Directive 98/37/EC
Machinery Working Group
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The following text includes the sections of the Guide to application of Directive 2006/42/EC covering Annex I – General principles and sections 1.1 and 1.2.

Comments received from members of the Machinery Working Group have been taken into account.

This section will be published when the complete Guide is ready. The text will be corrected and updated before publication. However it is not expected that substantive modifications will be made to these sections.

ANNEX I

Essential health and safety requirements relating to the design and construction of machinery

GENERAL PRINCIPLES

§157 The General Principles

The essential health and safety requirements (EHSRs) set out in Annex I are introduced by four General Principles. The first one, dealing with risk assessment, explains a basic requirement of Annex I to identify the hazards and assess the risks associated with machinery in order to identify and apply the relevant EHSRs. The other General Principles are essential for understanding the status and the implications of the EHSRs. These General Principles must be taken into account when applying each of the EHSRs to the design and construction of machinery.

GENERAL PRINCIPLES

1. *The manufacturer of machinery or his authorised representative must ensure that a risk assessment is carried out in order to determine the health and safety requirements which apply to the machinery. The machinery must then be designed and constructed taking into account the results of the risk assessment.*

   By the iterative process of risk assessment and risk reduction referred to above, the manufacturer or his authorised representative shall:

   — *determine the limits of the machinery, which include the intended use and any reasonably foreseeable misuse thereof,*

   — *identify the hazards that can be generated by the machinery and the associated hazardous situations,*

   — *estimate the risks, taking into account the severity of the possible injury or damage to health and the probability of its occurrence,*

   — *evaluate the risks, with a view to determining whether risk reduction is required, in accordance with the objective of this Directive,*

   — *eliminate the hazards or reduce the risks associated with these hazards by application of protective measures, in the order of priority established in section 1.1.2 (b).*

. . .

§158 Risk assessment

According to General Principle 2, the EHSRs are only applicable when the corresponding hazard exists for the machinery in question. In order to identify these hazards, taking into account all phases of the foreseeable lifetime of the machinery, the manufacturer or his authorised representative must ensure that a risk assessment is carried out according to the iterative process described in General Principle 1. For the terms 'hazard' and 'risk' – see §164, comments on section 1.1.1 (a) and §168, comments on section 1.1.1 (e).

The risk assessment may be carried out by the manufacturer himself, by his authorised representative or by another person acting on their behalf. If the risk assessment is carried out on behalf of the manufacturer by another person, the

manufacturer remains responsible for the risk assessment and the implementation of the necessary protective measures during the design and construction of machinery – see §78 to §81, comments on Article 2 (i), and §83 and §84, comments on Article 2 (j).

The second sentence of the first paragraph of General Principle 1 states that the machinery must then be designed and constructed taking into account the results of the risk assessment. Risk assessment is described as an iterative process because each risk reduction measure envisaged to deal with a particular hazard must be evaluated to see if it is adequate and does not generate new hazards. If this is not the case, the process must be carried out anew. This implies that the risk assessment process must be carried out in parallel with the design process of the machinery.

The last indent of the second paragraph underlines that the risk reduction measures to deal with the identified hazards are to be given an order of priority, according to the principles of safety integration – see §174, comments on section 1.1.2 (b).

The risk assessment and its outcome must be documented in the Technical file for machinery – see comments on Annex VII A 1 (a).

Standard EN ISO 14121-1 (A-type standard) explains the general principles for risk assessment of machinery.[1]

§159 Risk assessment and harmonised standards

The process of risk assessment is facilitated by the application of harmonised standards, since C-type standards for machinery identify the significant hazards that are generally associated with the category of machinery concerned and specify protective measures to deal with them. However the application of harmonised standards does not dispense the machinery manufacturer from the obligation to carry out a risk assessment.

A manufacturer who applies the specifications of a C-type standard must ensure that the harmonised standard is appropriate to the particular machinery concerned and covers all of the risks it presents. If the machinery concerned presents hazards that are not covered by the harmonised standard, a full risk assessment is required for those hazards and appropriate protective measures must be taken to deal with them.

Furthermore, where harmonised standards specify several alternative solutions without defining criteria for choice between them, the choice of the appropriate solution for the machinery concerned must be based on a specific risk assessment. This is particularly important when applying B-type standards – see §111, comments on Article 7 (2).

[1] EN ISO 14121-1: 2007 - *Safety of machinery - Risk assessment - Part 1: Principles* (ISO 14121-1:2007).

GENERAL PRINCIPLES *(continued).*

. . .

2. *The obligations laid down by the essential health and safety requirements only apply when the corresponding hazard exists for the machinery in question when it is used under the conditions foreseen by the manufacturer or his authorised representative or in foreseeable abnormal situations. In any event, the principles of safety integration referred to in section 1.1.2 and the obligations concerning marking of machinery and instructions referred to in sections 1.7.3 and 1.7.4 apply.*

. . .

§160 The applicability of the essential health and safety requirements

General Principle 2 must be borne in mind when reading each of the EHSRs set out in Annex I. The EHSRs are usually expressed in a categorical fashion, without qualification. However, they are only applicable when they are relevant and necessary. In other words, an EHSR applies when the hazard concerned is present on the particular model of machinery concerned. The first sentence of General Principle 2 also underlines that, when identifying the hazards for a given model of machinery, not just the intended conditions of use but also foreseeable abnormal situations must be taken into account. Foreseeable abnormal situations are those arising from reasonably foreseeable misuse - see §172, comments on section 1.1.1 (i).

The second sentence sets out an exception to General Principle 2, since the requirements set out in sections 1.1.2, 1.7.3 and 1.7.4 are applicable to all machinery.

GENERAL PRINCIPLES *(continued)*

. . .

3. *The essential health and safety requirements laid down in this Annex are mandatory; However, taking into account the state of the art, it may not be possible to meet the objectives set by them. In that event, the machinery must, as far as possible, be designed and constructed with the purpose of approaching these objectives.*

. . .

§161 The state of the art

General Principle 3 first recalls that the EHSRs, when they are applicable to a given model of machinery, are legally binding. This is clear from the terms of Article 5 (a) setting out the obligations of machinery manufacturers. In this respect, it is important to distinguish the EHSRs of Annex I from the specifications of harmonised standards, the application of which is voluntary – see §110, comments on Article 7 (2).

The EHSRs set out in Annex I are usually expressed without qualification. The second sentence of General Principle 3 recognises that, in some cases, it may not be possible to satisfy certain EHSRs fully, given the current state of the art. In

such cases, the machinery manufacturer must strive to fulfil the objectives set out in the EHSRs to the greatest extent possible.

The notion of *"the state of the art"* is not defined in the Machinery Directive; however it is clear from Recital 14 that the notion of *'the state of the art'* includes both a technical and an economic aspect. In order to correspond to the state of the art, the technical solutions adopted to fulfil the EHSRs must employ the most effective technical means that are available at the time for a cost which is reasonable taking account of the total cost of the category of machinery concerned and the risk reduction required.

Manufacturers of machinery cannot be expected to use solutions that are still at the research stage or technical means that are not generally available on the market. On the other hand, they must take account of technical progress and adopt the most effective technical solutions that are appropriate to the machinery concerned when they become available for a reasonable cost.

"The state of the art" is thus a dynamic concept: the state of the art evolves when more effective technical means become available or when their relative cost diminishes. Thus a technical solution that is considered to satisfy the EHSRs of the Directive at a given time may be considered inadequate at a later time, if the state of the art has evolved.

A machinery manufacturer can only take account of the state of the art at the time the machinery is constructed. If an evolution of the state of the art makes it possible to approach the objectives set out in the EHSRs more closely, a manufacturer producing a series of machines according to the same design must upgrade his design accordingly (while taking account of the time necessary for the redesign and the corresponding changes in the production process).

§162 Harmonised standards and the state of the art

Harmonised standards provide technical specifications that enable machinery manufacturers to comply with the EHSRs. Since harmonised standards are developed and adopted on the basis of a consensus between the interested parties, their specifications provide a good indication of the state of the art at the time they are adopted. The evolution of the state of the art is reflected in later amendments or revisions of harmonised standards.

In this respect, the level of safety afforded by the application of a harmonised standard provides a benchmark that must be taken into account by all manufacturers of the category of machinery covered by the standard, including those who choose to employ alternative technical solutions. A manufacturer who chooses alternative solutions must be able to demonstrate that these solutions are in conformity with the EHSRs of the Machinery Directive, taking account of the current state of the art. Consequently, such alternative solutions must provide a level of safety that it is at least equivalent to that afforded by application of the specifications of the relevant harmonised standard – see §110, comments on Article 7 (2).

When harmonised standards are not available, other technical documents may provide useful indications for applying the EHSRs of the Machinery Directive. Such documents include, for example, international standards, national standards, draft European standards, the Recommendations for Use issued by the European Coordination of Notified Bodies – see §137, comments on Article 14 (7) – or guidelines issued by professional organisations. However, application of such

technical documents does not confer a presumption of conformity with the EHSRs of the Machinery Directive – see comments on Annex II 1 A (8).

