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Arbouw Foundation
Guidelines on Physical Workload
for the Construction Industry

Amsterdam, May 1997

**Verbetering van
arbeidsomstandigheden
in de bouwnijverheid**

Arbouw:

The improvement of working conditions in the construction industry

The Arbouw Foundation was set up for employer and employee organisations in the construction industry. Since September 1986 Arbouw has been working on the task of promoting health and safety in the construction and related industries and reducing illness-related absence.

To this end Arbouw carries out research and develops instruments to enable all the disciplines involved in the construction process to improve working conditions in the construction industry.

Arbouw develops standards and models and draws up guidelines concerning working conditions and provides suitable information material. As an important element of its transfer of knowledge Arbouw runs courses, training sessions and workshops geared to suit the target groups.

In addition, the organisation of occupational health care in the construction industry is an important task. Arbouw supervises the uniformity of the provision of services via 'arbodiensten' (occupational health and safety departments) and monitors the costs and quality. Arbouw's area of attention covers the construction and related industries, principals, designers, trade, industry, the government and education. Arbouw's work is industry-specific and sector-specific.

The following organisations cooperate within Arbouw: the Algemeen Verbond Bouwbedrijf (AVBB, General Construction Industry Association), the Stichting Federatie Aannemers in de Afbouw- en Nevenbedrijven in de Bouwnijverheid (FAANB, Foundation of the Federation of Contractors in the Finishing and Related Industries in the Construction Industry), the Bouw- en Houtbond FNV (Construction and Wood Association) and the Hout- en Bouwbond CNV (Wood and Construction Association).

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

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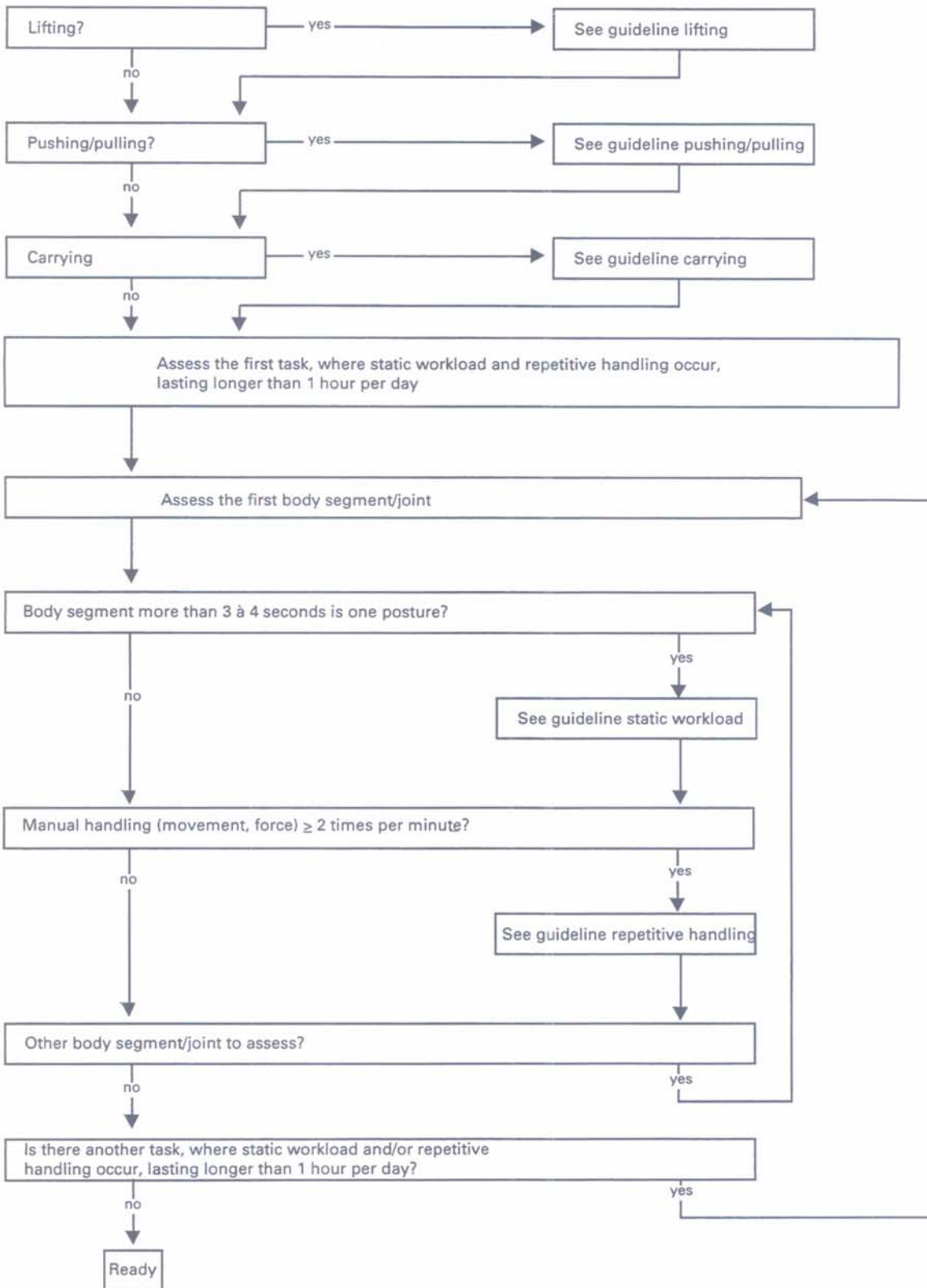
Introduction

