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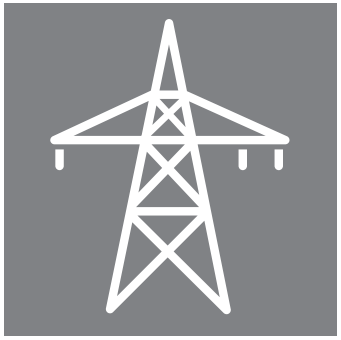

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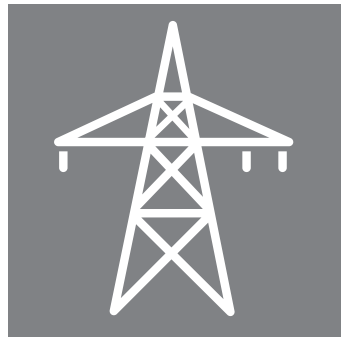
Guide for Risk Assessment in Small and Medium Enterprises

2 Hazards arising from Machinery and other Work Equipment

Indentification and Evaluation of Hazards; Taking Measures



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Section for Electricity
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Guide for Risk Assessment in Small and Medium Enterprises

2

Hazards arising from Machinery and other Work Equipment

Identification and Evaluation of Hazards; Taking Measures

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Section for Electricity
Section for Iron and Metal
Section for Machine and System Safety

Imprint

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Introductory Note

This brochure seeks to meet the requirements of risk assessment in relation to machinery and other work equipment.

It is structured as follows:

1. **Basic Information**
2. **Risk Assessment and Taking Measures**
   - **Step 1: Hazard Identification**
   - **Step 2: Risk Estimation and Risk Evaluation**
   - **Step 3: Selecting and Taking Measures**

Note:

This brochure is dealing exclusively with the European aspects, laid down in the directive for protection of workers at work (89/391/EEC and special directives). For specific national aspects please look up the respective legal transpositions (see Annex I).

This brochure does not deal with the documentation of risk assessment because procedures differ considerably from one member state to another (Annex II: Example for documentation).

Other topics treated in this series of brochures organised along the same lines and already published or being prepared are:

- **Noise**
- **Chemical hazards**
- **Hazards arising from electricity**
- **Hazards arising from fire and explosions**
- **Hazards arising from whole-body/hand-arm vibrations**
- **Slipping and falling from a height**
- **Physical strain (e.g. heavy and one-sided work)**
- **Mental workload**

1. Basic Information

1.1 | Legal basis – Health and Safety at Work

The Work Equipment Directive 89/655/EEC (30. December 1989, 2nd individual directive under Framework Directive for Safety and Health of Workers at Work 89/391/EEC) including Directive 95/63/EEC and Directive 2001/45/EEC (amending Directive 89/655/EEC) represents the legal basis governing minimum requirements for the protection of workers from hazards caused by machinery and other work equipment. This Directive provides minimum standards concerning the safety and health requirements for the use of work equipment (including machinery) by workers at work. The Directive has to be implemented in every country of the European Union in national law.

Work equipment:
Any machine, apparatus, tool or installation used at work.

1.2 | Legal Basis – Provisions for Manufacturers

The manufacturers of machinery have to adhere to safety provisions for design and construction of machinery (before they are placed on the market); users must be able to rely on the adherence to such provisions. Hence, there is a clear connection between provisions for manufacturers and users of machinery (Fig.1).

Legislation of special importance in the context of machinery safety includes the Machinery Directive 98/37/EC of 22 June 1998, which serves as a legal basis for manufacturers and sellers of machinery (as from 29.12.2009 the new Machinery Directive 2006/42/EC of 17 May 2006 will apply). The Machinery Directive must be adhered in the following cases:

- whenever machinery is placed on the market for the first time within the EU after 1.1.1995,
- whenever machinery is self-built by the users in a business operation,
- whenever significant and safety relevant changes are made on machines,
- whenever there are close interconnections between several machines (assemblies of machinery).

In addition to Machinery Directive, there are other Directives with requirements for manufactures of machinery, for example low voltage Directive 2006/95/EC, pressure equipment Directive 97/23/EEC or Directive 2004/108/EC on electromagnetic compatibility.