> ***GENERAL PRINCIPLES*** *(continued)*
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> . . .
>
> 4. *This Annex is organised in several parts. The first one has a general scope and is applicable to all kinds of machinery. The other parts refer to certain kinds of more specific hazards. Nevertheless, it is essential to examine the whole of this Annex in order to be sure of meeting all the relevant essential requirements. When machinery is being designed, the requirements of the general part and the requirements of one or more of the other parts shall be taken into account, depending on the results of the risk assessment carried out in accordance with point 1 of these General Principles.*

§163 The structure of Annex I

General principle 4 explains the structure of Annex I. The EHSRs set out in Part 1 of Annex I must be taken into account by manufacturers of all categories of machinery. With the exception of sections 1.1.2, 1.7.3 and 1.7.4 which are always applicable, the EHSRs set out in the other sections of Part 1 are applicable when the manufacturer's risk assessment shows that the hazard concerned is present.

Parts 2 to 6 of Annex I deal with the following specific hazards:

Part 2	hazards specific to certain categories of machinery: – foodstuffs machinery, – machinery for cosmetics or pharmaceutical products, – hand-held and hand-guided machinery, – portable fixing machinery and other portable impact machinery, – machinery for working wood and material with similar characteristics;
Part 3	hazards due to the mobility of machinery;
Part 4	hazards due to lifting operations;
Part 5	hazards specific to machinery intended for underground work;
Part 6	hazards due to the lifting of persons.

The relevance of the EHSRs set out in each of these parts depends on whether a given model of machinery belongs to one or more of the categories of machinery concerned by Parts 2 or 5 or whether the manufacturer's risk assessment show that the machinery presents one or more of the specific hazards referred to in Parts 3, 4 and 6 – see §160, comments on General Principle 2. For example, a mobile elevating work platform is subject to requirements set out in Parts 1, 3, 4, and 6. A hand-held circular saw for woodworking is subject to requirements set out in Parts 1 and 2.

In some cases, the EHSRs set out in Parts 2 to 6 are supplementary to EHSRs set out in the other parts of Annex I dealing with the same type of hazard. This is indicated in the comments on the sections concerned.

> ***1. ESSENTIAL HEALTH AND SAFETY REQUIREMENTS***
>
> ***1.1 GENERAL REMARKS***
>
> ***1.1.1 Definitions***
>
> *For the purpose of this Annex:*
>
> *(a) 'hazard' means a potential source of injury or damage to health;*
>
> . . .

§164 Hazard

The term *'hazard'* is used in the context of risk assessment with a meaning which may be different from everyday usage. In the context of risk assessment, *'hazard'* refers to a potential source of harm. The presence of a hazard is an inherent feature of the machinery and is independent of whether or not any injury or damage to health is actually likely to occur. For example, the presence in the machinery of parts at a high temperature is a potential source of injuries, such as burns, or of damage to health, such as heat stress-related illness; the presence in the machinery of sharp blades is a potential source of injuries such as cuts or amputation. During the phase of hazard identification, a hazard must be considered to be present, even if the part of the machinery presenting the hazard is inaccessible.

Hazards can be identified by their physical origin (for example, mechanical hazard, electrical hazard) or by the nature of the potential injury or damage to health (for example, cutting hazard, crushing hazard or electric shock hazard).
General Principle 1 requires the manufacturer to identify the hazards that are inherent to the machinery or that can be generated by its use, and the associated hazardous situations. A hazardous situation is a circumstance, an event or a sequence of events in which a person is exposed to a hazard. Hazardous situations can range in duration from a sudden event to a circumstance that is permanently present during use of the machinery.

> ***1.1.1 Definitions** (continued)*
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> . . .
>
> *(b) 'danger zone' means any zone within and/or around machinery in which a person is subject to a risk to his health or safety;*
>
> . . .

§165 Danger zone

The concept of *'danger zone'* makes it possible to locate the places where persons may be exposed to a hazard. In the case of risks involving contact with moving parts of the machinery, for example, the danger zone is limited to the proximity of the hazardous parts. In the case of other risks, such as, for example, the risk of being hit by objects ejected from the machinery or the risk of exposure to noise emissions or emissions of hazardous substances from the machinery, the danger zone may include substantial areas in the environment of the machinery.

One of the most effective ways to prevent risks is to design machinery so as to avoid the need for persons to enter danger zones – see §189, comments on section 1.2.2, and §239, comments on section 1.6.1.

> ***1.1.1 Definitions*** *(continued)*
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> . . .
>
> *(c) 'exposed person' means any person wholly or partially in a danger zone;*
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> . . .

§166 Exposed person

The definition of the term *'exposed person'* is very broad. Operators are one category of potentially exposed person – see §167, comments on section 1.1.1 (d). However, persons who do not have any direct involvement with the machinery may be present in a danger zone, particularly if the danger zones include areas in the environment of the machinery. In the case of machinery for professional use, such persons may be, for example, other employees of the company where the machinery is used or bystanders. In the case of machinery used on construction sites, on public roads or in urban areas, potentially exposed persons may include members of the public in the street or in buildings nearby. In the case of machinery such as agricultural machinery or machinery intended for use by consumers in the home or in the garden, potentially exposed persons may be family members including children. The EHSRs aim to prevent risks for all exposed persons. Consequently, the manufacturer's risk assessment must include an assessment of the likelihood of operators and of any other persons being in a danger zone.

> ***1.1.1 Definitions*** *(continued)*
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> . . .
>
> *(d) 'operator' means the person or persons installing, operating, adjusting, maintaining, cleaning, repairing or moving machinery;*
>
> . . .

§167 Operator

The definition of *'operator'* gives the term a very broad sense. In the Machinery Directive, the term is used to designate all persons with specific tasks involving the machinery and is not limited to production operators. Operators include all the different persons dealing with the machinery in the various phases of its lifetime - see §173, comments on section 1.1.2 (a). In the case of machinery intended for use at the workplace, the operators may be professionals who may or may not have been specially trained. In the case of machinery designed for use by consumers, the operators using the machinery are non-professional and must be assumed not to have been specially trained – see §258, comments on section 1.7.4.1 (d). It should be noted that certain kinds of machinery are placed on the market for both professional use and for use by consumers.

> ***1.1.1 Definitions*** *(continued)*
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> . . .
>
> *(e) 'risk' means a combination of the probability and the degree of an injury or damage to health that can arise in a hazardous situation;*

. . .

§168 Risk

Like the term *'hazard'*, the term *'risk'* is used in the Machinery Directive with a more precise sense than in everyday use. The existence of a risk depends on the hazards generated by the machinery and also on the interface between the machinery and the operators and other exposed persons. A hazard may be present on machinery, but if no person is liable to be exposed to that hazard, there is no risk.

Risks may be characterised by reference to the hazard or hazardous situation concerned (such as, for example, a risk due to contact with moving parts, a risk due to contact with hot surfaces, a risk due to noise emissions or emissions of hazardous substances); risks may also be characterised by reference to their possible consequences (such as, for example, a crushing risk, a cutting risk, a risk of being burnt, a risk of loss of hearing).

The third step of the process of risk assessment is to estimate the risks, taking into account the severity of the possible injury or damage to health and the probability of its occurrence – see §158, comments on General Principle 1. The estimation of the risk is based on a combination of these two factors. The most serious risks involve a combination of a high probability of occurrence and the possibility of fatal or severe injury or damage to health. However a low probability of occurrence may still result in a serious risk if fatal or severe injuries or damage to health may result. Risks must therefore be evaluated on a case-by-case basis, taking account of the fact that risks may be different in the phases of the lifetime of the machinery, depending on the operations concerned and the state of the machinery during each phase – see §173, comments on section 1.1.2 (a).

***1.1.1 Definitions** (continued)*

. . .

(f) 'guard' means a part of the machinery used specifically to provide protection by means of a physical barrier;

. . .

§169 Guard

The term 'guard' is used for parts of the machinery specifically designed to fulfil a protective function. Other parts of the machinery that fulfil a primarily operational function, such as, for example, the frame of the machinery, may also fulfil a protective function but are not referred to as guards.

Guards are defined as providing protection by means of a physical barrier such as, for example, a casing, a shield, a cover, a screen, a door, an enclosure or a fence. The word 'physical barrier' implies that a guard is constituted by a solid material such as, for example, steel or plastic, to be chosen according to the protection required. The materials used may be continuous or perforated and may be rigid or flexible.

Guards are one of the means that can be used to prevent access to danger zones in or around machinery. In many cases, the guard acts as a barrier in both directions in order to protect against two or more risks simultaneously. For example, a guard may be fitted both to prevent persons entering a danger zone

and also to prevent ejected objects, noise emissions, radiation or hazardous substances from reaching persons in the environment of the machinery.

The Machinery Directive distinguishes three main kinds of guards: fixed guards, interlocking moveable guards and adjustable guards restricting access – see §217, comments on section 1.4.2 of Annex I.

When placed independently on the market, guards are considered as safety components – see §42, comments on Article 2 (c) and comments on Annex V, (1), (3) and (7).

> ***1.1.1 Definitions*** *(continued)*
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> . . .
>
> *(g) 'protective device' means a device (other than a guard) which reduces the risk, either alone or in conjunction with a guard;*
>
> . . .

§170 Protective devices

Protective devices are distinguished from guards since they do not constitute a physical barrier between the exposed person and the danger zone but reduce risks by preventing exposure to the hazard by other means. Protective devices include, for example, two-hand control devices, sensitive protective equipment such as pressure-sensitive mats and sensitive edges, trip bars and trip wires, and opto-electronic protective devices such as light curtains, laser scanners or camera-based safeguarding systems – see §221, comments on section 1.4.3 of Annex I.

When placed independently on the market, protective devices are considered as safety components – see §42, comments on Article 2 (c) and comments on Annex V, (2) and (7).

> ***1.1.1 Definitions*** *(continued)*
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> . . .
>
> *(h) 'intended use' means the use of machinery in accordance with the information provided in the instructions for use;*
>
> . . .