Guidelines are presented for five areas of physical workload, i.e. lifting, pushing/pulling, carrying, static load, and repetitive work. All guidelines are based upon the following evaluation categories:

-  basic, i.e. non-increased, health risk for $\geq 90\%$ of males ($P90\sigma$);
-  increased health risk; *action may be planned in stages; immediate action is to be preferred.*
For the guidelines on external force exertion, such as for lifting and carrying, pushing/pulling, and repetitive arm work, this zone denotes that between 25% and 90% of men ($P25\sigma$ - $P90\sigma$) are able to exert a certain force. Static postures and repetitive movements that are associated with an increased health risk, are included in this zone for a task duration of between 1 and 4 hours;
-  strongly increased health risk; *immediate action is necessary.* For the guidelines on external force exertion (refer above), the zone denotes that $\leq 25\%$ of men ($P25\sigma$) are able to exert a certain force. Static postures and repetitive movements that are associated with an increased health risk, are included in this zone for a task duration >4 hours.

If application of the guidelines shows no increased health risk, where an increased level of physical complaints for a group of employees involved has been found, further analysis is necessary.

Scheme for application of guidelines



Arbouw Foundation - Guideline on lifting

(mainly based on NIOSH, 1991, Mital et al., 1993, and NF X 35-106, 1985)

The following conditions are *red*:

- weight more than 25 kg when in a standing position;
- weight more than 10 kg when in a sitting, squatting, or kneeling position;
- weight more than 17 kg when lifting one-handed;
- horizontal location (H) more than 63 cm;
- asymmetry angle (A) more than 135°;
- vertical location (V) more than 175 cm or less than 0 cm;
- frequency (F) more than 15 lifts/minute.

The first two tables below distinguish between symmetric and asymmetric lifting, where a lifting index ≤ 1 is *green*, a lifting index 1-3 is *yellow*, and a lifting index ≥ 3 is *red*. In the case of limited headroom the lifting index found in one of these tables has to be multiplied by a multiplier taken from the third table below. An index greater than 1 means an increased health risk, concerning musculoskeletal complaints/disorders in particular. A greater index means a higher risk. The fourth table below presents the guidelines for lifting in a sitting, squatting, or kneeling position or for lifting one-handed.

Lifting index for *symmetric* lifting (asymmetry angle (A) 0°), vertical location (V) 175 cm, vertical travel distance (D) 175 cm, work/lifting duration 8 hours and no recovery time. The figures in brackets are for lifting under optimal symmetric conditions, i.e. vertical location (V) 75 cm, vertical travel distance (D) 0 cm, work/lifting duration 1 hour and recovery time 7 hours. A lifting index ≤ 1 is *green*, a lifting index 1-3 is *yellow*, and a lifting index ≥ 3 is *red*.