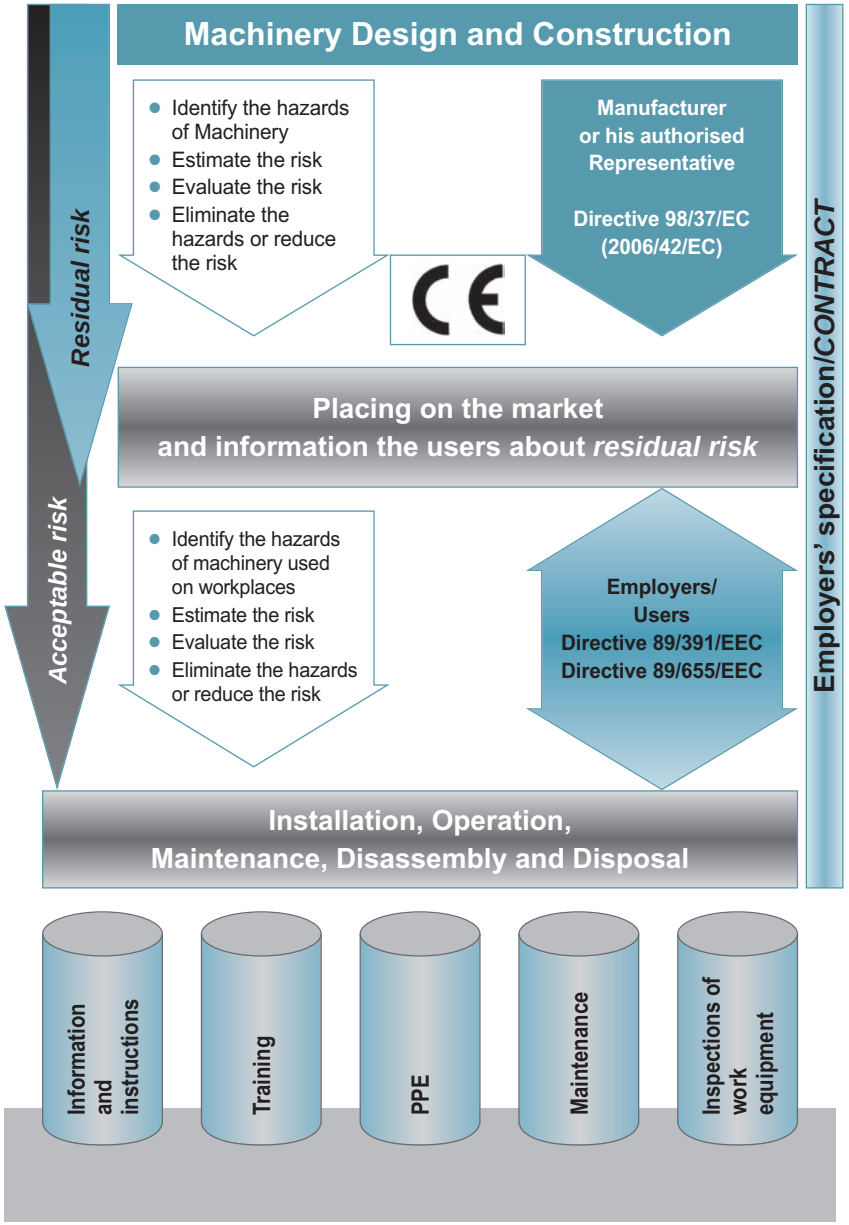


Figure 1: Legislative manufacturers' and employers' machinery safety obligations

CE marking on machinery (Fig.2) certifies that machinery is in compliance with all relevant Directives.

If there aren´t any specific Directives with requirements for manufacturers of work equipment the Directive 2001/95/EC on general product safety must be adhered.

Figure 2: CE marking on machinery

1.3 Responsibilities of Employers concerning Machinery Safety and Safety of other Work Equipment

The employers are obliged to **select and to make available machinery/work equipment that is suitable for the proposed purpose** and to the specific working conditions so that it may be used by workers without impairment to safety and health:

What is your (employer) duty, before you buy new or used machinery?

- Does the product of the manufacturer intended fit your needs (see Annex III)?
- Did you check the safe realization of maintenance, fault clearance and trouble shooting according to the operating instruction?
- Did you define and check the qualification of the workers (also for maintenance, troubleshooting)?
  - Is additional training required?
- Did you check the environmental/ambient effects (noise, dust, hazardous substances)?
- Did the manufacturer take measures for risk reduction (e.g. noise reduction)?

Did you get all *(safety-related)* **documentation when buying machinery:**

- EC declaration of conformity
- CE marking
- instructions and drawings, e.c. have to contain all information stated in the Machinery Directive
- instruction manual (including residual risks in the respective national language).

It is advised to include relevant safety requirements and rules in the sales contract when buying machinery or other work equipment.

Where it is not fully possible that machine can be used by workers without risk to their safety or health, the employer has to assess all **hazards** for safety and health of the workers caused by the use of machinery/work equipments. At a next step he has to determine appropriate **measures to minimize the risks**.

The employer has to organize appropriate **inspections** carried out by competent persons for machinery/work equipment exposed to conditions causing deterioration which is liable to result in dangerous situations.