§171 Intended use

The first step of the risk assessment process described in General Principle 1 is to determine the limits of the machinery, which include the intended use of the machinery. Machinery is not necessarily safe for all possible uses: for example, the manufacturer of machinery intended for working metal has usually not designed the machinery for safely working wood and *vice versa*; for example, the manufacturer of a mobile elevating work platform usually has not designed the machine to be safely used as a crane. The manufacturer's risk assessment and the design and construction of the machinery must therefore be based on specified use or uses. The specification of the intended use of the machinery must cover, where appropriate, the different operating modes and phases of use of the machinery – see §173, comments on section 1.1.2 (a).

In particular, the parameters on which the safe use of the machinery depends and their limits must be precisely specified. Such parameters include, for example, the maximum load for lifting machinery; the maximum slope on which mobile machinery can be used without loss of stability; the maximum wind-speed in which machinery can be safely used outdoors; the maximum dimensions of workpieces and the type of material that can be safely processed by a machine tool.
The intended use of the machinery is the use defined and described in the manufacturer's instructions – see comments on section 1.7.4.2 (g).

> ***1.1.1 Definitions** (continued)*
> . . .
> *(i) 'reasonably foreseeable misuse' means the use of machinery in a way not intended in the instructions for use, but which may result from readily predictable human behaviour.*
> . . .

§172 Reasonably foreseeable misuse

The first step of the risk assessment process described in General Principle 1 also requires the manufacturer to take account of reasonably foreseeable misuse of machinery. The machinery manufacturer cannot be expected to take account of all possible misuse of the machinery. However, certain kinds of misuse, whether intentional or unintentional, are predictable on the basis of experience of past use of the same type of machinery or of similar machinery, accident investigations and knowledge about human behaviour – see §173, comments on sections 1.1.2 (a), and §175, comments on section 1.1.2 (c) and comments on section 1.7.4.2 (h).

Standard EN ISO 12100-1 gives the following examples of the kinds of misuse or readily predictable human behaviour that may have to be taken into account:

- loss of control of the machine by the operator;
- reflex behaviour of a person in case of malfunction, incident or failure during the use of the machine;
- behaviour resulting from lack of concentration or carelessness;
- behaviour resulting from taking the line of least resistance in carrying out a task;
- behaviour resulting from pressures to keep machinery running in all circumstances;
- the behaviour of certain persons such as children.

Such behaviour can result in a range of misuse situations, such as, for example, using a crane or a MEWP without deploying the stabilisers; leaving the door open on an earthmoving truck in hot weather thereby defeating the air filtering and noise control equipment; two people operating a press designed for use by a single person.

Particular attention must be given to factors that may lead to the removal, disabling or defeating of guards and protective devices – see §216, comments on section 1.4.1.

> ***1.1.2 Principles of safety integration***
>
> *(a) Machinery must be designed and constructed so that it is fitted for its function, and can be operated, adjusted and maintained without putting persons at risk when these operations are carried out under the conditions foreseen but also taking into account any reasonably foreseeable misuse thereof.*
>
> *The aim of measures taken must be to eliminate any risk throughout the foreseeable lifetime of the machinery including the phases of transport, assembly, dismantling, disabling and scrapping.*
>
> . . .

§173 Principles of safety integration

Section 1.1.2, setting out the principles of safety integration (sometimes referred to as *'safety by design'*), is a key section of Annex I. Section 1.1.2 sets out a basic methodology for designing and constructing safe machinery which is fundamental to the approach of the Machinery Directive.[2] General Principle 2 states that this EHSR is applicable to all machinery. When applying the other EHSRs, the principles of safety integration set out in section 1.1.2 must be followed.

Section 1.1.2 (a) first states that machinery must be fitted for its function. The Machinery Directive is primarily concerned with safety and does not contain any specific requirements relating to the performance of machinery. It is generally considered that the performance of machinery is a matter to be left to the market and that users will select machinery with performance characteristics appropriate to their needs. However the aptitude of machinery to fulfil its function correctly does affect safety in so far as inadequate functioning of the machinery may lead to hazardous situations or be conducive to misuse.

Section 1.1.2 (a) then sets out the general objective that machinery must be designed and constructed so that it can be operated, adjusted and maintained without putting persons at risk. The term *'persons'* covers both operators and any other exposed persons – see §166 and §167, comments on sections 1.1.1 (c) and (d). In order to achieve this objective, the manufacturer must consider both the intended conditions of use, but also any reasonably foreseeable misuse of the machinery – see §172, comments on section 1.1.1 (i).

The second paragraph of section 1.1.2 (a) sets out the objective of preventing risks throughout the foreseeable lifetime of the machinery, including the phases of transport, assembly, dismantling, disabling and scrapping. On the one hand, this requirement implies that safety related components and assemblies must be sufficiently strong and durable – see §207, comments on section 1.3.2, and comments on sections 4.1.2.3, 4.1.2.4, 4.1.2.5 and 6.1.1 - and that adequate instructions must be given for the maintenance and replacement of components subject to fatigue and wear – see comments on section 1.7.4.2 (r). On the other hand, this paragraph requires the manufacturer to address not only the risks

[2] EN ISO 12100-1 : 2003 - *Safety of machinery - Basic concepts, general principles for design* - Part 1: *Basic terminology, methodology* (ISO 12100-1:2003), and

EN ISO 12100-2: 2003 - *Safety of machinery - Basic concepts, general principles for design* - Part 2: *Technical principles* (ISO 12100-2:2003).

generated during operation, setting and maintenance of the machinery but also during the other phases of its lifetime:

– ***transport***

Measures to prevent the risks associated with the transport of machinery include, for example:

– the design of machinery to facilitate its handling – see §180, comments on section 1.1.5;

– measures to ensure the stability of the machinery during transport – see §206, comments on sections 1.3.1, and comments on section 4.1.2.1;

– measures to ensure adequate mechanical strength during transport – see comments on section 4.1.2.3;

– providing instructions for safe transport – see comments on section 1.7.4.2 (o) and (p).

Such measures are particularly important for machinery intended to be transported between successive sites during its lifetime.

– ***assembly and dismantling***

Design of machinery to facilitate assembly and dismantling are also particularly important in the case of machinery intended for temporary installation on successive sites during its lifetime. The measures to be taken include, for example:

– preventing errors of fitting – see §225, comments on section 1.5.4;

– providing adequate instructions – see comments on section 1.7.4.2 (i) and (o).

– ***disabling and scrapping***

The Machinery Directive does not include requirements relating to the disposal, recycling or reuse of machinery components or materials when machinery is scrapped.

The measures referred to in the second paragraph to prevent risks during the disabling and scrapping of the machinery at the end of its lifetime are therefore those that can be taken by the machinery manufacturer. Such measures may include, for example, ensuring that parts containing hazardous substances are suitably and indelibly marked, ensuring that hazardous substances contained in the machinery can be safely evacuated and ensuring that any stored energy can be safely dissipated when the machinery is disabled, in order to avoid hazards during scrapping – see §178, comments on section 1.1.3.

> ***1.1.2 Principles of safety integration*** *(continued)*
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> . . .
>
> *(b) In selecting the most appropriate methods, the manufacturer or his authorised representative must apply the following principles, in the order given:*
>
> — *eliminate or reduce risks as far as possible (inherently safe machinery design and construction),*
>
> — *take the necessary protective measures in relation to risks that cannot be*

eliminated,

— *inform users of the residual risks due to any shortcomings of the protective measures adopted, indicate whether any particular training is required and specify any need to provide personal protective equipment.*

. . .

§174 The 3-step method

Section 1.1.2 (b) sets out the approach to be adopted when determining the measures to be taken to deal with the risks that have been identified and assessed by means of the risk assessment described in General Principle 1. The three successive steps are put in an order of priority (often referred to as *'the 3-step method'*):

Step 1 = first priority	-	*Inherently safe design measures*
Step 2 = second priority	-	*Technical protective measures*
Step 3 = third priority	-	*Information for users*

This order of priority must be applied when selecting measures to deal with a given risk in order to satisfy the corresponding EHSR. Consequently, the manufacturer must exhaust all the possible inherently safe design measures before resorting to protective measures. Similarly, he must exhaust the possible protective measures before relying on warnings and instructions to operators. Application of the 3-step method must also take due account of the state of the art – see §161, comments on General Principle 3.

– ***Step 1 = first priority***

The first priority is given to inherently safe design measures because they are more effective than protective measures or warnings. Some examples of inherently safe design measures are, for example:

- eliminating the hazard altogether, for example, replacing flammable hydraulic fluid with a non-flammable type – see §178, comments on section 1.1.3;
- designing the control system and control devices in order to ensure safe functioning – see §184 to §185, comments on sections 1.2 and comments on section 3.3;
- ensuring the inherent stability of machinery by its shape and the distribution of masses – see §206, comments on sections 1.3.1;
- ensuring that accessible parts of the machinery do not have sharp edges or rough surfaces – see §209, comments on section 1.3.4;
- ensuring sufficient distance between moving and fixed parts of the machine to avoid the risk of crushing – see §212, comments on section 1.3.7;
- avoiding accessible surfaces with extreme temperatures – see §226, comments on section 1.5.5;
- reducing emissions of noise, vibrations, radiation or hazardous substances at source – see §229, comments on section 1.5.8, §231, comments on section 1.5.9, §232, comments on section 1.5.10, and §235, comments on section 1.5.13;

- reducing, where possible, the speed and the power of moving parts or the travel speed of the machinery itself;
- locating hazardous parts of machinery in inaccessible places– see §212, comments on section 1.3.7;
- locating adjustment and maintenance points outside danger zones – see §239, comments on section 1.6.1 of Annex I.