weight	horizontal location (H)	frequency		
		5-9 lifts/minute	1-5 lifts/minute	<1 lift/minute
0-5 kg	≤ 25 cm	2.8 (0.5)	1.2 (0.3)	0.5 (0.3) <i>green</i>
	25-40 cm	4.2 (0.7)	1.9 (0.5)	0.9 (0.4)
	40-63 cm	7.1 (1.7)	2.9 (0.8)	1.4 (0.6)
5-10 kg	≤ 25 cm	5.9 (0.9)	2.3 (0.6)	1.1 (0.5) <i>yellow</i>
	25-40 cm	8.3 (1.5)	3.7 (1.0)	1.7 (0.8)
	40-63 cm	14.2 (2.3)	5.9 (1.5)	2.7 (1.3)
10-15 kg	≤ 25 cm	8.3 (1.4)	3.5 (0.9)	1.6 (0.8)
	25-40 cm	12.5 (2.2)	5.6 (1.4)	2.6 (1.2)
	40-63 cm	21.4 (1.9)	8.8 (2.3)	4.1 (1.9)
15-20 kg	≤ 25 cm	11.1 (1.9)	4.7 (1.2)	2.2 (1.0) <i>red</i>
	25-40 cm	16.6 (2.9)	7.4 (1.9)	3.5 (1.6)
	40-63 cm	26.5 (4.7)	11.7 (3.0)	5.4 (2.6)
20-25 kg	≤ 25 cm	13.8 (2.3)	5.8 (1.5)	2.7 (1.3)
	25-40 cm	20.8 (3.7)	9.3 (2.4)	4.3 (2.0)
	40-63 cm	35.7 (5.8)	14.7 (3.8)	6.8 (3.2)

Lifting index for *asymmetric* lifting (asymmetric angle (A) 135°), vertical location (V) 175 cm, vertical travel distance (D) 175 cm, work/lifting duration 8 hours and no recovery time. The figures in brackets are for lifting under optimal asymmetric conditions, i.e. vertical location (V) 75 cm, vertical travel distance (D) 0 cm, work/lifting duration 1 hour and recovery time 7 hours. A lifting index ≤ 1 is *green*, a lifting index 1-3 is *yellow*, and a lifting index ≥ 3 is *red*.

weight	horizontal location (H)	frequency (F)		
		5-9 lifts/minute	1-5 lifts/minute	<1 lift/minute
0-5 kg	≤ 25 cm	4.6 (0.8)	2.0 (0.5) yellow	0.9 (0.5) green
	25-40 cm	7.1 (1.3)	3.3 (0.8)	1.5 (1.7)
	40-63 cm	12.5 (2.0)	5.0 (1.3)	2.4 (1.1)
5-10 kg	≤ 25 cm	9.1 (1.6)	4.0 (1.1)	1.9 (0.9) yellow
	25-40 cm	14.2 (2.6)	6.7 (1.7)	3.0 (1.4)
	40-63 cm	25.0 (4.0)	10.0 (2.6)	4.8 (2.3)
10-15 kg	≤ 25 cm	13.6 (2.5)	6.0 (1.6)	2.8 (1.4) yellow
	25-40 cm	21.4 (3.9)	10.0 (2.5)	4.6 (2.1)
	40-63 cm	37.5 (6.0)	15.0 (4.0)	7.1 (3.4)
15-20 kg	≤ 25 cm	18.1 (3.3)	8.0 (2.1)	3.8 (1.8)
	25-40 cm	29.1 (5.1)	13.3 (3.4)	6.1 (2.9)
	40-63 cm	50.0 (8.0)	20.0 (5.3)	9.5 (4.5)
20-25 kg	≤ 25 cm	22.7 (4.1)	10.0 (2.7)	4.7 (2.3)
	25-40 cm	35.7 (6.4)	16.6 (4.2)	7.6 (3.6)
	40-63 cm	62.5 (10.0)	25.0 (6.6)	11.9 (5.7)

Limited headroom multiplier

	multiplier
fully upright	1.00
95% upright	1.67
90% upright	2.50
85% upright	2.60
80% upright	2.78

Guidelines for lifting in a sitting, squatting, or kneeling position or for lifting one-handed infrequently.

	weight	
	green	yellow limit
sitting, squatting or kneeling	4.5 kg	10.0 kg
one-handed	7.5 kg	17.0 kg

For frequent lifting (≥ 2 /minute) and longer durations (>1 hour/day) the guidelines on repetitive work apply.