Qualification of competent persons is laid down in national regulations. The demanded qualification and frequency of inspection is a documented process and laid down in the legal requirements.

2. Risk Assessment and Taking Measures

Assessment of risk caused by machinery or other work equipment is a part of work place assessment required by Directive 89/391/EEC.

Steps of risk assessment and taking measures

When assessing the risks caused by machinery and other work equipment the following procedure can be used (Fig.3):

Step 1: Hazard Identification

Pursuant to Article 3 of the Directive, the hazards that may arise from using the work equipment have to be identified.

Step 2: Risk Estimation and Risk Evaluation

The risk of an accident is determined on the basis of the factors “severity of damage” and “probability of damage”.

Step 3: Selecting and Taking Measures

Measures must, to the greatest possible extent, aim at removing or at least minimizing hazards. If this is not possible, appropriate protective devices must be put in place. Any possible residual hazards must be covered by person-related measures (training, PPE, instructions).

For identification of hazards, the employer has to collect the following information:

- Existing relevant **rules and directives** concerning use of machinery or other work equipment,
- **Manufacturers' instructions** for machinery with information about **residual risks**,
- **Records** of work accidents and occupational diseases,
- **Knowledge and experience** about hazards of employees,
- **Specific work place condition**.

Identification of hazards has to include **all life cycle phases** of machinery/work equipment, e. g. assembly, installation, setting and adjustments, operation, maintenance, disassembly and disposal.

It is not the task of the employer to repeat or proof the hazard analysis of the manufacturer (according Directive 2006/42/EC) but to identify the residual level of risks for the employees working with machine/work equipment arising from specified hazards and to control these risks by specific measures!

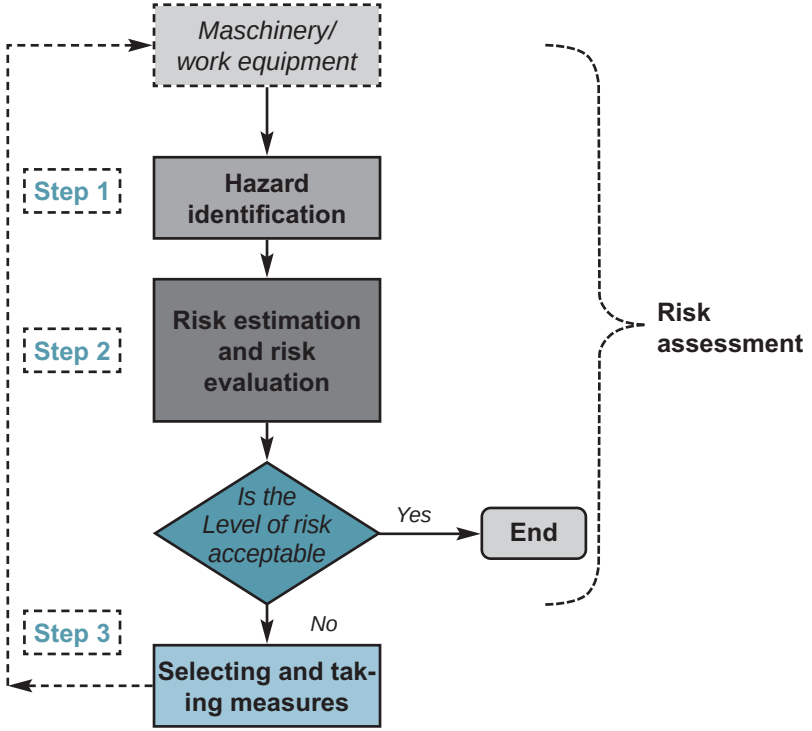


Figure 3: Iterative process of risk assessment – risk management

Step 1: Hazard Identification

Checklist for the process of hazards identification
(Machinery or other Work Equipment)

