IFA
Institut für Arbeitsschutz der
Deutschen Gesetzlichen Unfallversicherung

Evaluation of physical work load in accordance with DGUV Information 208-033 (formerly BGI/GUV-I 7011) (Annex 3)

Annex 3 of DGUV Information 208-033 [1] (formerly BGI/GUV-I 7011) states a number of methods for the assessment of physical work load in accordance with Stage 3 – support by external specialists.

An example of such an assessment method is referred to below by way of the measured variables and principles of assessment of the CUELA[1] measurement method. This method employs a personal measurement system for the objective recording of physical work load (see also e.g. Ellegast et al. 2000; Hoehne-Hückstädt et al. 2007 [2, 3]).

Part 1 shows, in tabular form, the **angular ranges** of a number of body joints, classified in accordance with the traffic-light model (red/amber/green). The parameters, directions of movement, and literature upon which classification is based are stated in each case for the head, torso, and upper and lower extremities.

In consideration of the scale of physiological movement, the angle categories are classified as neutral/acceptable (green), medium/conditionally acceptable (amber) or terminal/unacceptable (red).

Important: parameters such as duration, frequency, dynamics of movements, statics of postures, or external circumstances (e.g. posture with the upper body or arm supported) are not considered in the classification of the angular ranges. These conditions (refer also to the secondary conditions stated in the standard) must also be considered during evaluation of the joint position or body posture under analysis.

Part 2 also shows the **moments and forces**, in addition to the angles. The CUELA measurement method includes evaluation strategies for:

- Moments and compressive forces of the intervertebral discs in the region of the lower (lumbar) spine
- Moments in the shoulder joint
- Hand forces

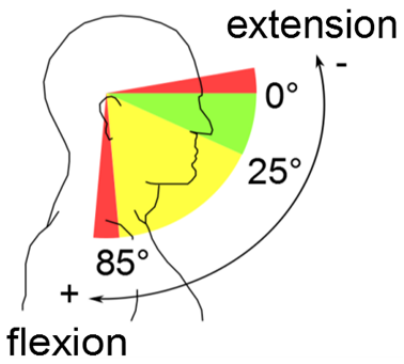
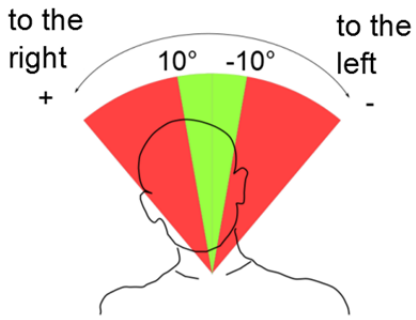
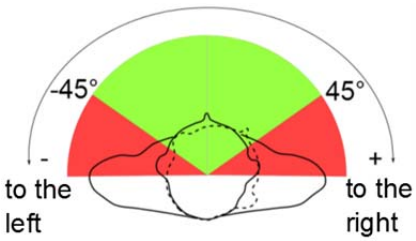
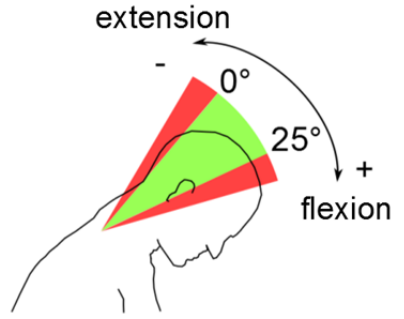
Part 3 contains special criteria for the recording and evaluation of **manual working processes**.

Overall, it must be considered that evaluation of all parameters stated delivers only individual criteria for the overall assessment of a task or working process.