Arbouw Foundation - Guideline on pushing/pulling

(mainly based on Mital et al., 1993, and NF X 35-106, 1985)

1. Pushing/pulling with the whole body while walking

The tables below distinguish between pushing to set an object in motion (initial force exertion), pulling to set an object in motion (initial force exertion), and pushing or pulling to keep an object in motion (sustained force exertion). The guidelines are valid for two-handed pushing/pulling for a whole working day (8 hours), and an optimal height of the hands during force exertion (95-130 cm). A detailed analysis is necessary if slipping is likely to occur (or actually occurs) or in the case of high movement speed, awkward posture, asymmetric force exertion (one-handed, course changes), or a bad view of the surroundings (surface, obstacles, etcetera). All cells of the tables contain a pushing/pulling-index, besides the green, yellow, or red evaluation result. An index greater than 1 means an increased health risk, concerning musculoskeletal complaints/disorders in particular. A greater index means a higher risk.

Pushing to set an object in motion (initial force exertion). * = usually not possible because slipping is likely to occur.

force	frequency			
	2.5/minute-1/minute	1/minute-1/5 minutes	1/5 minutes-1/8 hours	≤1/8 hours
0-25 kgf	1.0 green	1.0 green	0.9 green	0.8 green
25-30 kgf*	1.2 yellow	1.2 yellow	1.1 yellow	1.0 green
30-45 kgf*	1.8 yellow	1.7 yellow	1.6 yellow	1.5 yellow
45-50 kgf*	2.0 red	1.9 yellow	1.8 yellow	1.7 yellow
50-65 kgf*	2.6 red	2.5 red	2.3 red	2.2 yellow
>65 kgf*	>2.6 red	>2.5 red	>2.3 red	>2.2 red

Pulling to set an object in motion (initial force exertion). * = usually not possible because slipping is likely to occur.

force	frequency			
	2.5/minute-1/minute	1/minute-1/5 minutes	1/5 minutes-1/8 hours	≤1/8 hours
0-20 kgf	1.0 green	1.0 green	1.0 green	1.0 green
20-40 kgf*	2.0 yellow	2.0 yellow	2.0 yellow	2.0 yellow
40-45 kgf*	2.3 red	2.3 red	2.3 yellow	2.3 yellow
45-50 kgf*	2.5 red	2.5 red	2.5 red	2.5 yellow
>50 kgf*	>2.5 red	>2.5 red	>2.5 red	>2.5 red

Pushing or pulling to keep an object in motion (sustained force exertion). * = usually not possible because slipping is likely to occur. - = combination of frequency and distance is not realistic.

force	distance	frequency			
		2.5/minute-1/minute	1/minute-1/5 minutes	1/5 minutes-1/8 hours	≤1/8 hours
0-5 kgf	2-15 m	0.8 green	0.4 green	0.4 green	0.3 green
	15-30 m	-	0.8 green	0.4 green	0.3 green
	30-60 m	-	-	0.6 green	0.4 green
5-10 kgf	2-15 m	1.5 yellow	0.9 green	0.7 green	0.6 green
	15-30 m	-	1.5 yellow	0.8 green	0.6 green
	30-60 m	-	-	1.2 yellow	0.9 green
10-15 kgf	2-15 m	2.3 red	1.3 yellow	1.1 yellow	0.9 green
	15-30 m	-	2.3 red	1.3 yellow	0.9 green
	30-60 m	-	-	1.8 yellow	1.3 yellow
15-20 kgf	2-15 m	3.1 red	1.7 red	1.5 yellow	1.2 yellow
	15-30 m	-	3.1 red	1.7 yellow	1.2 yellow
	30-60 m	-	-	2.3 red	1.7 yellow
20-25 kgf*	2-15 m	3.8 red	2.2 red	1.9 yellow	1.5 yellow
	15-30 m	-	3.8 red	2.1 yellow	1.5 yellow
	30-60 m	-	-	2.9 red	2.2 red
25-30 kgf*	2-15 m	4.6 red	2.6 red	2.2 red	1.8 yellow
	15-30 m	-	4.6 red	2.5 red	1.8 yellow
	30-60 m	-	-	3.5 red	2.6 red
>30 kgf*	2-15 m	>4.6 red	>2.6 red	>2.2 red	>1.8 red
	15-30 m	-	>4.6 red	>2.5 red	>1.8 red
	30-60 m	-	-	>3.5 red	>2.6 red

2. Pushing/pulling with the whole body while staying on the spot

The guidelines for setting an object in motion (refer to the first two tables in section 1) also apply to pushing/pulling with the whole body while staying on the spot.