Work area: _____ Control no.: _____

Checked by: _____ Date: _____

Type of machine or work equipment: _____

Type of hazard group	Specification of hazards	Exists	Mitigation applied Yes	Mitigation applied No	Specification of existing mitigations
• Mechanical	○ Unprotected moving machine parts, e.g.cutting/ stitching, catching, crushing, shearing				2006/42/EC
	○ Parts with dangerous surfaces, e.g.corners edges, sharp points, blades, roughness				2006/42/EC
	○ Slipping, tripping, falling, twisting one`s foot; falling from height				2006/42/EC
	○ Uncontrolled moving parts, e.g. tilting, swinging, rolling sliding, thrownout parts/loads				2006/42/EC
	○ Movable transportation equipment/ work equipment, e.g. bumping, hiting, running over, tilting, falling down				
• Electrical	○ Contact to parts under voltage ○ Electric arcs				2006/95/EC
	○ Eletrostatic load				
• Thermal	○ Hot medium/ surface				
	○ Cold medium/ surface				
• Noise	○ Exposure limit values exceeded (from surrounding, nearby machine)				2003/10/EC
• Vibration	○ Whole body vibrations				2002/44/EC
	○ Hand-arm vibrations				2002/44/EC
• Radiation	○ Radioactive				
	○ Electro-magnetic				2004/40/EC
	○ Non ionising, e.g. Laser				2006/25/EC
	○ Ionising, e.g. X-ray				
• Hazardous substances	○ Hazardous gases, vapours, aerosols, liquids, solids				98/24/EC
	○ Biological substances				2000/54/EC
	○ Explosive/flammable substances				1999/92/EC
• Ergonomics	○ Necessity to handle heavy loads				90/269/EEC
	○ Repetitive activity ○ Static posture work				
• Combination or specific hazards from workplace	○ Pollution				89/654/EEC
	○ Lightening (not enough)				
	○ Dust and noise				
	○ Climate				

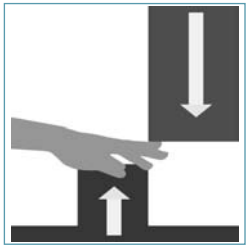
Comment: Please keep in mind that this checklist is only an aid and a basis for further deliberations.

Picture 4 shows examples for mechanical hazards.

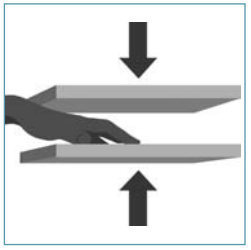
■ ***cutting***

■ ***catching***

■ ***shearing***



■ ***shearing***



■ ***crushing***

Figure 4: Examples of mechanical hazards

Step 2: Risk Estimation and Risk Evaluation

When carrying out risk evaluation there should be used regulations or standards containig specific requirements or threshold values concerning hazards of machinery and other work equipment.

When there are no such limits in the regulations the risks have to be evaluated as a combination (R = P x D) of the following factors:

- The expected severity of a damage (P).
- The probability of such damage to occur (D).

The factor damage severity

There are several approaches to define the expected severity of a damage; this brochure relies on estimations of the expected duration of incapacity to work (number of days on sick leave) as a basis.

The factor probability

The probability of damage (an accident) occurring depends on several factors, with the following three aspects being the main contributors:

1. probability due to the type of machinery or/and work,
2. duration of stay in the danger zone,
3. possibility of avoiding or limiting the harm.

The first factor is mainly machinery-related and can also be derived from accident statistics for machinery; the second factor depends on purely organizational matters which are inherent in the undertaking; and third factor related on personal skills and knowledge how he/she can react on hazard situation (level of instructions, training, warning equipments).

Please note:

EN 14121-1 and EN 954-1(EN ISO 13849-1) list an additional factor, “possibility of averting danger”. This factor needs to be taken into consideration under the first item in this section.

Risk assessment

Generally spoken, the appraisal of risks relates the potential severity of damage to the probability of damage occurring. Risk appraisal aims at helping to assess reasonable practical expenditure and the degree of urgency which further measures need to be taken with, whilst always taking into account that the legal minimum requirements have to be met.

Risk assessment and primarily risk appraisal have to be done whenever general protection objectives have to be met in a specific undertaking or if measures beyond the minimum standards are taken.

On the basis of risk appraisal, measures must be taken; in this context, the following general rule applies:

> The higher the risk (in this case, the risk category) the more urgently measures need to be taken.

Model for risk appraisal:

For every hazard determined a risk group can be determined according to the following matrix. This matrix is only one possible way, there exist also other procedures.

The need for action to reduce risk is determined by the risk accepted in the enterprise. In any case the minimum legal requirements have to be met.

Possible extent of damage (D) / *Probability (P) of occurrence of damage*	**Light injuries or illness**	**Medium injuries or illness**	**Serious injuries or illness**	**Possible death, catastrophe**
very low	**1**	**2**	**3**	**4**
low	**2**	**3**	**4**	**5**
medium	**3**	**4**	**5**	**6**
high	**4**	**5**	**6**	**7**
Measured value	***Risk***	***Description***		
1 – 2	Low	Risk acceptable		
3 – 4	Significant	Reduction of risk necessary		
5 – 7	High	Reduction of risk urgently necessary		

Table 1: Risk appraisal/ risk matrix

Step 3: Selecting and Taking Measures

For determination of measures you should take into account the relevant legal requirements/rules for machinery/work equipment.