– ***Step 2 = second priority***

When it is not possible to eliminate hazards or sufficiently reduce risks by inherently safe design measures, the second priority is given to technical protective measures to prevent persons from being exposed to the hazards. Some examples of technical protective measures are, for example:

- guards: fixed guards, interlocking moveable guards with guard locking where necessary or adjustable guards restricting access – see §218 to §220, comments on sections 1.4.2.1 to 1.4.1.3;
- protective devices – see §221, comments on section 1.4.3;
- insulation of live electrical parts – see §222, comments on section 1.5.1;
- enclosure of sources of noise – see §229, comments on section 1.5.8;
- damping of vibrations – see §231, comments on section 1.5.9;
- containment or evacuation of hazardous substances – see §235, comments on section 1.5.13;
- aids to compensate the lack of direct visibility – see comments on section 3.2.1;
- protective structures against the risk of rolling or tipping over or the risk of falling objects (ROPS and FOPS) – see comments on sections 3.4.3 and 3.4.4;
- stabilisers – see comments on sections 4.1.2.1.

– ***Step 3 = third priority***

Finally, for the residual risks that cannot be adequately reduced by inherently safe design measures or by technical protective measures, information must be given to exposed persons in the form of warnings, signs and information on the machinery and given to users in the instructions so that the necessary precautions and measures can be taken by the users.[3] Some examples of such warnings and instructions are:

- Information or warnings on the machinery in the form of symbols or pictograms – see §245, comments on section 1.7.1;
- warning acoustic or light signals – see §248, comments on section 1.7.1.2;

[3] Such measures are subject to the national provisions implementing Directive 89/391/EEC as amended on the introduction of measures to encourage improvements in the safety and health of workers at work (the "Framework" Directive) and to the individual Directives adopted within this framework – see comments on Article 15.

- indicating of the mass of machinery or parts thereof which must be handled with lifting equipment during the different phases of its foreseeable lifetime – see comments on section – see §253, comments on section 1.7.3;
- warning against the use of machinery by certain persons such as, for example, young people under a certain age – see comments on section 1.7.4.2 (g);
- specifying the need to provide the necessary information and training to operators – see comments on section 1.7.4.2 (k).
- information relating to the safe assembly and installation of the machinery – see comments on section 1.7.4.2 (i);
- information on the complementary protective measures to be taken in the workplace – see comments on section 1.7.4.2 (l);
- specifying the need to provide the appropriate personal protective equipment to operators and ensure that it is used – see comments on section 1.7.4.2 (m).[4]

Providing warnings and instructions for use is considered as an integral part of the design and construction of the machinery. However the fact that this third step is the last in the order of priority given in section 1.1.2 (b) implies that warnings and instructions must not be a substitute for inherently safe design measures and technical protective measures when these are possible, taking into account the state of the art.

> ***1.1.2 Principles of safety integration*** *(continued)*
>
> . . .
>
> *(c) When designing and constructing machinery and when drafting the instructions, the manufacturer or his authorised representative must envisage not only the intended use of the machinery but also any reasonably foreseeable misuse thereof.*
>
> *The machinery must be designed and constructed in such a way as to prevent abnormal use if such use would engender a risk. Where appropriate, the instructions must draw the user's attention to ways — which experience has shown might occur — in which the machinery should not be used.*
>
> . . .

§175 Preventing abnormal use

Section 1.1.2 (c) follows logically from section 1.1.2 (a). Since the machinery manufacturer must envisage both the intended use of the machinery and also reasonably foreseeable misuse - see §172, comments on section 1.1.1 (i) – measures must also be taken to prevent foreseeable abnormal use that would engender a risk. These measures must be chosen according to the order of priority set out in section 1.1.2 (b). Thus the manufacturer must as far as possible prevent foreseeable abnormal use by technical means. Example of such means include, for example:

[4] The provision of personal protective equipment at the workplace is subject to the national provisions implementing Council Directive 89/656/EEC on the minimum health and safety requirements for the use by workers of personal protective equipment at the workplace.

- providing means for restricting the operation of the machinery or of certain control devices to authorised persons – see §204, comments on section 1.2.5 and comments on section 3.3;
- designing machinery to prevent errors of fitting – see §225, comments on section 1.5.4;
- fitting devices to prevent the travel of mobile machinery when the driver is not at the controls – see comments on section 3.3.2;
- fitting devices to prevent the operation of machinery unless stabilisers are in position – see comments on section 4.1.2.1;
- fitting devices to prevent the overloading of lifting machinery – see comments on sections 4.2.2 and 6.1.2.

Where there remains a residual risk of foreseeable misuse that cannot be entirely prevented by such technical means, appropriate warnings must be given on the machinery – see §249, comments on section 1.7.2 – and in the instructions – see comments on section 1.7.4.2 (h).

> ***1.1.2 Principles of safety integration*** *(continued)*
>
> . . .
>
> *(d) Machinery must be designed and constructed to take account of the constraints to which the operator is subject as a result of the necessary or foreseeable use of personal protective equipment.*
>
> . . .

§176 Constraints due to the use of PPE

Section 1.1.2 (d) deals with a particular aspect of the intended use of machinery. Machinery operators may be required to wear or carry personal protective equipment (PPE) to deal with residual hazards generated by the machinery itself, such as, for example, hearing protectors to protect against noise emissions or eye protectors to protect against the risk of projections of hazardous substances or objects. They may also be required to use PPE to protect against hazards that are not generated by the machinery but which are present in the environment in which the machinery is used. For example, machinery operators may have to wear protective footwear to protect their feet against shocks and sharp objects present on the construction site or in the workshop where the machinery is used. Machinery operators may have to wear protective gloves or protective clothing if the machinery is used in cold or hot atmospheres or in adverse weather conditions.

The design and construction of the machinery and, in particular, the design, positioning and dimensions of the control devices, must take account of the constraints to which the operator is likely to be subject due to such use of PPE. For example, on machinery designed to be used in cold conditions, the spacing, size and design of foot-pedals should be such as to accommodate the wearing of large boots.

> ***1.1.2 Principles of safety integration*** *(continued)*
>
> . . .
>
> *(e) Machinery must be supplied with all the special equipment and accessories*

essential to enable it to be adjusted, maintained and used safely.

§177 Special equipment and accessories

Section 1.1.2 (e) does not require machinery manufacturers to supply standard tools and equipment required for adjustment and maintenance operations (screwdrivers, spanners, wrenches, hoists and the like) that may be used with different kinds of machinery. However, if the safe adjustment, maintenance or use of the machinery requires the use of equipment or accessories that are specific to machinery concerned, such equipment or accessories must be made available by the machinery manufacturer with the machinery. Such special equipment may include, for example, devices for the removal of parts of the machinery for cleaning purposes or devices for feeding or loading and unloading workpieces.

1.1.3 Materials and products

The materials used to construct machinery or products used or created during its use must not endanger persons' safety or health. In particular, where fluids are used, machinery must be designed and constructed to prevent risks due to filling, use, recovery or draining.

§178 Materials and products used

The requirement set out in section 1.1.3 deals with several kinds of risk:

a) Risks due to materials or products used to construct the machinery such as, for example, metals, plastics, textiles or paints.

   Attention must be given to risks for the health and safety of operators or other exposed persons due to contact with these materials or, for example, due to hazardous substances that may be emitted by these materials when they heat up, are disturbed or are subject to wear. As far as possible, these risks must be prevented by the choice of innocuous materials for the construction of the machinery.

b) Risks due to materials or products used by the machinery such as fuels, lubricants, hydraulic fluids, chemicals, battery electrolyte, water, steam, compressed air and so on.

   Such risks can be eliminated or reduced by designing the machinery to use innocuous materials or products or by substituting hazardous materials or products with less hazardous ones. The manufacturer’s instructions must specify the appropriate materials or products to be used with the machinery. Where risks remain, protective measures must be taken to protect operators against exposure to hazardous materials or products used by the machinery, for example, by ensuring that they are inaccessible or adequately contained. Where necessary, appropriate warnings must be given on the machinery and in the instructions.

   The second sentence underlines particular aspects that must be considered when fluids are used. The measures to be taken to prevent risks due to filling, use, recovery or draining of fluids include, for example, the appropriate location and design of tanks and reservoirs and of their filling and draining points and the fitting of a retention tray under hydraulic equipment if leaks cannot be entirely prevented. When tanks are pressurised, they must be provided with means of reducing them to a safe

pressure and of checking the pressure prior to the opening of filling or draining points.

c) Risks due to materials or products worked, processed or transformed by the machinery, such as metals, rubber, plastics, wood, foodstuffs, cosmetics and so on.

The manufacturer of the machinery must take account of the materials to be worked by the machinery and take measures to prevent risks due to hazards such as, for example, sharp edges, splinters, ejected fragments or hot or cold materials.

d) Risks due to materials or products created during the use of the machinery. Such materials may either be the intended products of the machinery or by-products or waste such as, for example, chips, shavings, fumes or dust.

It should be noted that the reference in section 1.1.3 to *"risks due to … products created during the use"* of the machinery does not concern the product safety of products produced by machinery.

