

► Ergonomics



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Ergonomics

Definition:

”Ergonomics is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory principles, data and methods to design in order to optimise human well-being and overall system performance”

(International Ergonomics Association, IEA, 2006)



The ergonomic value stream

Value stream

Product

Customer involvement

Product description

Product design

Material

Life cycle

The design and engineering of a new product, including e.g. choice of material, influence the working environment in production.

Important actors

Designer

Engineer



The ergonomic value stream

Value stream

Process

- Production system
- Production flow
- Level of automation
- Work method
- Work intensity

The production process is designed through the choice of production system and work methods.

Important actors

- System developer
- Planner
- Production engineer
- Buyer



The ergonomic value stream

Value stream

Work organisation
Flexibility
Training
Roles
Autonomy
Work hours

The work tasks in production are clustered and/or divided over time and between individuals.

Important actors

Manager
Group leader



The ergonomic value stream

Value stream

Work place
Work height
Work distance
Force
Vibrations
Vision

The design of the work place have a large impact on weights, working positions and movements.

Important actors

Manager
Group leader



The ergonomic value stream

Value stream

Individe

Competence and skills

Physical and mental competence

Each individuals
physical attributes
measures, strength,
and competence
determines the
workload.

Important actors

All employees

Manager

Human resources



Manual handling

Characteristics of the handled object:

- High weight or volume
- Unwieldiness
- Poor stability
- Bad placement (e.g. When body has to be twisted in order to handle the object).
- Hazardous shape/Characteristics



Manual handling

Demand for physical strain:

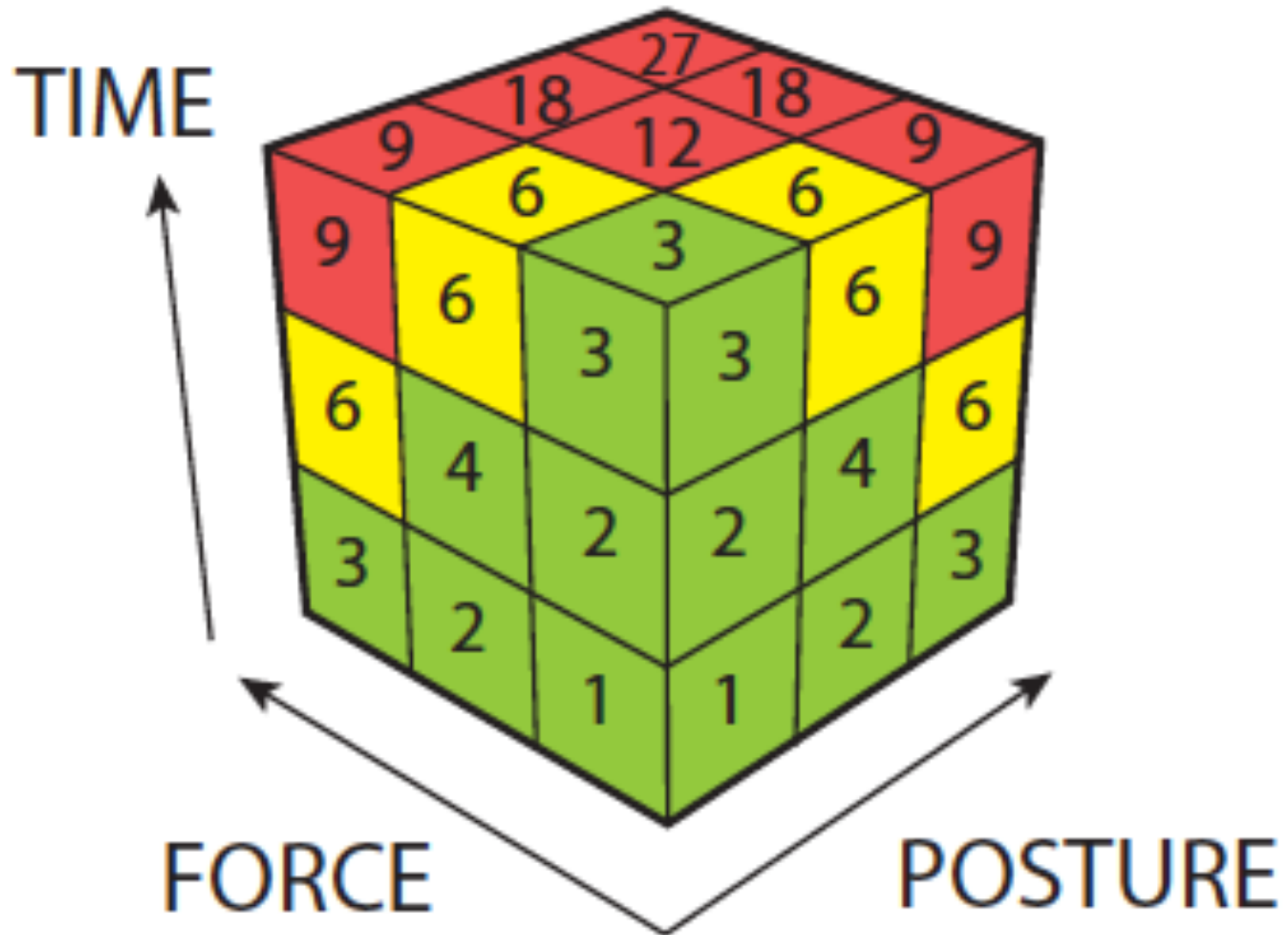
- Strenuous
- Require twist of the body.
- May cause the load to move suddenly.
- Is performed with limited balance.