Prioritization of measures

Regarding the hazards related to machinery or other work equipment, people often tend to jump to the conclusion that training or personal protective equipment is enough without thinking about measures that are more far-reaching:

> Removal or minimization of hazards takes priority over technical measures, and these take priority over person-related measures!

More specifically, measures can be prioritized as follows in the case of machinery:

1. **removal or minimization of hazards,**
2. **technical protective measures,**
3. **organizational measures,**
4. **person-related measures (PPE).**

The following overview has been compiled to give guidance in respect of the individual groups of measures.

to 1.: Removal or minimization of hazards

When it comes to identifying the right measures, the first question will always be whether a danger can be removed altogether or if the residual risk can be reduced to an acceptable minimum. Since measures of this kind usually concern the structure or **design of machinery**, it will be a responsibility of the designer and manufacturer of machinery (Fig. 5).

■ ***crushing hazard***

■ ***no crushing hazard***

Figure 5: Example of hazard removal

The next step on the way to safe machinery is to keep **safety distances**, i.e. to prevent persons from entering danger zones in the first place. The standard EN ISO 13857 lists relevant safety distances to prevent danger zones being reached by the upper and lower limbs, respectively.

Here some examples for safety distances (Fig. 6).

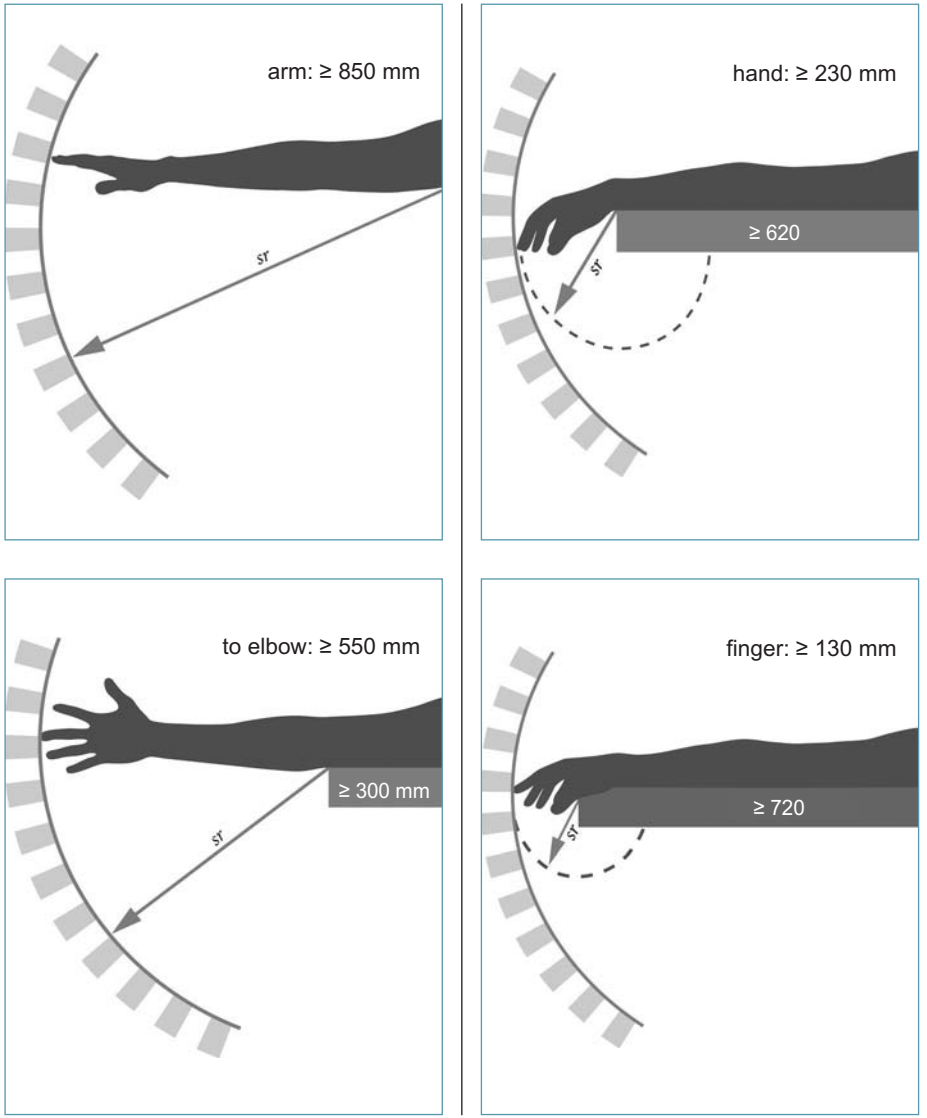


Figure 6: Examples of safety distances (feed opening ≤ 120mm)

to 2.: Technical protective measures

Most of technical protective measures concern construction or design of machinery and so the designer and manufacturer is responsible. But it can be necessary to meet further technical protective measures concerning specific working conditions of machinery/work equipment.