Certain aspects of the risks mentioned in (a) to (d) above are subject to specific EHSRs – see comments on section 1.3.3 on risks due to falling or ejected objects, comments on section 1.5.5 on extreme temperatures, comments on section 1.5.6 on the risk of fire, comments on section 1.5.7 on the risk of explosion and comments on section 1.5.13 on emissions of hazardous materials and substances.

1.1.4 Lighting

Machinery must be supplied with integral lighting suitable for the operations concerned where the absence thereof is likely to cause a risk despite ambient lighting of normal intensity.

Machinery must be designed and constructed so that there is no area of shadow likely to cause nuisance, that there is no irritating dazzle and that there are no dangerous stroboscopic effects on moving parts due to the lighting.

Internal parts requiring frequent inspection and adjustment, and maintenance areas must be provided with appropriate lighting.

§179 Integral lighting

The machinery manufacturer is entitled to assume that the ambient lighting in the place of use is of normal intensity. Normal intensity can be judged, for example, by taking into account the levels for indoor and outdoor workplaces indicated in standards EN 12164, parts 1 and 2.[5]

The first paragraph of section 1.1.4 requires the manufacturer to provide lighting integral to the machinery when normal ambient lighting is likely to be inadequate to ensure safe operation of the machinery. Such lighting may be necessary, for example, at work stations that are likely to be in the shade or in enclosed or covered work stations or cabs. Such lighting may also be necessary where the visual tasks of the operators require a higher level of luminance than is likely to be provided by the ambient lighting. The third paragraph of section 1.1.4 adds the

[5] EN 12464-1: 2002 - *Light and lighting - Lighting of work places - Part 1: Indoor work places;*

EN 12464-2: 2007 - *Lighting of work places - Part 2: Outdoor work places.*

requirement for integral lighting for internal parts to which access is frequently required for inspection, adjustment and maintenance purposes.

The second paragraph of section 1.1.4 concerns the design of the integral lighting, to ensure that it does not generate other hazards.

Specifications for integral lighting are given in standard EN 1837.[6]

> ***1.1.5 Design of machinery to facilitate its handling***
>
> *Machinery, or each component part thereof, must:*
>
> — *be capable of being handled and transported safely,*
>
> — *be packaged or designed so that it can be stored safely and without damage.*
>
> *During the transportation of the machinery and/or its component parts, there must be no possibility of sudden movements or of hazards due to instability as long as the machinery and/or its component parts are handled in accordance with the instructions.*
>
> *Where the weight, size or shape of machinery or its various component parts prevents them from being moved by hand, the machinery or each component part must:*
>
> — *either be fitted with attachments for lifting gear, or*
>
> — *be designed so that it can be fitted with such attachments, or*
>
> — *be shaped in such a way that standard lifting gear can easily be attached.*
>
> *Where machinery or one of its component parts is to be moved by hand, it must:*
>
> — *either be easily moveable, or*
>
> — *be equipped for picking up and moving safely.*
>
> *Special arrangements must be made for the handling of tools and/or machinery parts which, even if lightweight, could be hazardous.*

§180 Handling of machinery and parts of machinery

The requirements set out in section 1.1.5 are to be applied in the light of an analysis of the different phases of the lifetime of the machinery concerned – see §173, comments on section 1.1.2 (a).

Section 1.1.5 applies to 'machinery or each component part thereof'. This does not mean that all parts of machinery must be designed for safe handling, but only those parts of the machinery, or the machinery itself, which may have to be handled separately.

Portable hand-held and/or hand guided machinery is subject to specific requirements – see comments on section 2.2.1.

Handling of machinery or parts of machinery is frequently carried out during phases other than normal operation such as, for example, transport, loading and unloading, assembly, installation, dismantling, setting or maintenance. A hand-held power tool intended for consumer use, for example, must be packaged so that it can be safely transported, stored during distribution and carried home by the consumer. A machine tool, for example, must be packaged for transport to the

[6] EN 1837: 1999 - *Safety of machinery - Integral lighting of machines.*

user's premises and designed and constructed so that it can be safely loaded, transported, unloaded and moved to the place of installation. Heavy parts of machinery such as, for example the mould of an injection moulding machine or the die of a metal working press, may need to be changed frequently, depending on the work to be carried out.

Machinery intended to be installed on successive sites during its lifetime, such as, for example, tower cranes, must be designed so that their elements can be safely handled during assembly and disassembly and safely loaded and attached on the means of transport between installation sites. Special attention should be given to parts that may become unstable during transport, for example, on a lorry travelling on uneven ground. Loading instructions are required and, in some cases, extra equipment may be needed ensure stability during transport, such as, for example, a transport support frame.

The third and fourth paragraphs of section 1.1.5 distinguish machinery or component parts that cannot be safely moved by hand from machinery or parts that can be safely moved by hand. When evaluating whether machinery or parts of machinery fall into one or other category, account should be taken of national regulations implementing the provisions of Directive 90/269/EEC,[7] and of the criteria given in the relevant harmonised standards.[8]

When designing machinery or parts of machinery to be safely moved or lifted by hand, sharp edges must be avoided. Particular attention must be given to the required posture of the operator.[9]

> ***1.1.6 Ergonomics***
>
> *Under the intended conditions of use, the discomfort, fatigue and physical and psychological stress faced by the operator must be reduced to the minimum possible, taking into account ergonomic principles such as:*
>
> – *allowing for the variability of the operator's physical dimensions, strength and stamina,*
>
> – *providing enough space for movements of the parts of the operator's body,*
>
> – *avoiding a machine-determined work rate,*
>
> – *avoiding monitoring that requires lengthy concentration,*
>
> – *adapting the man/machinery interface to the foreseeable characteristics of the operators.*

§181 Ergonomic principles

The requirements set out in section 1.1.6 refer to ergonomics. The discipline of ergonomics can be defined as follows:

[7] Council Directive 90/269/EEC of 29 May 1990 on the minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers (fourth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC).

[8] EN 1005-2: 2003 - *Safety of machinery - Human physical performance - Part 2: Manual handling of machinery and component parts of machinery.*

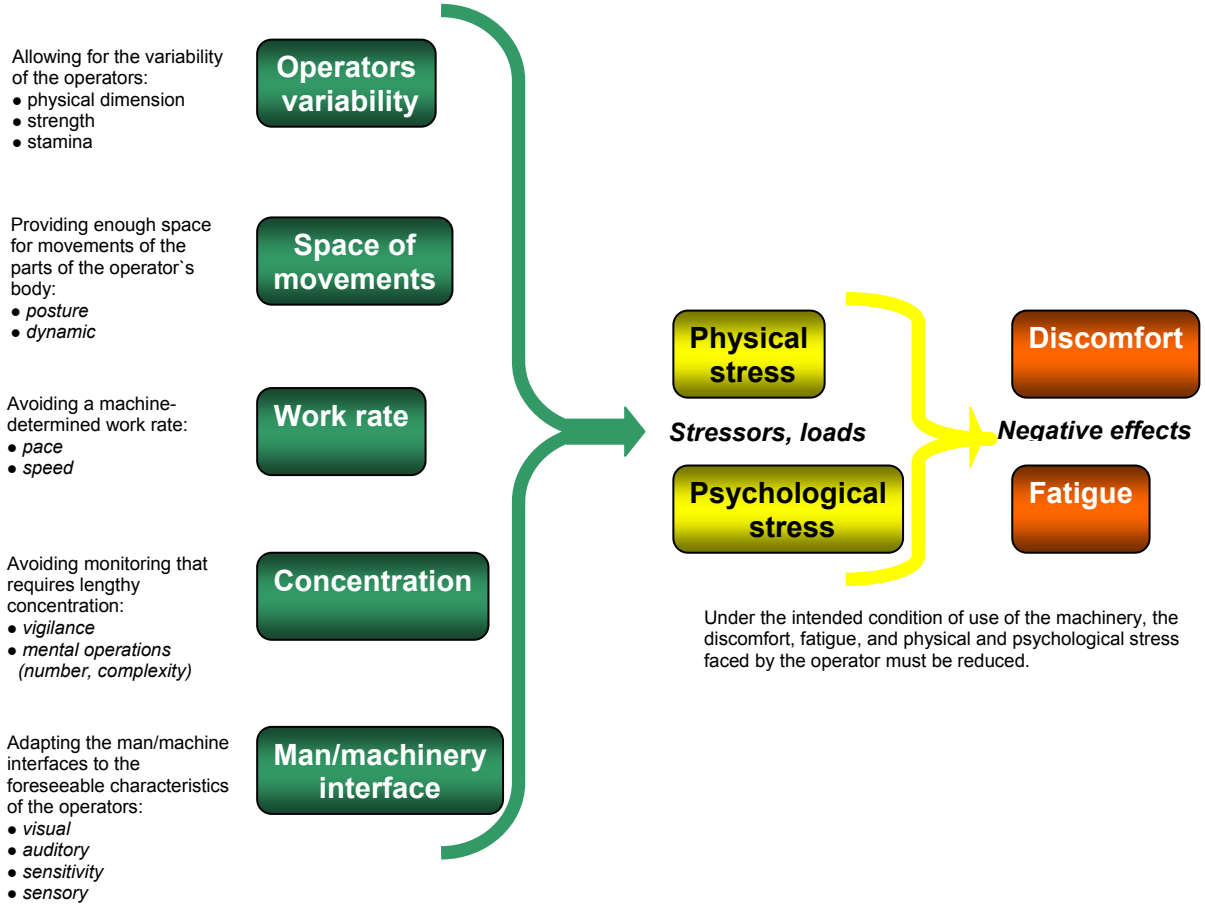
[9] EN 1005-4: 2005+A1: 2008 - *Safety of machinery - Human physical performance - Part 4: Evaluation of working postures and movements in relation to machinery*.