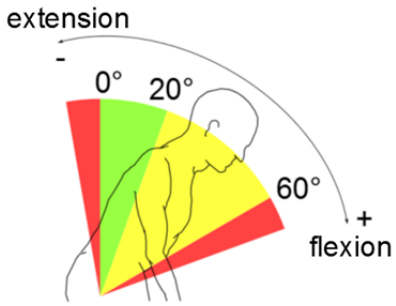
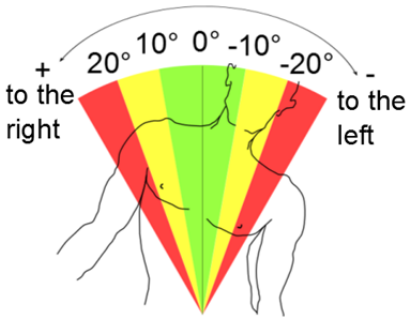
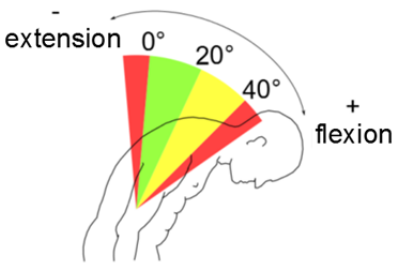
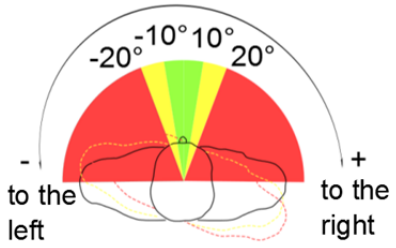
[1] CUELA: computer-based measurement and long-term analysis of stresses upon the musculoskeletal system

1 Angle ranges of different joints of the body

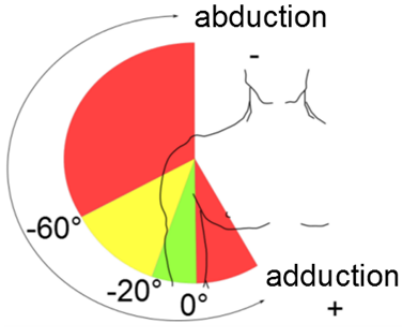
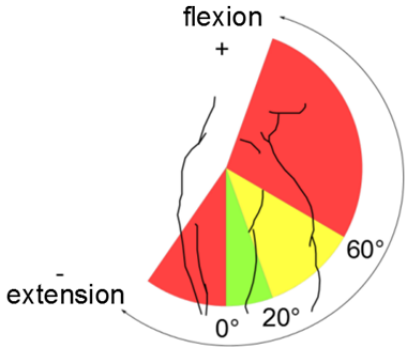
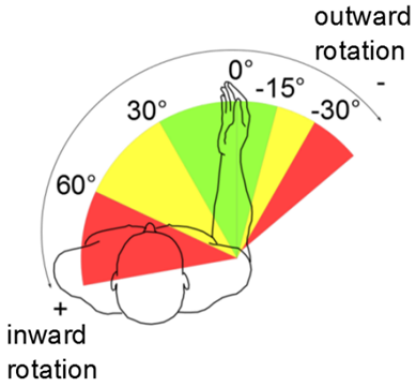
a) Head and neck

Parameter	Direction of movement	Guideline values for evaluation [°]	
Inclination of the head 	**+**: forwards (flexion) **–**: backwards (extension)	**green:** **yellow:** **red:** **red:**	**0 to 25** **25 to 85** **> 85** **< 0** **with reference to ISO 11226 [4]** (without consideration of the secondary conditions stated in the standard)
Lateral head inclination 	**+**: to the right **–**: to the left	**green:** **red:** **red:**	**-10 to 10** **< -10** **> 10** **with reference to EN 1005-4 [5]** (without consideration of the secondary conditions stated in the standard)
Neck torsion 	**+**: to the right **–**: to the left	**green:** **red:** **red:**	**-45 to 45** **< -45** **> 45** **with reference to EN 1005-4 [5]** (without consideration of the secondary conditions stated in the standard)
Bending of the neck 	**+**: forwards (flexion) **–**: backwards (extension)	**green:** **red:** **red:**	**0 to 25** **> 25** **< 0** **with reference to ISO 11226 [4]** (without consideration of the secondary conditions stated in the standard)