In general **safeguards** are classified in the EN 12100-2 as follows:

- guards,
- protective devices.

Examples see Fig. 7-9.

Guards and protective devices shall:

- be robust of construction,
- not give rise to any additional hazard,
- not be easy to by-pass or render non-operational,
- be located at an adequate distance from the danger zone,
- cause minimum obstruction to the view of the production process,
- enable essential work to be carried out on installation and/or replacement of tools and also for maintenance by restricting access only to the area where the work has to be done, if possible without the guard or protective device having to be removed.

Users of machinery with protective devices must make sure that the protective devices:

- are always in place and used,
- are always functional and ready for use (visual inspection prior to use),
- are used properly and as intended,
- (if necessary) are properly set or adjusted,
- are never avoided or disabled.

Selection of the appropriate safeguards

When selecting protective devices (Fig. 7, 8), the following aspects have to be taken into account:

- type of machinery operation (retooling, exchange of work pieces, tool changes, maintenance …),
- complexity of workflows,
- ergonomic considerations,
- safeguards must not obstruct the workflow,
- safeguards must not block visual inspection and access,
- safeguards must not cause new hazards (e.g. spots where body parts may be crushed),
- operators must not be tempted to remove the protective devices.

Protective devices must be integrated in the machinery as smoothly as possible and should not obstruct to the greatest extent possible the operator or the workflow!

Examples for safeguards:

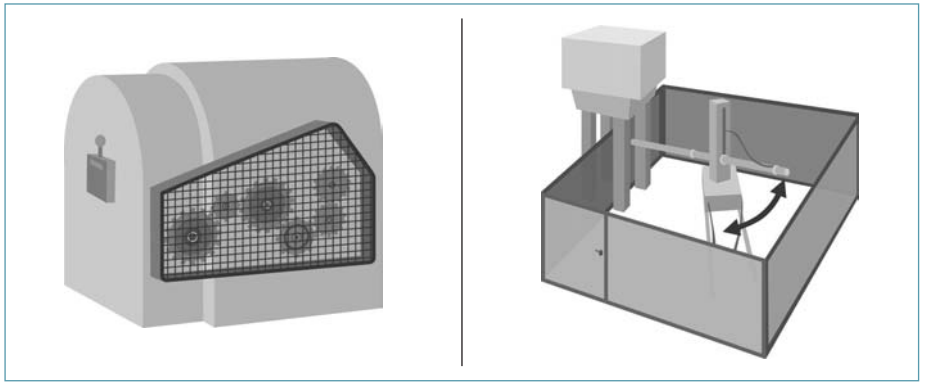


Figure 7: Guards – safety guard and safety fence

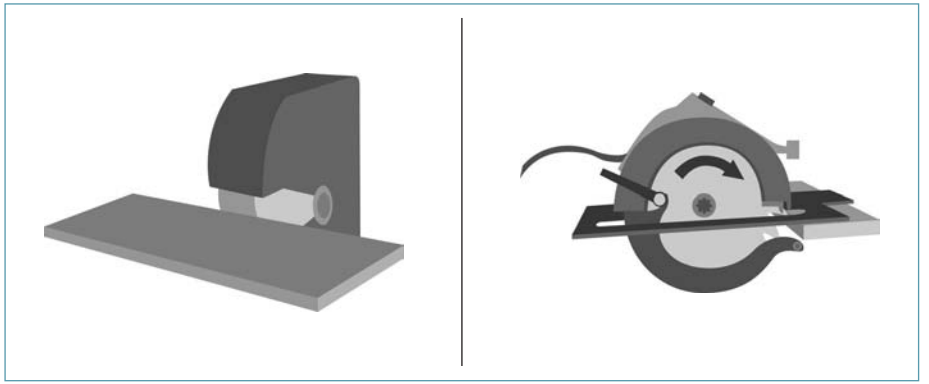


Figure 8: Guards – protective covers

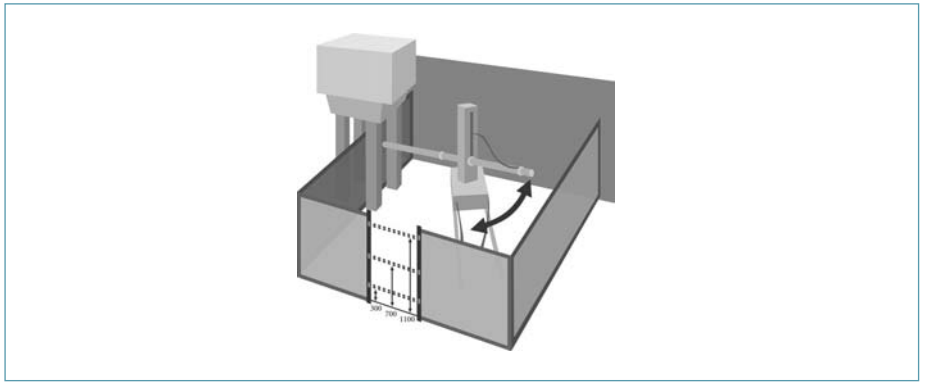


Figure 9: Protective devices – light barrier

to 3.: Organisational measures

Organisational measures should be seen as very individualized and tailored to the needs of the undertaking. Employers may reduce risks by means of appropriate organizational measures, such as:

- allowing only a minimum number of persons to be in a danger zone,
- increasing the distance to an emission source, e.g. noisy machinery, for workers who do not operate the machinery,
- work processes and workflows optimized for safety,
- the establishment of specific qualification requirements,
- minimum age for the use of certain types of machinery,
- establishment of prohibited access to the work area,
- marking danger zones,
- making arrangements for special training for workers with especially hazardous working conditions or using particularly hazardous work equipment,
- periodic **instructions**,
- periodic **inspections** of machinery/work equipment.

Requirements for instructions

Instructions will have to cover the following content:

- starting-up and running the machinery,
- if applicable, installation and dismantling,
- fault-removal during work and procedures in case of breakdowns,
- if applicable, tooling of work equipment,
- appropriate protective devices for the required purpose and how they work,
- other person-related protective measures, as required.

Instruction should be organized and designed as follows:

- it should be documented and comprehensible,
- workers must be given new instruction whenever new machinery and work processes are introduced or existing ones are changed,
- it must be adapted to the development of hazards and the emergence of new risks,
- it must also include measures to be taken in case of foreseeable breakdowns,
- if required, instruction must be repeated at regular intervals, and in any case when wrong and improper behaviour of workers is noticed,
- instructions must be clear and intelligible, the employer has to make sure that everything has been understood.

It is the employer's obligation under the Work Equipment Directive to ensure that the information is adhered to, and to provide the training necessary in this context. The employer has to ensure that:

- work is executed in accordance with the information in the operating instructions,
- the machines are operated by workers who have been trained and instructed accordingly,
- workers with special training are deployed to do particularly hazardous jobs (e.g. maintenance),
- work processes and coordination have been discussed and are safe,
- required personal safety equipment is available and used.

Requirements for inspections of machinery and work equipment

Machinery/work equipment exposed to conditions causing deterioration which is liable to result in dangerous situations shall be checked by periodic inspections by competent persons.

The employers have to determine kinds and periods of inspections taken into account:

- Duration of use, e.g. seldom use or continual operation,
- Influence of the weather,
- Work accidents,
- Maintenance measures (notice: inspection periods can be prolonged by enlarged maintenance measures),
- Safety-related changes of work equipment, e.g. new software, change of drive.

The results of inspections must be recorded and kept at the disposal of the authorities concerned (see Annex IV: Form "Documentation of inspection periods for used work equipment").

to 4.: Person-related measures

Person-related measures shall be used when the risks concerning safety and health at work cannot be avoided or sufficiently limited by technical means of collective protection or by measures, methods or procedures of work organization. Person-related measures aim at enabling persons to handle hazards accordingly, such as:

- Training for safe operation of used machinery/work equipment,
- Person-related qualification,
- Personal protective equipment (PPE).

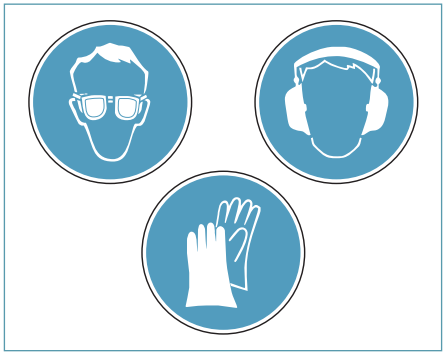


Fig. 10: Person-related measures

Personal protective equipment means all equipment designed to be worn or held by the worker to protect him against one or more hazards likely to endanger his safety and health at work.

The provision of personal protective equipment by the employer as well as the use by the employees at work is regulated in the COUNCIL DIRECTIVE 89/656/EEC of 30. November 1989 on the minimum health and safety

requirements for the use by workers of personal protective equipment at the workplace (third individual directive within the meaning of Article 16 (1) of Directive 89/391/EEC).

The necessity to use of PPE implements employers' obligations.