3. Pushing/pulling with the upper limbs

The guidelines below are valid if the postures of the trunk and the upper limbs are evaluated as green (refer to the guideline on repetitive work), if the hands do not reach further forwards than three-quarters of the maximum reach distance (trunk upright), and if the hands are between pelvis height and shoulder height.

Guidelines for infrequent pushing/pulling with the upper limbs. A and B refer to the various types of force exertion distinguished in the guideline on repetitive work.

	force	
	green	yellow limit
A	7.5 kgf	17.0 kgf
B	19.0 kgf	43.0 kgf

For frequent pushing/pulling (≥ 2 /minute) and longer durations (>1 hour/day) the guidelines on repetitive work apply.

Arbouw Foundation - Guideline on carrying

(mainly based on Mital et al., 1993)

The following condition is *red*:

- weight more than 25 kg;
- weight more than 10.5 kg for infrequent one-handed carrying.

The guideline below is valid for two-handed carrying for a whole working day (8 hours), and the hands at an optimal height (knuckle height, arms hanging down). All cells of the tables contain a carrying-index, besides the evaluation result green, yellow, or red. An index greater than 1 means an increased health risk, concerning musculoskeletal complaints/disorders in particular. A greater index means a higher risk.

weight	distance	frequency			
		3/minute-1/minute	1/minute-1/5 minutes	1/5 minutes-1/8 hour	≤1/8 hour
0-10 kg	≤2.0 m	0.5 green	0.5 green	0.4 green	0.4 green
	2-8.5 m	0.8 green	0.6 green	0.5 green	0.4 green
10-15 kg	≤2.0 m	0.8 green	0.7 green	0.7 green	0.6 green
	2-8.5 m	1.2 yellow	0.9 green	0.6 green	0.6 green
15-20 kg	≤2.0 m	1.1 yellow	1.0 green	0.9 green	0.8 green
	2-8.5 m	1.5 yellow	1.2 yellow	1.0 green	0.8 green
20-25 kg	≤2.0 m	1.3 yellow	1.2 yellow	1.1 yellow	1.0 green
	2-8.5 m	1.9 red	1.5 yellow	1.3 yellow	1.0 green
>25 kg	≤2.0 m	>1.3 red	>1.2 red	>1.1 red	>1.0 red
	2-8.5 m	>1.9 red	>1.5 red	>1.3 red	>1.0 red

Guideline for infrequent one-handed carrying (standing or walking up to 90 meters).

infrequent one-handed carrying (standing or walking)	weight	
	6 kg	10.5 kg
	green	yellow limit
	yellow	red limit

Arbouw Foundation - Guideline on static postures

(mainly based on ISO/CD 11226, 1995)

It is recommended to use the guidelines below to begin with on tasks lasting longer than 1 hour (continuous or a total of distinct periods) per working day (N.B. shorter task durations cannot be considered safe in all cases). In the case that two or more tasks load the same body region (through static postures and/or repetitive work), the durations of these tasks are to be taken together. It is recommended to interpret the results of guideline application in relation to the complaints and disorders of the particular body region found for the group of employees involved. An evaluation result yellow/red becomes yellow in the case of a task duration of between 1 and 4 hours, whereas it becomes red in the case of a task duration >4 hours.

The guidelines on low back, shoulder and shoulder girdle as well as on neck and upper back are based on a description of the actual posture (observed/measured) with respect to a reference posture, i.e. a sitting or standing posture with a non-rotated upright trunk, a non-kyphotic lumbar spine posture, and the arms hanging freely, while looking straight ahead along the horizontal. Guidelines on sitting also include raised sitting.

Low back

trunk inclination							
<0°		0-20°		20-60°		>60°	
yellow**	red**	green	green*	yellow*	red*	yellow	red

- Asymmetric trunk posture (axial rotation and/or lateral flexion): yellow red
- For sitting: kyphotic lumbar spine posture (valid for: trunk inclination between 0° and 20°): yellow red
- * = with full trunk support: green; without full trunk support: consult an expert for evaluating holding time - recovery time regimes (see ISO/CD 11226); if that is not possible, the evaluation result is yellow in the case of a task duration of between 1 and 4 hours, whereas it is red in the case of a task duration >4 hours (expert guess of the authors); if two or more tasks load the same body region, the durations of these tasks are to be taken together.
- ** = with full trunk support: green.