"Ergonomics (or the study of human factors) is the scientific discipline concerned with the understanding of interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance".[10]

Section 1.1.6 lists five ergonomic principles that must be taken be taken into account when designing machinery. It should be underlined that this list is not exhaustive but is intended to draw the attention of manufacturers to certain important aspects of ergonomic principles.

The ergonomic aspects referred to in section 1.1 6 can be distinguished into 2 groups. The first group includes ergonomic factors that have to be taken into account. Section 1.1.6 mentions 5 such factors. Good design reduces the negative impact of these factors on persons whereas inadequate design is likely to give rise to discomfort, fatigue or physical or psychological stress. These effects may, in turn, give rise to musculoskeletal disorders, for example. They also tend to make accidents more likely. The negative consequences for operators resulting from inadequate design form the second group of ergonomic issues:

The following diagram illustrates requirements set out in section 1.1.6:



Guidance on the practical application of ergonomic principles to the design and construction of machinery is given in a family of harmonised standards developed by CEN TC 122 – *Ergonomics*. The relationship between these standards and the ergonomic factors listed above is presented in a separate table and in series of information sheets (LINK).

[10] EN ISO 6385: 2004 - *Ergonomic principles in the design of work systems* (ISO6385:2004).

In addition to the general requirement set out in section 1.1.6, ergonomic principles must also be taken into account when applying the EHSRs set out in a number of other sections of Annex I. For example, the following EHSRs include important ergonomic aspects:

EHSRs applicable to all machinery:

- Lighting (section 1.1.4),
- Handling of machinery or parts of machinery (section 1.1.5),
- Operating positions (sections 1.1.7 and 1.1.8),
- Control devices (section 1.2.2),
- Extreme temperatures (section 1.5.5),
- Noise (section 1.5.8),
- Vibrations (section 1.5.9),
- Radiation (section 1.5.10),
- Emissions of hazardous materials and substances (section 1.5.13),
- Risk of tripping, slipping and falling (section 1.5.15),
- Machinery maintenance (section 1.6.1),
- Access to operating positions and servicing points (section 1.6.2),
- Operator intervention (section 1.6.4),
- Information (section 1.7);

Supplementary EHSRs for portable hand-held and/or hand guided machinery:

- General requirements (section 2.2.1),
- Instructions - vibrations (section 2.2.1.1),

Supplementary EHSRs for the mobility of machinery:

- Driving positions (section 3.2.1),
- Seating (section 3.2.2),
- Positions for other persons (section 3.2.3),
- Control devices (section 3.3.1),
- Starting/moving (section 3.3.2),
- Movement of pedestrian controlled machinery (section 3.3.4),
- Means of access (section 3.4.5),
- Signs, signals and warnings (section 3.6.1),
- Instructions - vibrations (section 3.6.3.1);

Supplementary EHSRs for lifting operations:

- Movement of loads during handling (section 4.1.2.7),

– Access to the carrier (sections 4.1.2.8.2),
– Control of movements (section 4.2.1);

Supplementary EHSRs for the lifting of persons:

– Control devices (section 6.2),
– Access to the carrier (section 6.4.3).

> ***1.1.7 Operating positions***
>
> *The operating position must be designed and constructed in such a way as to avoid any risk due to exhaust gases and/or lack of oxygen.*
>
> *If the machinery is intended to be used in a hazardous environment presenting risks to the health and safety of the operator or if the machinery itself gives rise to a hazardous environment, adequate means must be provided to ensure that the operator has good working conditions and is protected against any foreseeable hazards.*
>
> *Where appropriate, the operating position must be fitted with an adequate cabin designed, constructed and/or equipped to fulfil the above requirements. The exit must allow rapid evacuation. Moreover, when applicable, an emergency exit must be provided in a direction which is different from the usual exit.*

§182 Operating positions in hazardous environments

Operating positions are the places on or at the machinery where operators, as defined in section 1.1.1 (d), carry out their tasks. The manufacturer's instructions must describe the workstation(s) likely to be occupied by operators – see comments on section 1.7.4.2 (f).

The requirement set out in the first paragraph of section 1.1.7 applies mainly to machinery with internal combustion engines. This requirement implies, firstly, that the emission of hazardous exhaust gases must be reduced as far as possible. For example, in the case of machinery designed to be used in enclosed spaces, appropriate systems for the extraction or filtering of exhaust gases must be fitted. Secondly, where there remains a risk of exposure to hazardous exhaust gases, means must be provided to ensure that operators do not inhale such gases and are provided with an adequate supply of breathable air.

The second paragraph of section 1.1.7 is more general and requires operators to be protected against any risks due to the foreseeable use of the machinery in a hazardous environment. Such risks may include, for example, exposure to hot and cold atmospheres, to risks due to noise, radiation, humidity, adverse weather conditions or atmospheres polluted by hazardous substances. The manufacturer must therefore take account of the intended and foreseeable conditions of use of the machinery. For example, if the machinery is placed on the market in a country with a mild climate, it might not be necessary to provide protection against extremely cold weather, whereas protection against dust or heat might be needed. Special consideration needs to be given to machinery that generates hazardous substances, such as dust, fume or toxic aerosols, by its very operation; examples are machinery for rock crushing and screening, machinery for grain handling and paint spray booths.

The third paragraph of section 1.1.7 refers to one of the means that can be used to ensure that operating positions are protected. *'Cabin'* in this paragraph is a generic term for an enclosed operating position such as, for example, a cab on mobile machinery or an enclosed control panel on fixed industrial machinery. In order to fulfil the requirements set out in the first two paragraphs of section 1.1.7, the cabin or enclosure must be provided with the necessary means of purifying and conditioning the air entering the enclosure and preventing inward leaks, for example, by maintaining a positive pressure differential with the outside atmosphere. As well as ensuring protection against hazardous environments, such enclosures can also be designed and constructed to protect operators against exposure to noise emissions – see §229, comments on section 1.5.8. On some mobile machinery, the cab may include a structure to protect against the risk of rolling or tipping over or the risk due to falling objects or both – see comments on sections 3.4.3 and 3.4.4.

> ***1.1.8 Seating***
>
> *Where appropriate and where the working conditions so permit, work stations constituting an integral part of the machinery must be designed for the installation of seats.*
>
> *If the operator is intended to sit during operation and the operating position is an integral part of the machinery, the seat must be provided with the machinery.*
>
> *The operator's seat must enable him to maintain a stable position. Furthermore, the seat and its distance from the control devices must be capable of being adapted to the operator.*
>
> *If the machinery is subject to vibrations, the seat must be designed and constructed in such a way as to reduce the vibrations transmitted to the operator to the lowest level that is reasonably possible. The seat mountings must withstand all stresses to which they can be subjected. Where there is no floor beneath the feet of the operator, footrests covered with a slip-resistant material must be provided.*

§183 Seating and the provision of seats

The requirement set out in section 1.1.8 deals with a specific aspect of the interface between the operator and the machinery that can be a source both of discomfort, fatigue and damage to health if badly designed – see §181, comments on section 1.1.6.

The first paragraph of section 1.1.8 requires machinery to be designed to enable seats to be installed, *'where appropriate and where the working conditions so permit'*. Machinery manufacturers must therefore consider whether operators are likely to be more comfortable and to carry out all or part of their tasks more easily and efficiently when seated.[11] Where this is the case, the work station, in other words, the place at the machinery where the operators are to be seated, must be designed so that the necessary seats can be installed. This implies paying attention, in particular, to the height of the work surfaces, to the location and design of the control devices and the other parts of the machinery to which the operators must have access and to the space provided for the seat itself and for the operators upper and lower limbs.

[11] EN 1005-4: 2005+A1: 2008 - *Safety of machinery - Human physical performance - Part 4: Evaluation of working postures and movements in relation to machinery*.

The second paragraph of section 1.1.8 is applicable when the operator is intended to sit during operation and the operating position is an integral part of the machinery, in other words, when the operator's seat is not to be installed on the floor next to the machinery but on a part of the machinery itself. In that case, the seat must be provided with the machinery.

The second and third paragraphs of section 1.1.8 set out requirements for the seat. The seat must be designed to enable the operator to maintain a stable position taking account of the foreseeable conditions of use including, in particular, foreseeable movements of the machinery.

The relevant parameters of the seat itself such as the height, width, depth and angle of the seat, the position of the backrest and, where appropriate, the position of the arm and footrests, must be adjustable to take account of the variability of operators' physical dimensions. The position of the seat relative to the position of the control devices, including foot-pedals, to be used by the operator must also be adjustable. This can be achieved by allowing for adjustment of the position of the seat, of the control devices or both.[12]

For machinery where the seated operator may be exposed to vibration due to the functioning of the machinery itself or due to the movement of the machinery on uneven ground, the provision of a seat with an appropriate damped suspension system is one way to reduce the risk of exposure of seated operators to whole body vibration – see §231, comments on section 1.5.9.[13]

1.2 CONTROL SYSTEMS

1.2.1 Safety and reliability of control systems

Control systems must be designed and constructed in such a way as to prevent hazardous situations from arising. Above all, they must be designed and constructed in such a way that:

– *they can withstand the intended operating stresses and external influences,*

– *a fault in the hardware or the software of the control system does not lead to hazardous situations,*

– *errors in the control system logic do not lead to hazardous situations,*

– *reasonably foreseeable human error during operation does not lead to hazardous situations.*

Particular attention must be given to the following points:

– *the machinery must not start unexpectedly,*

– *the parameters of the machinery must not change in an uncontrolled way, where such change may lead to hazardous situations,*

– *the machinery must not be prevented from stopping if the stop command has already been given,*

– *no moving part of the machinery or piece held by the machinery must fall or*

[12] See EN ISO 14738: 2008 - *Safety of machinery - Anthropometric requirements for the design of workstations at machinery* (ISO 14738:2002, including Cor 1:2003 and Cor 2:2005).