Manual handling

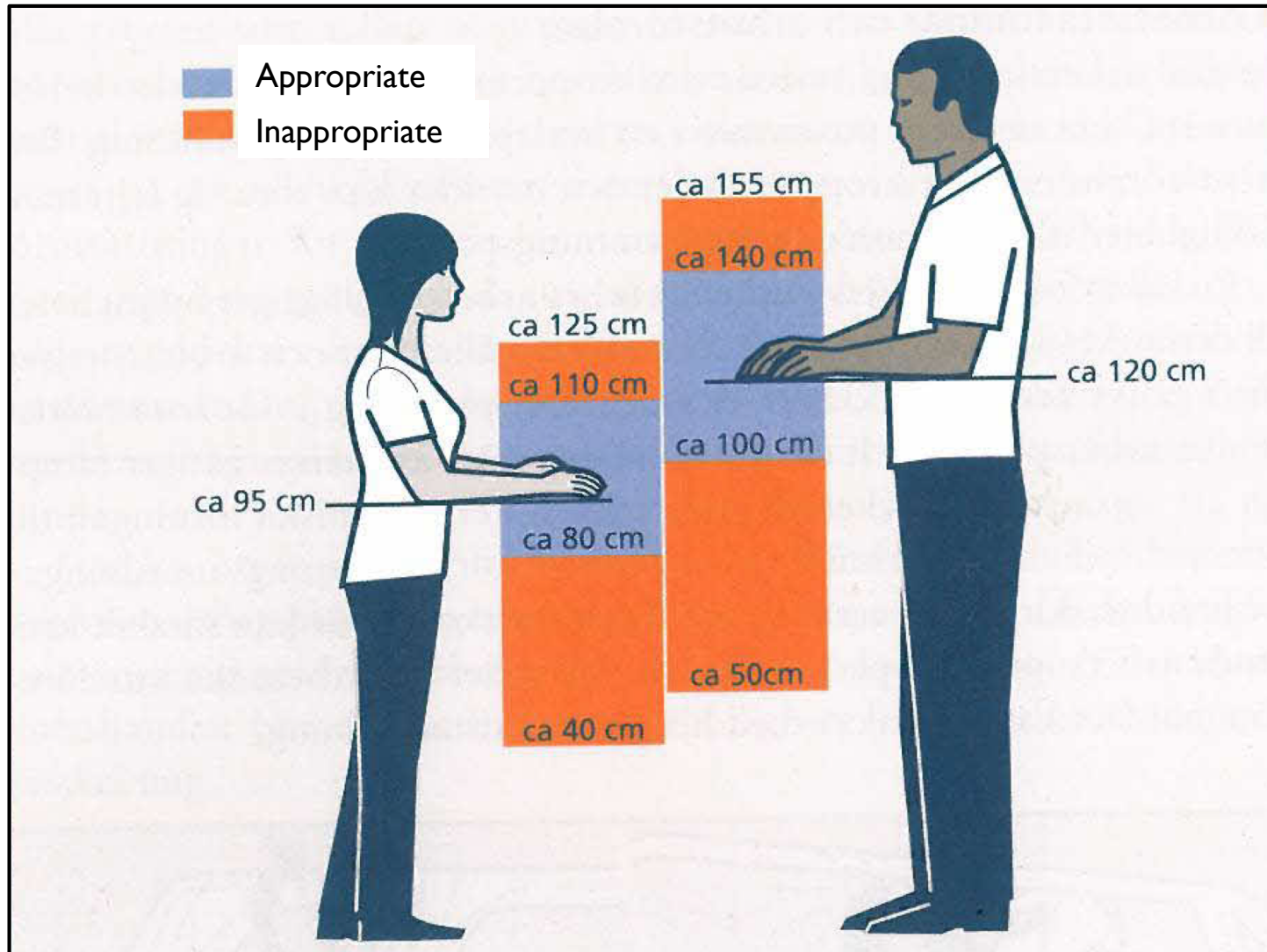
Design of the workplace environment

- Limited work space (especially, limited height)
- Rough/uneven, (or slippery) ground
- The workplace limits the possibility of using good working positions.
- Various levels (in floor, or working surface)
- Unstable floor/ground
- Unsatisfactory climate (i.e. Temperature, humidity or ventilation).