Shoulder and shoulder girdle

upper arm elevation					
0-20°		20-60°		>60°	
green	green*	yellow*	red*	yellow	red

- Upper arm retroflexion (i.e. elbow behind the trunk when viewed from the side of the trunk), upper arm adduction (i.e. elbow not visible when viewed from behind the trunk), or extreme upper arm external rotation: yellow red
- Raised shoulder: yellow red
- * = with full arm support: green; without full arm support: consult an expert for evaluating holding time - recovery time regimes (see ISO/CD 11226); if that is not possible, the evaluation result is yellow in the case of a task duration of between 1 and 4 hours, whereas it is red in the case of a task duration >4 hours (expert guess of the authors); if two or more tasks load the same body region, the durations of these tasks are to be taken together.

Neck and upper back

- **Green:**
 - head inclination 0° - 25° and neck flexion (i.e. head inclination minus trunk inclination) 0° - 25° .

- **Green/yellow/red:**
 - head inclination 25° - 85° ;
 - with full trunk support, consult an expert for evaluating holding time - recovery time regimes (see ISO/CD 11226); if that is not possible, the evaluation result is yellow in the case of a task duration of between 1 and 4 hours, whereas it is red in the case of a task duration >4 hours (expert guess of the authors); if two or more tasks load the same body region, the durations of these tasks are to be taken together;
 - without full trunk support, the holding time for trunk inclination is critical, and should be evaluated.

- **Yellow/red:**
 - head inclination $<0^{\circ}$;
changing to **green** in the case of full head support;
 - head inclination $>85^{\circ}$;
 - neck flexion (head inclination minus trunk inclination) $<0^{\circ}$ (i.e. neck extension) or $>25^{\circ}$;
 - asymmetric neck posture, i.e. axial rotation and/or lateral flexion of the head versus the upper part of the trunk.

Other joints

The following conditions are **yellow/red**:

- extreme joint positions;
- for a kneeling position: no adequate knee protection;
- for standing (except when using a buttock rest): flexed knee;
- for sitting: knee angle $>135^{\circ}$ (180° = the upper leg in line with the lower leg), unless the trunk is inclined backwards and fully supported (as in car driving);
- for sitting: knee angle $<90^{\circ}$ (1) (180° = the upper leg in line with the lower leg).

Pedal operation

The following conditions are **yellow/red**:

- standing;
- sitting, leg-actuated;
- sitting, ankle-actuated, force exertion >5.5 kgf;
- sitting, ankle-actuated, pedal operating already by merely supporting foot weight.

General

The following conditions are **yellow**:

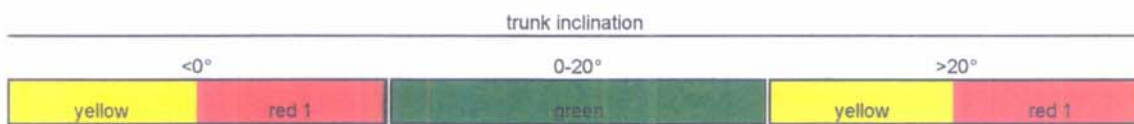
- standing continuously ≥ 1 hour/day;
- standing for a total of distinct periods ≥ 4 hours/day.

Arbouw Foundation - Guideline on repetitive work

(mainly based on NF X 35-106, 1985, and prEN 1005-4, 1996)

It is recommended to use the guidelines below to be begin with on tasks lasting longer than 1 hour (continuous or a total of distinct periods) per working day (N.B. shorter task durations cannot be considered safe in all cases). If two or more tasks load the same body region (through static postures and/or repetitive work), the durations of these tasks are to be taken together. It is recommended to interpret the results of guideline application in relation to the complaints and disorders of the particular body region found for the group of employees involved. An evaluation result yellow/red becomes yellow in the case of a task duration of between 1 and 4 hours, whereas it becomes red in the case of a task duration >4 hours.

Low back



- Asymmetric trunk posture (axial rotation and/or lateral flexion): yellow red 1.
- 1 An increased health risk is present if ≥ 2 /minute an evaluation result yellow/red is found (N.B. lower frequencies cannot be considered safe in all cases).

Shoulder and shoulder girdle



- Upper arm retroflexion (i.e. elbow behind the trunk when viewed from the side of the trunk), upper arm adduction (i.e. elbow not visible when viewed from behind the trunk), or extreme upper arm external rotation: yellow red 1.
 - Raised shoulder: yellow red 1.
- 1 An increased health risk is present if ≥ 2 /minute an evaluation result yellow/red is found (N.B. lower frequencies cannot be considered safe in all cases).

