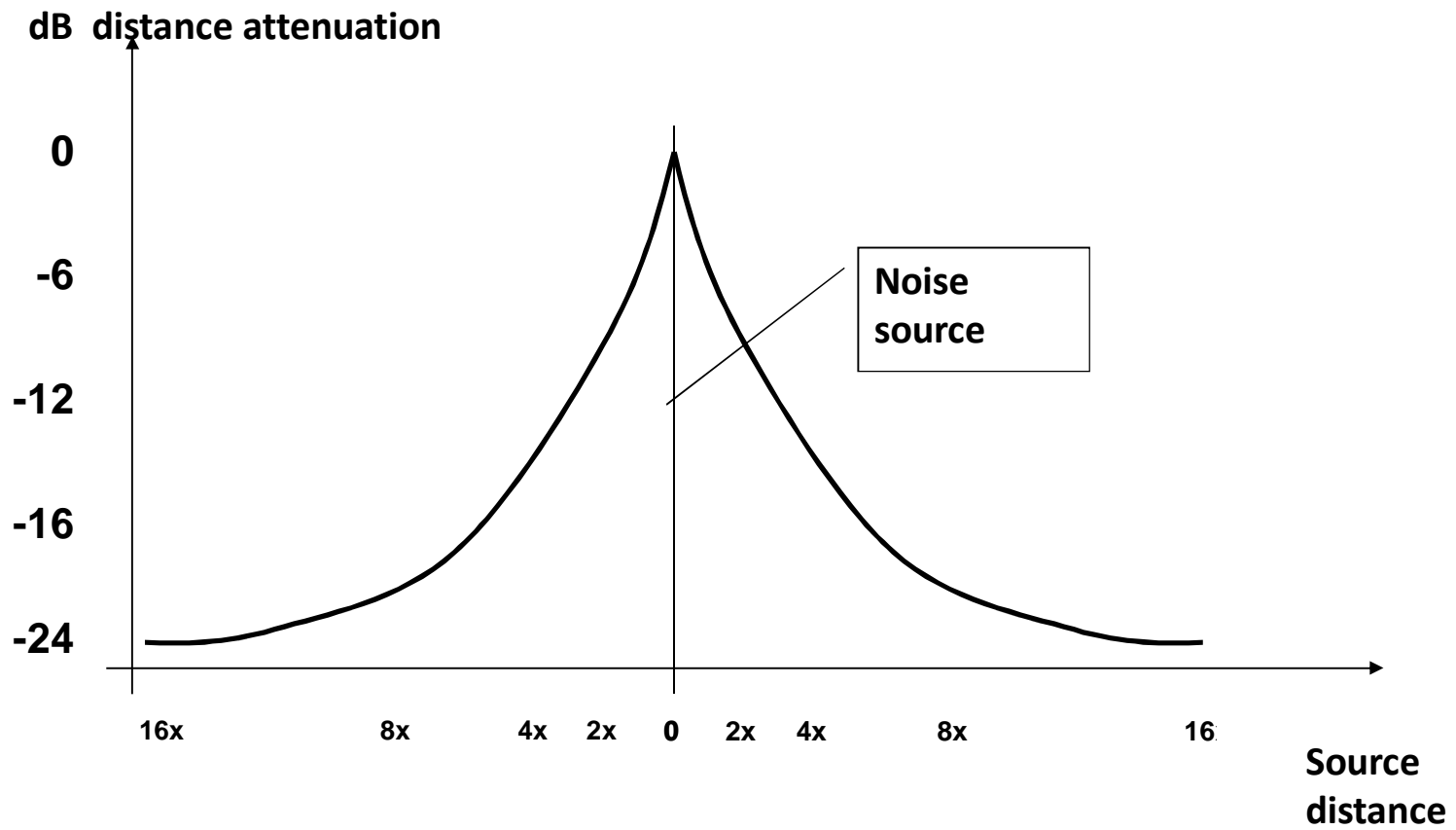




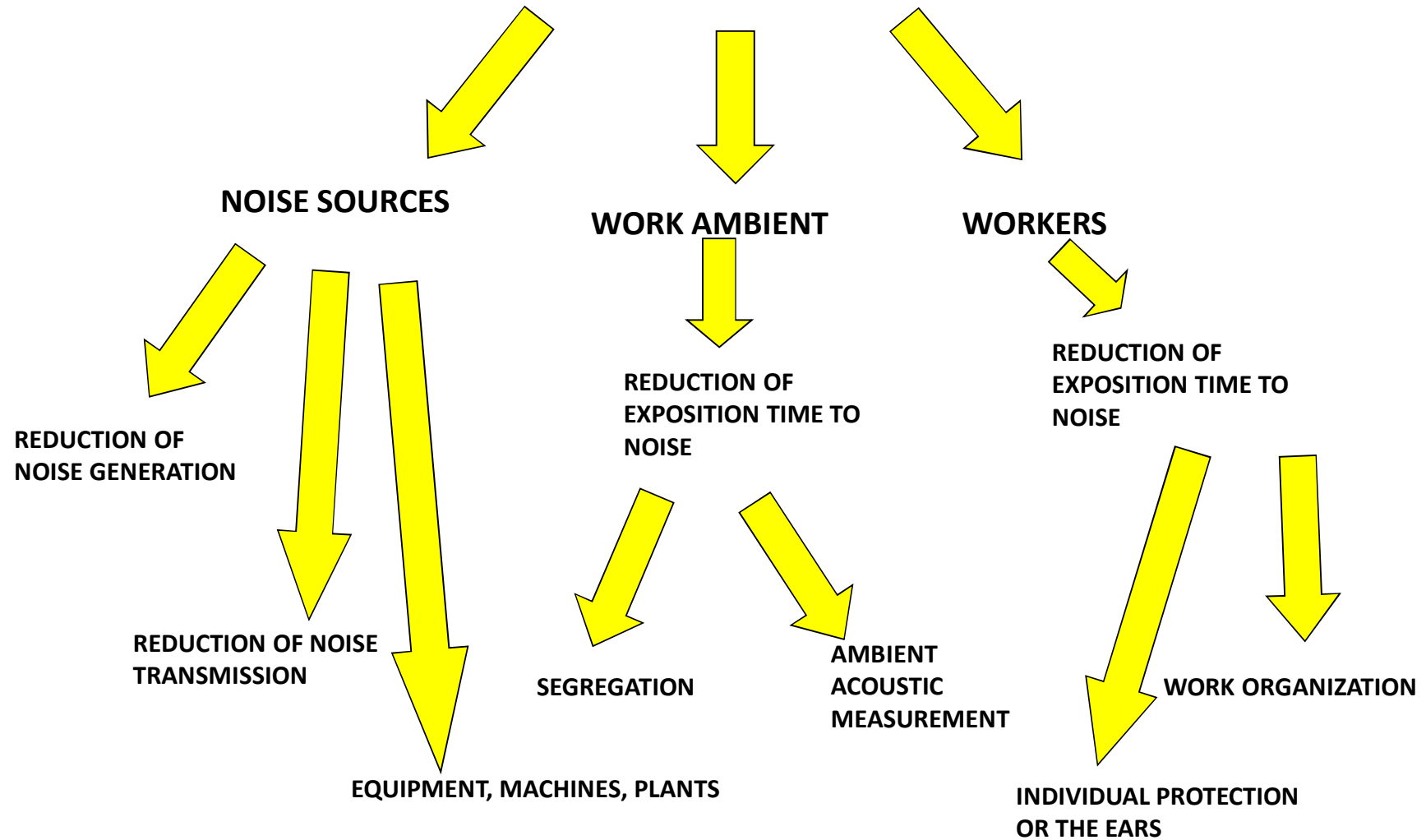
## NOISE LEVELS

	<b>Example of noise:.</b>	<b>Human reaction:</b>
<b>0 dBA</b>	no sound is perceptible	the threshold of hearing
<b>10 dBA</b>	Breathing	the sound is barely audible.
<b>20 dBA</b>	whispers heard a meter away; light wind in trees	a sense of deep calmness.
<b>30 dBA</b>	a low-voice conversation	a sense of calmness
<b>40 dBA</b>	library, refrigerator, a quiet street at night.	a peaceful area the beginning of disturbance