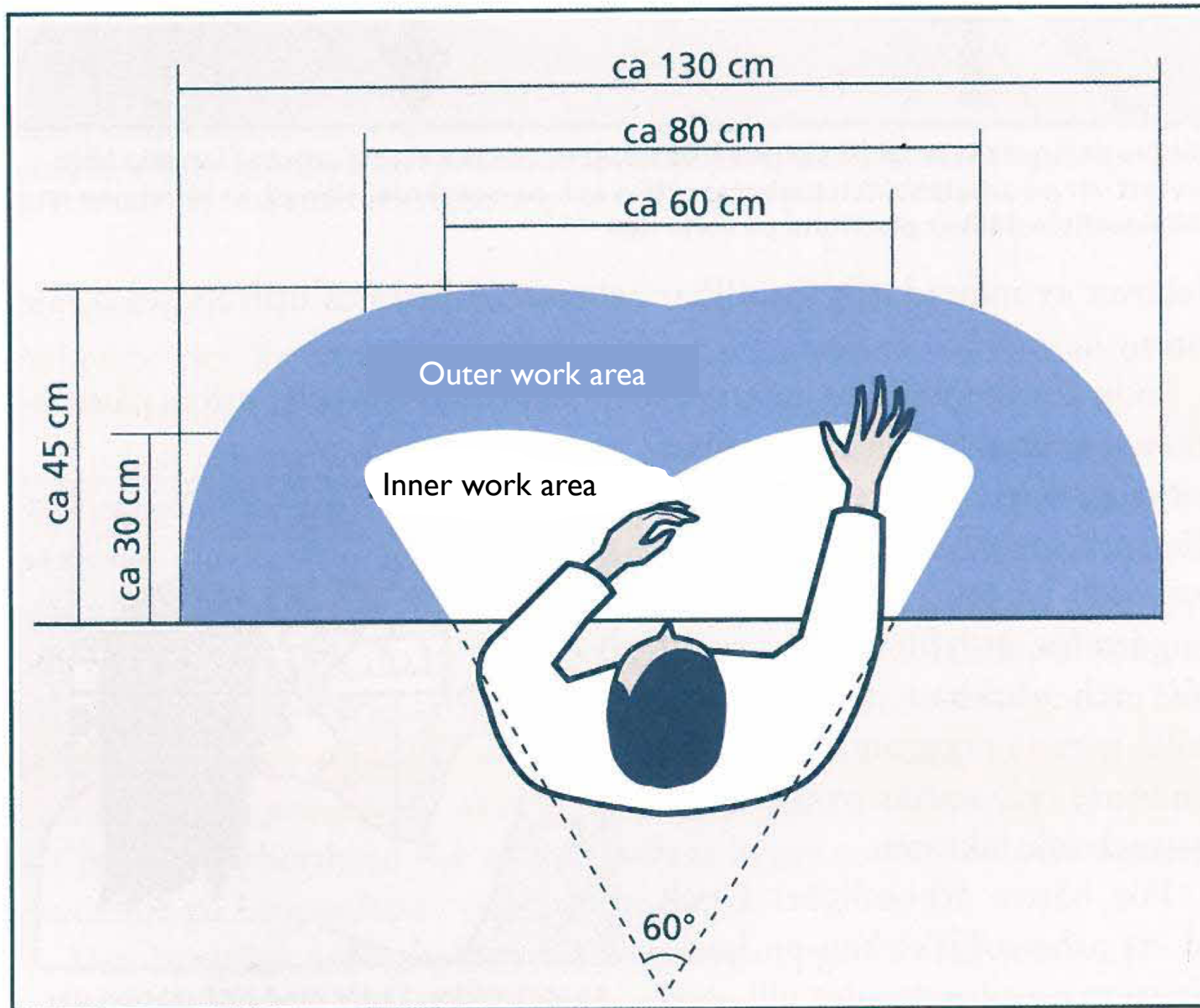


Appropriate working heights





Appropriate working areas





Manual lifting and carrying

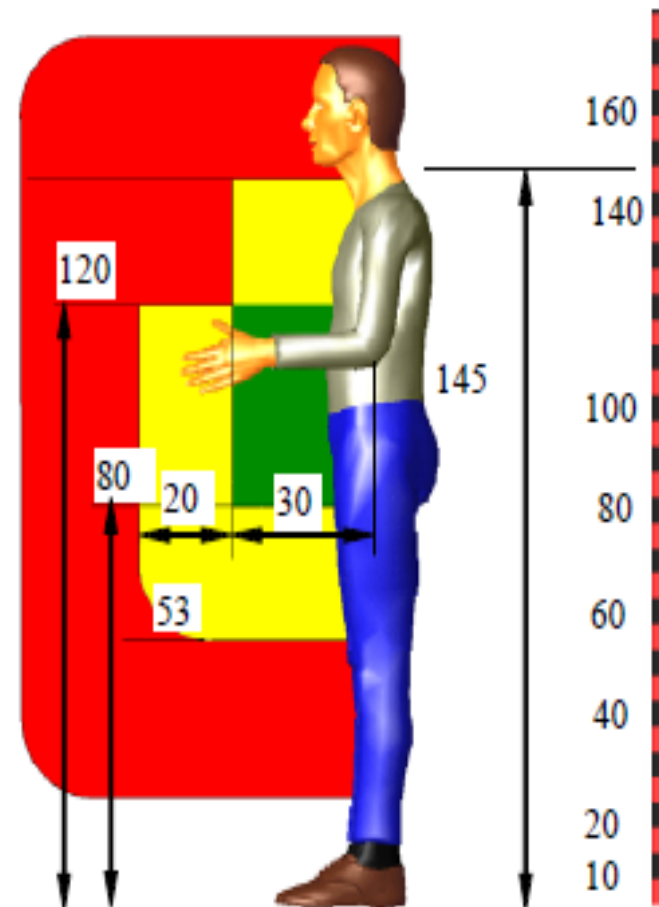
Work burden, Work positions, Movements

Evaluation templates

- No negative impact
- Possible negative impact, depending on number of movements or the duration of the position.
- Negative impact, when long time exposition (total >2h/day) or often (>100 times/day).