[13] See, for example, EN ISO 7096: 2008 - *Earth-moving machinery - Laboratory evaluation of operator seat vibration* (ISO 7096:2000).

be ejected,

- *automatic or manual stopping of the moving parts, whatever they may be, must be unimpeded,*
- *the protective devices must remain fully effective or give a stop command,*
- *the safety-related parts of the control system must apply in a coherent way to the whole of an assembly of machinery and/or partly completed machinery.*

For cable-less control, an automatic stop must be activated when correct control signals are not received, including loss of communication.

§184 Safety and reliability of control systems

The control system of machinery is the system which responds to input signals from parts of the machinery, from operators, from external control equipment or any combination of these and generates corresponding output signals to the machinery actuators, causing the machine to behave in the intended manner. Control systems can use different technologies or combinations of technologies such as, for example, mechanical, hydraulic, pneumatic, electric, or electronic technologies. Electronic control systems may be programmable.

The design and construction of the control system in order to ensure safe and reliable functioning of the machinery are key factors in ensuring the safety of the machinery as a whole. Operators must be able to ensure that the machinery functions safely and as expected at all times.

The requirements set out in section 1.2.1 apply to all parts of the control system that, in the event of a fault or a failure, can lead to hazards due to unintended or unexpected behaviour of the machinery. They are of particular importance for the design and construction of the parts of the control system related to safety functions such as, for example, the parts of the control system related to interlocking and guard-locking devices for guards, to protective devices or to emergency stop controls, since a failure of safety related parts of the control system is liable to give rise to a hazardous situation when the corresponding safety function is next required to operate. Certain safety functions may also be operational functions, such as, for example, a two-hand start control device.

The first paragraph of section 1.2.1 and its 4 indents set out the basic requirements for the reliability and safety of control systems. The second paragraph of section 1.2.1 and its 7 indents describe the main hazardous events and situations that must be avoided.

According to the first indent of the first paragraph of section 1.2.1, control systems must be able to withstand intended operating stresses and external influences, taking into account foreseeable abnormal situations – see §160, comments on General Principle 2, and §175, comments on section 1.1.2 (c). The control system must thus be able to withstand the mechanical effects generated by operation of the machinery itself or by its environment such as, for example, shocks, vibrations, and abrasion. Control systems must be able to withstand the effects of the internal and external conditions under which the machinery is intended to function such as, for example, humidity, extreme temperatures, corrosive atmospheres and dust. The correct functioning of control systems must not be affected by electromagnetic radiation, whether generated by parts of the machinery itself or by external elements in the conditions in which the machinery is intended to be used – see §233, comments on section 1.5.11.

The second and third indents of the first paragraph of section 1.2.1 deal with the behaviour of the control system in case of a fault or error in the hardware or software. These requirements take account of the possibility of faults occurring in the control system due, for example, to the failure of a mechanical, hydraulic, pneumatic or electrical component or to an error in the software of a programmable system. Control systems must be designed and constructed so that, if such faults or errors occur, they do not lead to hazardous situations such as those described in the second paragraph of section 1.2.1.

The hazardous functions of the machinery can be brought under control, for example, by stopping the function, removing power from the function or preventing the hazardous action of the function. If the relevant functions of the machinery are able to continue despite the occurrence of a fault or a failure, for example, by means of a redundant architecture, there must be a means of detecting the fault or failure so that the necessary action can be taken to achieve or maintain a safe state.

The means to be used to fulfil this requirement depend on the type of control system, on the part of the control system concerned and on the risks that could arise in case of its failure.

The concepts that can be used include:

- The exclusion or reduction of the probability of faults or failures which may affect the safety function by recourse to particularly reliable components and by applying well-tried safety principles, such as, for example, the principle of the positive mechanical action of a component on another component;
- The use of standard components with a check on the safety functions at suitable intervals by the control system;
- The redundancy of parts of the control system such that a single fault or failure does not lead to the loss of the safety function. Technical diversity of the redundant elements can be used to avoid common cause failures;
- Automatic monitoring to ensure that faults or failures are detected and that the necessary protective measures are initiated to prevent the risk concerned. The protective measures may include the stopping of the hazardous process, preventing the re-start of this process or the triggering of an alarm.

These concepts can be applied in different combinations.

The level of performance required for a given safety related part of the control system depends on the level of the risk for which the safety function is intended and is to be determined on the basis of the manufacturer's risk assessment. C-type standards for particular categories of machinery provide guidance on the level of performance required for the different safety related parts of the control system.

The achievement of the required level of performance for safety related parts of control systems must be validated, taking account both of the hardware and software aspects of such systems.

Specifications for the design of safety-related parts of control systems are given in standards EN ISO 13849-1[14] and standard EN 62061.[15]

The fourth indent of the first paragraph of section 1.2.1 deals with reasonably foreseeable human error during operation. In order to satisfy this requirement, control systems must, as far as possible, be designed with error tolerance. This involves measures such as the detection of errors and providing appropriate feedback to the operator to facilitate the correction of errors.

General principles for human interaction with machinery to minimise operator errors are given in standard EN 894-1.[16]

The third paragraph of section 1.2.1 covers a particular hazard associated with cable-less control systems, such as, for example, remote control systems using radio, optical or sonar signals: incorrect signals or loss of communication between the control devices and the machinery to be controlled. It should be noted that section 3.3 provides supplementary requirements for remote control systems for mobile machinery.

> ***1.2.2 Control devices***
>
> . . .

§185 Control devices

Control devices are parts of the control system which detect input signals given by the operators, usually by means of hand or foot pressure. There are many different kinds of control devices including, for example, push-buttons, levers, switches, knobs, sliders, joy-sticks, hand wheels, pedals, keyboards and tactile screens. Control devices may be located on the machinery itself or, in the case of remote controls, may be located at a distance from the machinery and be linked to the machinery, for example, by means of wires, or by means of radio, optical or sonar signals.

Application of the requirements set out in section 1.2.2 requires particular attention to ergonomic principles, since control devices are at the interface between the machinery and the operators – see §181, comments on section 1.1.6.

Specifications relating to the requirements set out in the following paragraphs of section 1.2.2 are given in the standards of the EN 894 series[17] and the standards of the EN 61310 series.[18]

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[14] EN ISO 13849-1:2008 - *Safety of machinery — Safety-related parts of control systems* — Part 1: *General principles for design* (ISO 13849-1:2006).

[15] EN 62061:2005 - *Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems* (IEC 62061:2005).

[16] EN 894-1:1997+A1: 2008 – *Safety of machinery – Ergonomic requirements for the design of displays and control actuators – Part 1: General principles for human interactions with displays and control actuators.*

[17] EN 894-1:1997+A1: 2008 – *Safety of machinery – Ergonomic requirements for the design of displays and control actuators* – Part 1: *General principles for human interactions with displays and control actuators;*

EN 894-2:1997 + A1:2008 - *Safety of machinery – Ergonomics requirements for the design of displays and control actuators* – Part 2: *Displays*;

EN 894-3:2000 + A1:2008 - *Safety of machinery - Ergonomics requirements for the design of displays and control actuators* - Part 3: *Control actuators.*

In addition to the general requirements for control devices set out in section 1.2.2, the following sections of Annex I provide supplementary requirements for control devices for certain categories of machinery or for certain risks:

- portable hand-held and/or hand-guided machinery: sections 2.2.1 and 2.2.2.1;
- mobility of machinery - section 3.3;
- lifting operations – section 4.2.1;
- machinery for underground work - section 5.3;
- machinery for lifting persons - sections 6.2 and 6.4.2.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> *Control devices must be:*
>
> – *clearly visible and identifiable, using pictograms where appropriate,*
>
> . . .

§186 Identification of control devices

The first indent of section 1.2.2, on the visibility and clear identification of control devices, aims to enable operators to use the devices without hesitation and avoid unintended commands due to operators confusing one control device with another. Since operators are often liable to perform different tasks and use several different machines in the course of their activity, it is important for manufacturers to identify control devices using, as far as possible, standardised colours, shapes and pictograms so that operators are not surprised when change tasks or move from one machine to another. If the function of a control device is obvious from its standard shape and location, such as for example, a steering wheel or handlebars on mobile machinery, additional means of identification are not required.

If the controls are identified by means of written or verbal information, this information is subject to the language requirements relating to information and warnings on the machinery – see §245, comments on section 1.7.1.

[18] EN 61310-1:2008 - *Safety of machinery — Indication, marking and actuation* — Part 1: *Requirements for visual, acoustic and tactile signals* (IEC 61310-1:2007);

EN 61310-2:2008 - *Safety of machinery - Indication, marking and actuation - Part 2: Requirements for marking* (IEC 61310-2:2007);

EN 61310-3:2008 – *Safety of machinery – Indication, marking and actuation* – Part 3: *Requirements for the location and operation of actuators* (IEC 61310-3:2007).

1.2.2 Control devices (continued)

. . .

– *positioned in such a way as to be safely operated without hesitation or loss of time and without ambiguity,*

. . .