<b>50 dBA</b>	moderate rain, washing machine	
<b>60 dBA</b>	normal conversation	
<b>70 dBA</b>	busy street, vacuum cleaner	disruptive when on the telephone
<b>80 dBA</b>	alarm clock, factory, noisy restaurant	difficult to have a conversation; a feeling of heavy noise
<b>90 dBA</b>	subway, lawnmower, alarm	
<b>110 dBA</b>	loud concert, club	bearable for a short period of time; maximum vocal effort to be heard
<b>120 dBA</b>	emergency vehicle siren, airplane takeoff heard from about 300 meters	beginning of pain
<b>130 dBA</b>	jackhammer, pneumatic tool	pain.
<b>140 dBA</b>	airplane takeoff heard from about 50 meteres	unbearable pain

# NOISE DISTANCE ATTENUATION

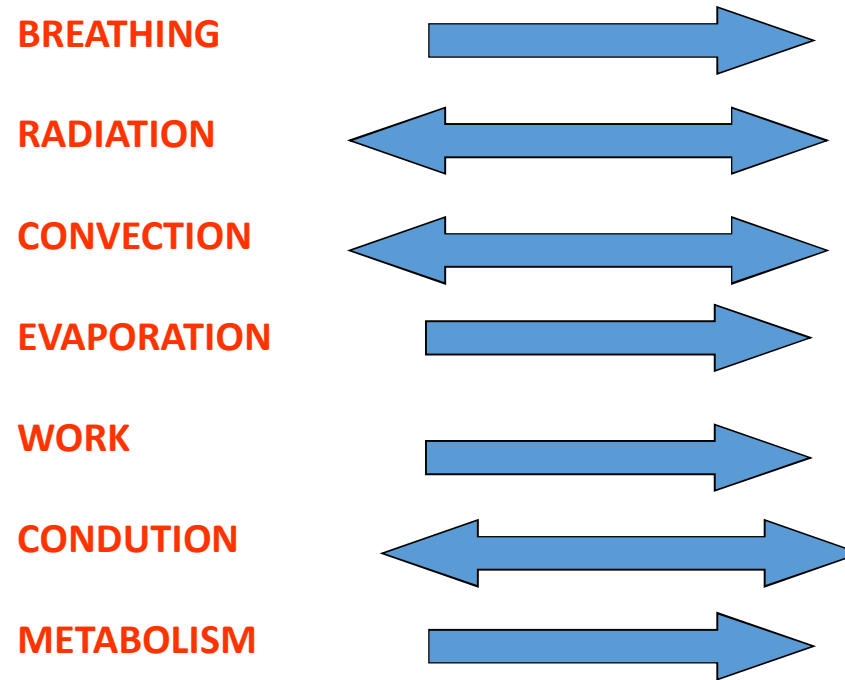


# COUNTERMEASURES AGAINST THE NOISE

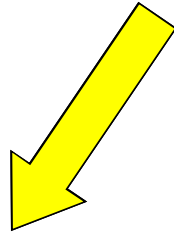


# MICROCLIMATE

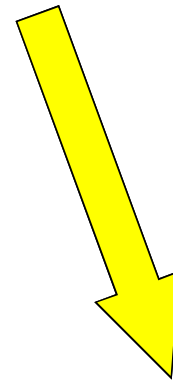
## ENERGY BALANCE OF HUMAN BODY



# MICROCLIMATE VENTILATION



**CLEANING OF AIR**



**ELIMINATION OF AIR STREAM**