Work area	Frequency times/h			
	1-10	10-30	30-60	60-
	12,0	7	3	2
	7,0	5	2	1
	2,5	2	-	-

172 cm = Average height man/woman



When handling multiple objects in the same work cycle, the frequencies are added.
 When the work is performed sitting, all weights should be halved. Maximum 7kg.



Mapping ergonomics

Examples of methods for mapping:

- RULA
- REBA
- Ergonova
- Ergo SAM
- OWAS
- PEEA
- Etcetera...



RULA Employee Assessment Worksheet

Complete this worksheet following the step-by-step procedure below. Keep a copy in the employee's personnel folder for future reference.

A. Arm & Wrist Analysis

Step 1: Locate Upper Arm Position

Step 1a: Adjust...
 If shoulder is raised: +1;
 If upper arm is abducted: +1;
 If arm is supported or person is leaning: -1

Step 2: Locate Lower Arm Position

Step 2a: Adjust...
 If arm is working across midline of the body: +1;
 If arm out to side of body: +1

Step 3: Locate Wrist Position

Step 3a: Adjust...
 If wrist is bent from the midline: +1

Step 4: Wrist Twist

If wrist is twisted mainly in mid-range = 1;
 If twist at or near end of twisting range = 2

Step 5: Look-up Posture Score in Table A
 Use values from steps 1,2,3 & 4 to locate Posture Score in table A

Step 6: Add Muscle Use Score

If posture mainly static (i.e. held for longer than 1 minute) or:
 If action repeatedly occurs 4 times per minute or more: +1

Step 7: Add Force/load Score

If load less than 2 kg (intermittent): +0;
 If 2 kg to 10 kg (intermittent): +1;
 If 2 kg to 10 kg (static or repeated): +2;
 If more than 10 kg load or repeated or shocks: +3

Step 8: Find Row in Table C
 The completed score from the Arm/wrist analysis is used to find the row on Table C

SCORES

B. Neck, Trunk & Leg Analysis

Step 9: Locate Neck Position

Step 9a: Adjust...
 If neck is twisted: +1; If neck is side-bending: +1

Step 10: Locate Trunk Position

Step 10a: Adjust...
 If trunk is twisted: +1; If trunk is side-bending: +1

Step 11: Legs

If legs & feet supported and balanced: +1;
 If not: +2

Step 12: Look-up Posture Score in Table B
 Use values from steps 8,9, & 10 to locate Posture Score in Table B

Step 13: Add Muscle Use Score

If posture mainly static or:
 If action 4/minute or more: +1

Step 14: Add Force/load Score

If load less than 2 kg (intermittent): +0;
 If 2 kg to 10 kg (intermittent): +1;
 If 2 kg to 10 kg (static or repeated): +2;
 If more than 10 kg load or repeated or shocks: +3

Step 15: Find Column in Table C
 The completed score from the Neck/Trunk & Leg analysis is used to find the column on Chart C

Final Score =

Subject: _____

Company: _____

Date: / /

Scorer: _____

Department: _____

FINAL SCORE: 1 or 2 = Acceptable; 3 or 4 investigate further; 5 or 6 investigate further and change soon; 7 investigate and change immediately

Source: McAtamney, L. & Corlett, E.N. (1993) RULA: a survey method for the investigation of work-related upper limb disorders, *Applied Ergonomics*, 24(2) 91-99.