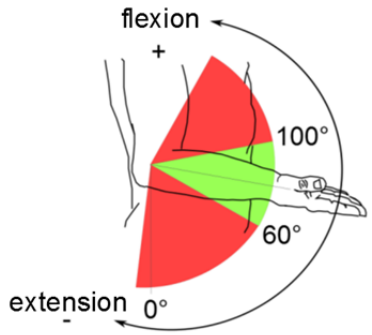
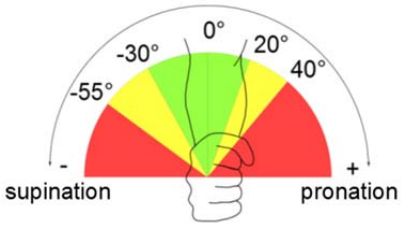
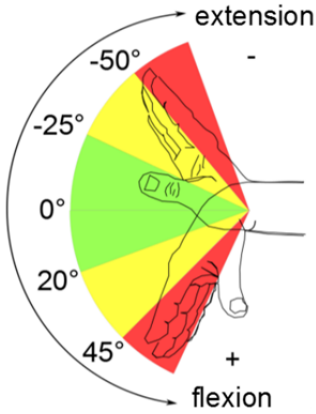
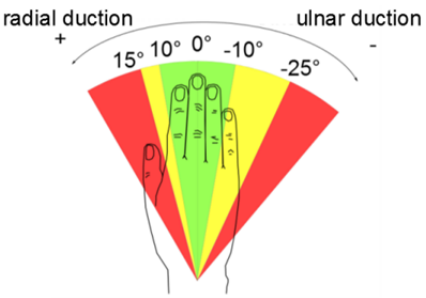
b) Upper part of the body and trunk

Parameter	Direction of movement	Guideline values for evaluation [°]	
Inclination of the trunk 	**+**: forwards (flexion) **–**: backwards (extension)	**green:** **yellow:** **red:** **red:**	**0 to 20** **20 to 60** **> 60** **< 0** **with reference to ISO 11226 [4] and EN 1005-4 [5]** (without consideration of the secondary conditions stated in the standard)
Lateral inclination of the trunk 	**+**: to the right **–**: to the left	**green:** **yellow:** **yellow:** **red:** **red:**	**-10 to 10** **-10 to -20** **10 to 20** **< -20** **> 20** **with reference to ISO 11226 [4] and supplemented by Drury 1987 [6]** (without consideration of the secondary conditions stated in the standard)
Bending of the back 	**+**: forwards (flexion) **–**: backwards (extension)	**green:** **yellow:** **red:** **red:**	**0 to 20** **20 to 40** **> 40** **< 0** **own assessment with reference to EN 1005-4 [5]**
Back torsion 	**+**: to the right **–**: to the left	**green:** **yellow:** **yellow:** **red:** **red:**	**-10 to 10** **-20 to -10** **10 to 20** **< -20** **> 20** **own assessment with reference to EN 1005-4 [5]**

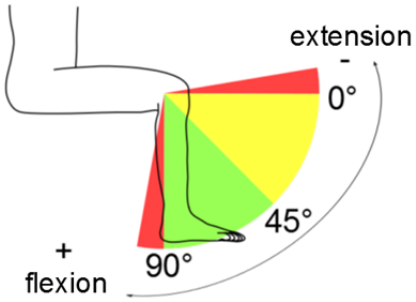
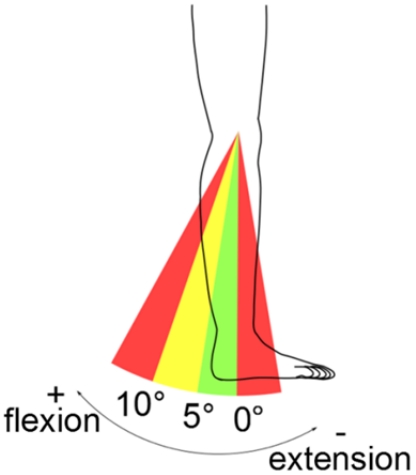
c) Shoulder/upper arms