- The employer shall choose and provide only PPE, which are complying with the relevant requirements of the Community provisions on design and manufacture with respect to safety and health.
- Information notice supplied by the manufacturer must be attached when PPE is placed on the market. It must contain in addition to the name and address of the manufacturer relevant information e.g. for use, storage, maintenance, servicing, to different levels of risk and the corresponding limits of use, the obsolescence deadline or period of obsolescence of PPE, the significance of markings.

  The employer should use these information for the operating instruction and for instructions for employees.
- Personal protective equipment shall be provided free of charge by the employer, who shall ensure its good working order and satisfactory hygienic condition by means of the necessary maintenance, repair and replacements.
- Essential information on each item of PPE shall be provided for the use in understandable form and language by the employer (for example as operating instruction).
- The employer shall instruct the employees in safety-related use of the PPE based on the manufacturer information. He shall, if appropriate, organize additional training in the wearing of personal protective equipment.

Annex I

Legislation issues – applied in this document

European Directives

89/391/EEC	Introduction of measures to encourage improvements in the safety and health of workers at work
89/655/EEC	Minimum Safety Health Requirements for the Use of Work Equipment by Workers at Work
95/63/EEC	amending Directive 89/655/EEC
2001/45/EEC	amending Directive 89/655/EEC
89/654/EEC	Minimum safety and health requirements for the workplace
89/656/EEC	Personal protective equipment
90/269/EEC	Manual handling of loads
98/24/EC	Chemical agents
2000/54/EC	Biological agents
2003/10/EC	Noise
2002/44/EC	Vibration
2006/42/EC	Machinery
2006/95/EC	Electrical equipment design for use within certain voltage limits
97/23/EC	Pressure Equipment
2004/108/EC	Electromagnetic compatibility

Standards

EN ISO 12100-1	Safety of machinery – General principles for design
EN ISO 12100-2	Safety of machine – Technical principles and specification
EN ISO 14121-1	Safety of machine – Basic terminology – Risk assessment
EN 1088	Guard locking devices
EN ISO 13849-1	Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design
EN 953	Safety of machinery – Guards – General requirements for the design and construction of fixed and movable guards
EN 894	Safety of machinery – Ergonomic requirements (series)
EN ISO 13580	Emergency Stop Equipment
EN ISO 13857	Safety of machinery – Safety distances to prevent hazard zones being reached by upper and lower limbs

Annex II

Documentation of risk assessment and the measures determined

Sheet No.

Enteprise
Address
Telephone

Person in change
Name

Approval management Yes/No
Date/signature

Date
Signature

Type of machinery/location:

Work area, Occupational category/person, Activity

No.	Hazard factor	Hazard source, hazardous condition	Risk	Need for action Yes/No		Responsible	Dead-line dd/mm/yy	Effec-tive Yes/No

Repeated control of measures

No.	Date	Objective, measures	Effective	
			Yes	No

Remarks

Name

Signature

Annex III

Final approval of manufacturing equipment

Specifacation of manufacturing equipment: _____

Order No: _____ Inventory No: _____ Charge account: _____

Basis

Power rating (e. G. deterination of reference quantities etc.): _____

_____

CE-marking/regulatory declaration yes/no_____

Personal requirements and qualification determined

Location: _____

Service requirements (e. G. current, water):_____

_____

Environmental impact (e. G. noise, dust, surface pollution):_____

_____

Notes: _____

_____

_____

Verified by: . _____

Name Date Signature

Initial conditioning

Funtional inspection/test carried out by: _____on: _____

Notes: _____

_____

_____

Electricit defects (out of specification): _____

_____

_____

Instructed persons: _____

_____

Documentation received (e. G. operating instructions, circuit diagrams) from_____

Operating instructions drafted on: _____ by: _____

Workplace assessment performed on: _____ by: _____

Periodic inspection an testing registerd: Yes/No

For the approval of the manufacturing equipment:

_____

Name Date Si9gnature

Annex IV

Documentation of inspections for used work equipment

Working area:

work equipment[1]	inventory number	inspection period[2]	specific working conditions[3] Changed inspection period	Cause	inspection by[4]	last inspection	results	kind of documentation
turning machine	*1*	*annual*						*machine card*
ladder	*2*	*annual*	*2 years*	*seldom use*				*checking book*

[1] Before use work equipment a visual control is necessary (generally).
[2] Inspection periods laid down in rules.
[3] Inspection periods laid down in rules shall be checked on base of risk assessment taken into account specific working conditions.
[4] The necessary qualifications of persons carrying out inspections shall be identificate by employers.

On websites of national Focal Points of European Agency for Safety and Health at Work Bilbao you find information about national rules and regulations for national implementation of European directives:

Start site:
http://osha.europa.eu/en/legislation