© Professor Alan Hedge, Cornell University. Feb. 2001



REBA Employee Assessment Worksheet

based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

A. Neck, Trunk and Leg Analysis

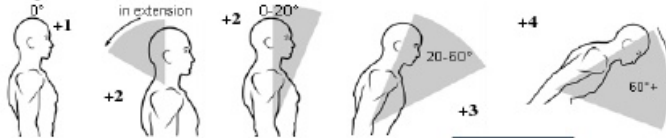
Step 1: Locate Neck Position



Step 1a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Neck Score

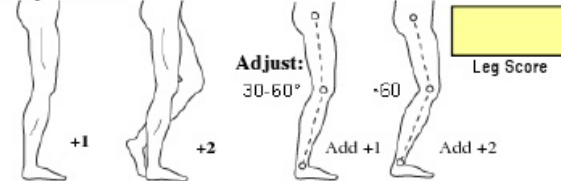
Step 2: Locate Trunk Position



Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 3: Legs



Leg Score

Step 4: Look-up Posture Score in Table A

Using values from steps 1-3 above, locate score in Table A

Posture Score A

Step 5: Add Force/Load Score

If load < 11 lbs: +0
If load 11 to 22 lbs: +1
If load > 22 lbs: +2
Adjust: If shock or rapid build up of force: add +1

Force/Load Score

Step 6: Score A, Find Row in Table C

Add values from steps 4 & 5 to obtain Score A.
Find Row in Table C.

Score A

Scoring:

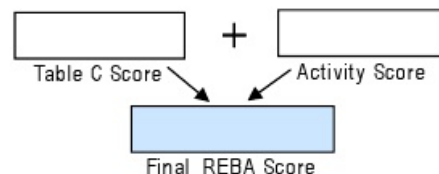
- 1 = negligible risk
- 2 or 3 = low risk, change may be needed
- 4 to 7 = medium risk, further investigation, change soon
- 8 to 10 = high risk, investigate and implement change
- 11+ = very high risk, implement change

SCORES

Table A		Neck											
		1				2				3			
Trunk Posture Score	Legs												
	1	1	2	3	4	1	2	3	4	1	2	3	4
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
5	4	6	7	8	6	7	8	9	7	8	9	9	

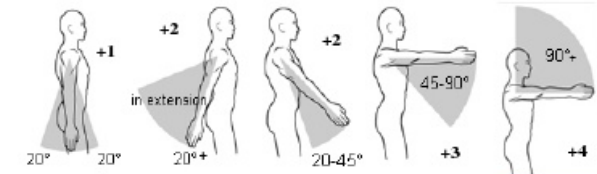
Table B		Lower Arm					
		1			2		
Upper Arm Score	Wrist						
	1	1	2	3	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
6	7	8	8	8	9	9	

Score A (score from table A + load/force score)	Table C												
	Score B, (table B value + coupling score)												
1	1	1	1	2	3	3	4	5	6	7	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8	8
3	2	3	3	3	4	5	6	7	7	8	8	9	9
4	3	4	4	4	5	6	7	8	8	9	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12	12



B. Arm and Wrist Analysis

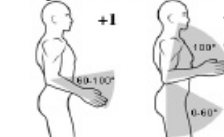
Step 7: Locate Upper Arm Position:



Step 7a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

Step 8: Locate Lower Arm Position:



Lower Arm Score

Step 9: Locate Wrist Position:



Wrist Score

Step 9a: Adjust...
If wrist is bent from midline or twisted: Add +1

Step 10: Look-up Posture Score in Table B

Using values from steps 7-9 above, locate score in Table B

Posture Score B

Step 11: Add Coupling Score

Well fitting Handle and mid rang power grip, **good**: +0
Acceptable but not ideal hand hold or coupling acceptable with another body part, **fair**: +1
Hand hold not acceptable but possible, **poor**: +2
No handles, awkward, unsafe with any body part, **Unacceptable**: +3

Coupling Score

Step 12: Score B, Find Column in Table C

Add values from steps 10 & 11 to obtain Score B. Find column in Table C and match with Score A in row from step 6 to obtain Table C Score.