Parameter	Direction of movement	Guideline values for evaluation []	
Shoulder joint adduction/abduction of the upper arm  	**+**: towards the body (adduction) **–**: away from the body (abduction)	**green:** **yellow:** **red:** **red:**	**0 to -20** **-20 to -60** **< -60** **> 0** **with reference to ISO 11226 [4] and EN 1005-4 [5]** (without consideration of the secondary conditions stated in the standard)
Shoulder joint flexion/extension of the upper arm  	**+**: forwards (flexion) **–**: backwards (extension)	**green:** **yellow:** **red:** **red:**	**0 to 20** **20 to 60** **< 0** **> 60** **with reference to EN 1005-4 [5]** (without consideration of the secondary conditions stated in the standard)
Shoulder joint rotation of the upper arm  	**+**: inwards (inward rotation) **–**: outwards (outward rotation)	**green:** **yellow:** **yellow:** **red:** **red:**	**-15 to 30** **-15 to -30** **30 to 60** **< -30** **> 60** **own assessment with reference to Drury, 1987 [6]**

d) Elbow, arm and hand

Parameter	Direction of movement	Guideline values for evaluation [°]	
Elbow joint flexion/extension of the forearm  	**+**: bending of the forearm (flexion) **–**: stretching of the forearm (extension)	**green:** **red:** **red:**	**60 to 100** **< 60** **> 100** **with reference to McAtamney und Corlett, 1993 [7]**
Elbow joint pronation/supination of the forearm  	**+**: palm of the hand downwards (pronation) **–**: palm of the hand upwards (supination)	**green:** **yellow:** **yellow:** **red:** **red:**	**-30 to 20** **-30 to -55** **20 to 40** **< -55** **> 40** **with reference to Drury, 1987 with 6]**
Wrist flexion/extension of the hand  	**+**: towards the palm (flexion) **–**: towards the back of the hand (extension)	**green:** **yellow:** **yellow:** **red:** **red:**	**-25 to 20** **-25 to -50** **20 to 45** **< -50** **> 45** **with reference to Drury, 1987 [6]**
Wrist radial/ulnar duction  	**+**: towards the thumb (radial duction) **–**: towards the little finger (ulnar duction)	**green:** **yellow:** **yellow:** **red:** **red:**	**-10 to 10** **-10 to -25** **10 to 15** **< -25** **> 15** **with reference to Drury, 1987 [6]**

e) Lower extremities, knee joints

Parameter	Direction of movement	Guideline values for evaluation [°]	
Knee joint angle of the knee seated  	**+**: bending of the lower leg (flexion) **–**: stretching of the lower leg (extension)	**green:** **yellow:** **red:** **red:**	**45 to 90** **0 to 45** **< 0** **> 90** **with reference to ISO 11226 [4]** (without consideration of the secondary conditions stated in the standard)
Knee joint angle of the knee standing  	**+**: bending of the lower leg (flexion) **–**: stretching of the lower leg (extension)	**green:** **yellow:** **red:** **red:**	**0 to 5** **5 to 10** **< 0** **> 10** **with reference to ISO 11226 [4]** (without consideration of the secondary conditions stated in the standard)

Besides this angle classification, the body postures are assessed in accordance with the **OWAS method** (Karhu 1977 [8]).