Neck and upper back

- **Green:**

- neck flexion (i.e. head inclination minus trunk inclination) 0° - 25° .

- **Yellow/red:**

- neck flexion (head inclination minus trunk inclination) $<0^{\circ}$ (i.e. neck extension) or $>25^{\circ}$ (1);
- asymmetric neck posture, i.e. lateral flexion and/or extreme axial rotation of the head versus the upper part of the trunk (1).

- 1 An increased health risk is present if ≥ 2 /minute an evaluation result yellow/red is found (N.B. lower frequencies cannot be considered safe in all cases).

Other joints

The following conditions are *yellow/red*:

- extreme joint positions (1);
- for a kneeling position: no adequate knee protection;
- for standing (except when using a buttock rest): flexed knee (1);
- for sitting: knee angle $>135^{\circ}$ (1) (180° = the upper leg in line with the lower leg), unless the trunk is inclined backwards and fully supported;
- for sitting: knee angle $<90^{\circ}$ (1) (180° = the upper leg in line with the lower leg).

- 1 An increased health risk is present if ≥ 2 /minute an evaluation result yellow/red is found (N.B. lower frequencies cannot be considered safe in all cases).

Pedal operation

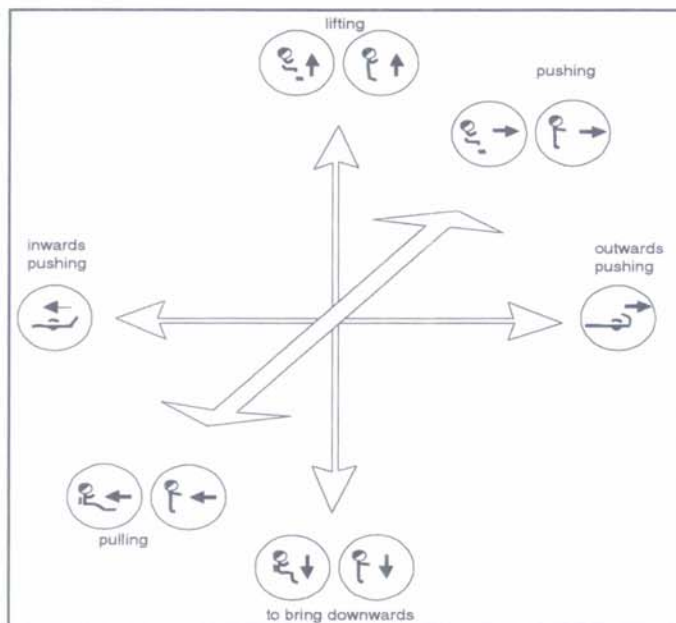
The following conditions are *yellow/red*:

- standing;
- sitting, leg-actuated.

Force exertion







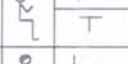

The tables below distinguish between general force limits and specific force limits.

- A. General force limits, i.e. one-handed or two-handed, sitting or standing, almost all directions (N.B. also including directions in between the main directions shown in the figure).



A	force			
	green	yellow limit	yellow	red limit
frequency				
≥2 and <3 /minute	3.0 kgf		6.5 kgf	
≥3 and <4 /minute	2.0 kgf		4.0 kgf	
≥4 and <5 /minute	1.5 kgf		3.0 kgf	
≥5 /minute	1.0 kgf		2.5 kgf	

B. Specific force limits. 1 = fore/aft direction; 2 = upward/downward direction; 1,2 = force limits are also valid for combined fore/aft and upward/downward directions. For one-handed pinching and pedal operation: see NF X 35-106.

push, sitting with back support (1)	
push, two handed, standing (1)	
pull, sitting with foot support (1)	
pull, two handed, standing (1)	
downward force, two handed, standing (2)	
upward force (lift), two handed, standing (2)	
turning a wheel, two handed sitting	
turning a wheel, two handed, standing	

B frequency	force	
	green yellow limit	yellow red limit
≥2 and <3 /minute	8.0 kgf	18.0 kgf
≥3 and <4 /minute	5.0 kgf	11.5 kgf
≥4 and <5 /minute	3.0 kgf	7.0 kgf
≥5 /minute	2.0 kgf	4.5 kgf

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