Score B

Step 13: Activity Score

- +1 1 or more body parts are held for longer than 1 minute (static)
- +1 Repeated small range actions (more than 4x per minute)
- +1 Action causes rapid large range changes in postures or unstable base

Task name: _____ Reviewer: _____ Date: ____/____/____

Example of red-yellow-green guidelines

Sitting	Some of the following occur during a significant part of the work shift.	Some of the following occur periodically during the work shift	The following applies to a significant part of the change of work.
 <p>Neck</p> <p>Back</p> <p>Shoulder arm</p> <p>Leg</p>	<ul style="list-style-type: none"> - Bent - twisted - at the same time bent and twisted - severely restricted freedom of movement 	<ul style="list-style-type: none"> - Bent - twisted - at the same time bent and twisted - severely restricted freedom of movement 	<ul style="list-style-type: none"> - in the middle position - freedom of movement
	<ul style="list-style-type: none"> - Bent - twisted - at the same time bent and twisted - severely restricted freedom of movement - back support is missing 	<ul style="list-style-type: none"> - Bent - twisted - at the same time bent and twisted - severely restricted freedom of movement 	<ul style="list-style-type: none"> - opportunities for free movement - well-designed backrest - possibility to switch to standing
	<ul style="list-style-type: none"> - Hands in or above shoulder height - The hand outside the forearm distance without support 	<ul style="list-style-type: none"> - Hands in or above shoulder height - The hand outside the forearm distance without support 	<ul style="list-style-type: none"> - work height and range adapted to task and individual - Good arm relief
	<ul style="list-style-type: none"> - Inadequate space for the legs No support for the feet - severely restricted freedom of movement - leg or foot controlled pedal work 	<ul style="list-style-type: none"> - Inadequate space for the legs No support for the feet - severely restricted freedom of movement - leg or foot controlled pedal work 	<ul style="list-style-type: none"> - free legroom - good footrest - rarely leg or footmanoevered pedal work - possibility to switch to standing