2 Forces and moments

Parameter	Guideline values for evaluation	
L5/S1 moments [Nm] 3D lever arm from the centre of the hand to L5/S1	**green:**	**0 to 40**
	yellow:	**40 to 80**
	orange:	**85 to 135**
	red:	**> 135**
		with reference to Tichauer, 1978 [9]
L5/S1 compressive force [kN]		**males**
	green:	**0.7 to 2.3**
	yellow:	**2.3 to 3.2**
	red:	**> 3.2**
		females
	green:	**0.7 to 1.8**
	yellow:	**1.8 to 2.5**
	red:	**> 2.5**
		with reference to "Dortmunder" guideline values, Jäger et al., 2001 [10]
shoulder joint moments [Nm] sum for both shoulder moments during the handling of loads or manual exertion of force	**green:**	**0 to 40**
	yellow:	**40 to 80**
	orange:	**80 to 120**
	red:	**> 120**
		with reference to Tichauer, 1978 [9]
hand forces [N]		**for evaluation, see: ISO 11228 Parts 1 and 2 [11, 12]**

3 Recording and evaluating manual working processes

Parameters

- Static postures (> 4 s)
- Repetition
  - Frequency of the joint movement in one plane around the mid-value
    With reference to Kilbom 1994 [13]
  - Measurement and evaluation report, with reference to Hansson et al. (2004 and 2009) [14, 15]
    - Median of the angular velocity for wrist flexion/extension ωwr [°/s]
    - Median of the mean power frequency (MPF) for wrist flexion/extension MPF_{wr} [Hz]
    - Proportion of kinematic micro-pauses [%]
      (ω_{wr} < 1°/s, t ≥ 0.5 s, wrist)
- Force exerted by the hands/strain upon the forearm muscles
  - Measurement and evaluation report, with reference to Hansson et al. 2004 and 2009 [14, 15]
    - Proportion of muscular physiological micro-pauses [%]
      (%MVC < 0.5, t ≥ 0.5 s)
    - P10 of the %MVC values (forearm EMG, static component)
    - P90 of the %MVC values (forearm EMG, dynamic component)
  - Measurement and evaluation report, with reference to Silverstein et al. 1986 [16]
    - Adjusted forearm EMG = MW[%MVC] + Var[%MVC]/MW[%MVC]
    - Adjusted grip force = F_{max} × adjusted forearm EMG [N]

Literature

[1] DGUV-Information 208-033 (bisher: BGI/GUV-I 7011): Belastungen für Rücken und Gelenke – was geht mich das an? (09.13). Hrsg.: Deutsche Gesetzliche Unfallversicherung, Berlin 2013

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[3] Hoehne-Hückstädt, U.; Herda, C.; Ellegast, R.P.; Hermanns, I.; Hamburger, R.; Ditchen, D.: Muskel-Skelett-Erkrankungen der oberen Extremität. BGIA-Report 2/2007. Eds.: Hauptverband der gewerblichen Berufsgenossenschaften, Sankt Augustin 2007

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[7] McAtamney, L.; Corlett, E.N.: RULA: a survey method for the investigation of work-related upper limb disorders. Appl. Ergon. 23 (1993) No 2, pp. 91-99

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[13] Kilbom, Å.: Repetitive work of the upper extremity: Part I – Guidelines for the practitioner. Int. J. Indust. Ergon. 14 (1994) pp. 51-57

[14] Hansson, G.; Balogh, I.; Ohlsson, K.; Skerfving, S.: Measurements of wrist and forearm positions and movements: effect of, and compensation for, goniometer crosstalk. J. Electromyogr. Kinesiol. 14 (2004) pp. 355-367

[15] Hansson, G.; Balogh, I.; Ohlsson, K.; Granqvist, L.; Nordander, C.; Arvidsson, I.; Akesson, I.; Unge, J.; Rittner, R.; Strömberg, U.; Skerfving, S.: Physical workload in various types of work: Part I. Wrist and forearm. Int. J. Indust. Ergon. 39 (2009) pp. 221-223

[16] Silverstein, B.; Fine, L.; Armstrong, T.: Hand wrist cumulative trauma disorders in industry. Brit. J. Ind. Med. 43 (1986) pp. 779-784