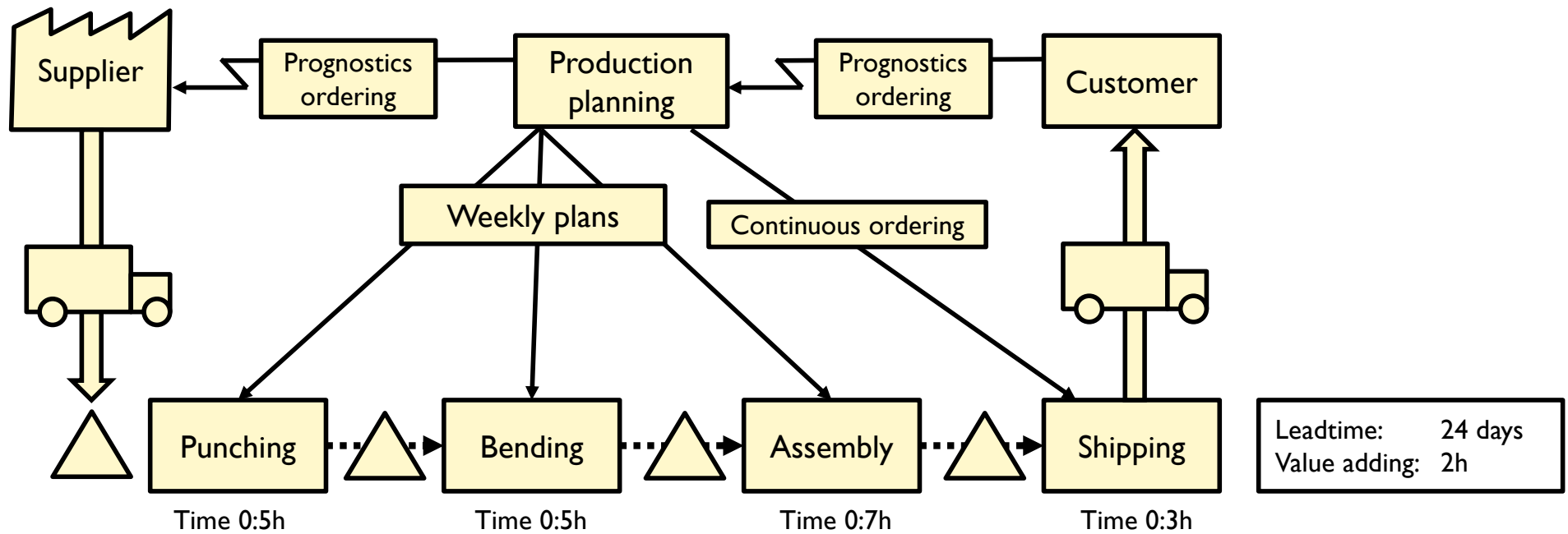


Example of red-yellow-green guidelines

Standing/ Walking	Some of the following occur during a significant part of the work shift.	Some of the following occur periodically during the work shift	The following applies to a significant part of the change of work.
	<ul style="list-style-type: none"> - Bent - twisted - at the same time bent and twisted - severely restricted freedom of movement 	<ul style="list-style-type: none"> - Bent - twisted - at the same time bent and twisted - severely restricted freedom of movement 	<ul style="list-style-type: none"> - upright position - freedom of movement
	<ul style="list-style-type: none"> - Bent - twisted - at the same time bent and twisted - severely restricted freedom of movement - unstable or inclined surface 	<ul style="list-style-type: none"> - Bent - twisted - at the same time bent and twisted - severely restricted freedom of movement - unstable or inclined surface 	<ul style="list-style-type: none"> - upright position - freedom of movement - opportunity to switch to sitting
	<ul style="list-style-type: none"> - Hands in or above shoulder height - The hand in or below the knee height - The hand outside the forearm distance without support 	<ul style="list-style-type: none"> - Hands in or above shoulder height - The hand in or below the knee height - The hand $\frac{3}{4}$ outside the forearm distance without support 	<ul style="list-style-type: none"> - work height and range of areas adapted to the task and individual
	<ul style="list-style-type: none"> - Inadequate space for the legs - No support for the feet - severely restricted freedom of movement - unstable or inclined surface - leg or foot controlled pedal work 	<ul style="list-style-type: none"> - Inadequate space for the legs - No support for the feet - severely restricted freedom of movement - unstable or inclined surface - leg or foot controlled pedal work 	<ul style="list-style-type: none"> - Free movement on stable, halftight, even and horizontal surfaces - no leg and rarely foot-operated pedal work - opportunity to switch to sitting



Ergonova Ergonomic Value Stream Mapping



Posture:	5	3	4	6
Force:	3	6	5	3
P x F x T:	7.5	9	14	6
Ergonomic category:	E	F	E	F

Strain/product:	36.5
Strain level:	4.3
Ergonomic potential:	7
Work variation:	8
Porosity:	5



Improvements

How do we improve the ergonomics?



Product design

Design guidelines, e.g. Design for assembly:

- Parts should be designed with surfaces so that they can be easily grasped, placed and fixtured.
- Avoid parts with sharp edges, burrs or points.
- Avoid heavy parts that will increase worker fatigue, increase risk of worker injury, and slow the assembly process.

(Excerpt from DFA guidelines)



Process design

When designing the production system; Regard:

- Production technology
- Material handling
- Level of automation
- Layout



Work organisation

Regard:

- Workforce flexibility (e.g. Work rotation)
- Workforce autonomy
- Work hours
- Training



Work place design

The work place:

- Lifting aids
- Adjustable work levels
- Power tools



Positioners





Scissor lift





Balancer





Reference literature

PRODUCTION ERGONOMICS DESIGNING WORK SYSTEMS TO SUPPORT OPTIMAL HUMAN PERFORMANCE

Berlin, C., and Adams, C., (2017), " PRODUCTION ERGONOMICS
DESIGNING WORK SYSTEMS TO SUPPORT OPTIMAL HUMAN PERFORMANCE",

Available here: <https://www.ubiquitypress.com/site/books/10.5334/bbe/>



Next lecture: Tuesday 2018-04-10

**Guest lecture: Kaizen/Kaikakku
Guest: Yuji Yamamoto**

Seminar: Yamamoto & Bellgran

**Focus your reading on:
The eight guidelines for problem solving**