§187 Positioning of control devices

The second indent of section 1.2.2 requires manufacturers to take account of ergonomic principles when positioning control devices on the machinery, to ensure that the devices are clearly visible to operators and that they can be reached and used efficiently and safely, without the need to adopt awkward postures.

The positioning of the control devices must take account of the tasks to be carried out by the operators and of the corresponding operating modes, of the position and characteristics of work stations or operating positions, of whether operators are likely to be standing or seated and of the need for operators to observe certain parts of the machinery while using the control devices.

The positioning of control devices should also take account of the position of the parts of the machinery affected by its use, following commonly accepted conventions. For example, a device controlling parts of the machinery to the right of the operator should be positioned on the right of the operating position; a device controlling an upward movement should be located above a button controlling a downward movement and so on.

Where control devices have to be operated in a given sequence, they should be arranged in that sequence. Devices controlling related functions should be grouped together and devices controlling unrelated functions should be clearly separated.

The control devices that are likely to be used most frequently or that need to be used continuously should be positioned within the central area of the operator's field of vision and within the immediate reach envelope where they can be reached without bending. Where necessary, this may require the provision of means of adjusting the position of the control devices to accommodate the variation of the body dimensions of operators.

1.2.2 Control devices (continued)

. . .

– *designed in such a way that the movement of the control device is consistent with its effect,*

. . .

§188 Movement of control devices

The requirement set out in the third indent of section 1.2.2 deals with two principles for the design of control devices which are to ensure conformity with the expectations of users and to comply with common practice in order to avoid

hazardous situations and errors. The requirement applies to the movements of control devices such as, for example, levers or hand wheels.

Wherever possible, the direction of movement of such devices should be consistent with the direction of the movement controlled by their use. In the case of control devices controlling other parameters, the direction of movement of the device should correspond to commonly accepted conventions such as, for example, the convention that turning a device clockwise increases the value of the parameter concerned and turning the device anti-clockwise reduces it.

Particular attention should be given to the design of control devices in machinery where the operating position is able to rotate with respect to the rest of the machinery, with the result that the direction of certain movements controlled by the control devices is inverted.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> – *located outside the danger zones, except where necessary for certain control devices such as an emergency stop or a teach pendant,*
>
> – *positioned in such a way that their operation cannot cause additional risk,*
>
> . . .

§189 Location of and positioning of control devices

The location and positioning of control devices outside the danger zones, required by the fourth and fifth indents of section 1.2.2, is one of the ways of avoiding the exposure of operators to hazards – see §165, comments on section 1.1.1 (b). This requirement must be applied taking account not only of areas where there is a risk of direct contact with hazardous elements of the machinery but also of areas where there may be risks due to ejected objects or emissions from the machinery. Ways to fulfil these requirements include, for example, locating the control devices at a sufficient distance from moving parts – see §212, comments on section 1.3.7 – or locating control devices behind a screen or inside an adequate cabin – see §182, comments on section 1.1.7.

Where it is necessary to derogate from this general rule, for example, in cases where control devices have to be provided within a danger zone for setting or maintenance purposes, the requirement set out in the fourth indent can be fulfilled by providing a setting or maintenance mode, the selection of which triggers particular protective measures such as, for example, low speed and/or incremental movement - see §204, comments on section 1.2.5. The provision of emergency stop devices within danger zones is also an exception to the general rule – see §202, comments on section 1.2.4.3.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> – *designed or protected in such a way that the desired effect, where a hazard is involved, can only be achieved by a deliberate action,*
>
> . . .

§190 Preventing inadvertent operation of control devices

The requirement set out in the sixth indent of section 1.2.2 aims to avoid inadvertent operation of control devices. Inadvertent operation can result from various causes, such as, for example, accidental contact between a part of the operator's body or of his or her clothing and a control device, unintentional operation of two adjacent control devices, a control device being caught on an obstacle in the environment of the machinery or use of a control device as a hand hold for access to the operating position – see comments on section 3.4.5.

Such risks must be assessed for the different phases of the foreseeable lifetime of the machinery, taking account of the operators' tasks and the corresponding operation modes, and must be prevented by appropriate design measures. Such measures include, for example:

- designing the control devices with sufficient resistance to avoid inadvertent operation by slight pressure;
- positioning the control devices in a recess or surrounding them with a collar;
- positioning and/or guarding control devices, to prevent contact with parts of the operator's body or clothing and to prevent them from being caught on obstacles in the environment of the machinery;
- fitting control devices the operation of which requires two independent actions;
- fitting control devices with a lock.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> – *made in such a way as to withstand foreseeable forces; particular attention must be paid to emergency stop devices liable to be subjected to considerable forces.*
>
> . . .

§191 Strength of control devices

The requirement set out in the seventh indent of section 1.2.2 concerns the mechanical strength of control devices. Breakage of control devices can result in a hazardous situation due to the inability to control the function concerned. Such a breakage can also itself result in injury.

In applying this requirement, the foreseeable conditions of use during the different phases of the foreseeable lifetime of the machinery and the different tasks and operating modes involved must be taken into account – see §207, comments on section 1.3.2. This is particularly important for emergency stop devices which have to be operated rapidly and are often designed to be hit – see §202, comments on section 1.2.4.3.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> *Where a control device is designed and constructed to perform several different actions, namely where there is no one-to-one correspondence, the action to be performed must be clearly displayed and subject to confirmation, where necessary.*
>
> . . .

§192 Control devices to perform different actions

The requirement set out in the second paragraph of section 1.2.2 applies where a single control device is able to control several different functions.

For example, certain control devices may perform different actions depending on the operating or control mode selected. Control devices may perform different actions depending on the interchangeable equipment fitted to the machinery. Certain joy-stick type control devices can control different actions by means of fore and aft movements, side to side movements and twisting movements, and the effects of the different movements of the joy-stick can be varied using top buttons or trigger switches incorporated in the device.

Use of such control devices can facilitate the control of certain categories of machinery by reducing the number and amplitude of the necessary hand and arm movements. However, it is particularly important when designing such devices to ensure that the effects of the various movements of the device are clearly identified and that the devices are designed to avoid confusion between the different actions that can be performed. Where necessary to avoid confusion, two separate actions must be necessary to control a given function.

The requirement set out in the second paragraph of section 1.2.2 also applies to so-called numerically controlled machinery or machinery with a programmable electronic control system, where the input signals are given by means of a keyboard or tactile screen. One way to avoid errors is for the software to indicate the action to be performed and require confirmation by the operator before the output signal is sent to the machinery actuators.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> *Control devices must be so arranged that their layout, travel and resistance to operation are compatible with the action to be performed, taking account of ergonomic principles.*
>
> . . .

§193 Control devices and ergonomic principles

The characteristics of control devices must be determined taking account of the various parameters of the operators' tasks, including, for example:

- the accuracy required in positioning the control device;
- the speed of setting required;
- the force required to operate the device.

Attention must be paid to the visibility of the control devices and to the ability of operators to reach and use them efficiently and safely in all task situations and operating modes, without having to adopt awkward postures. The layout of control devices, the travel distance of the moving parts of the devices and the force required to operate the devices must take account of the nature of the action to be performed, of the functional anatomy of the human hand or foot and the body dimensions of the operator population. In the case of control devices used frequently or continuously, the design of the devices must avoid repetitive movements involving awkward postures or excessive hand span that may contribute to musculoskeletal disorders.

Where hold-to-run control devices are required, they must be designed to reduce the constraints for operators as far as possible – see comments on sections 3.3.1, 4.2.1 and 6.2.

The space between control devices must be sufficient to reduce the risk of unintentional operation, without thereby demanding unnecessary movements. Particular attention should be given to whether operators are likely to use PPE such as protective gloves or protective footwear – see §176, comments on section 1.1.2 (d).

The arrangement and layout of control devices must also take account of human capacities for information processing, with respect to attention, perception and cognition.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> *Machinery must be fitted with indicators as required for safe operation. The operator must be able to read them from the control position.*
>
> . . .

§194 Indicators and displays

The requirement set out in the fourth paragraph of section 1.2.2 requires machinery to be fitted with the necessary indicators to enable operators to carry out their various tasks. These include, for example, indicators to inform operators on the value of the relevant parameters of the machinery (such as, for example, the speed, load, temperature or pressure of parts of the machinery) and on the effects of their action on the control devices, when this is not obvious.

Indicators may also provide warnings to operators when the relevant parameters exceed the safe range of values. Such indicators may be associated with limiting devices that trigger certain actions when safe parameters are exceeded. The indicators may also be used in combination with a specific mode of operation such as low speed or incremental operation.

Commonly used indicators include digital displays and screens, analogical displays such as dials and gauges, as well as tactile and auditory indicators. Indicators can be an integral part of the control devices themselves or independent. If they are independent, they must be designed and positioned so that they can be easily read and understood by the operators from the control position when using the related control devices. In particular, indicators must be designed to facilitate the rapid detection of abnormal behaviour of the machinery.

Indicators and displays are subject to the requirements set out in sections 1.7.1, 1.7.1.1, and 1.7.1.2 relating to information and warnings on the machinery, information devices and warning devices. In particular, any written or verbal information provided by indicators or displays is subject to the language requirements set out in section 1.7.1 – see §245 to §248, comments on sections 1.7.1, 1.7.1.1 and 1.7.1.2.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> *From each control position, the operator must be able to ensure that no-one is in the danger zones, or the control system must be designed and constructed in such a way that starting is prevented while someone is in the danger zone.*
>
> *If neither of these possibilities is applicable, before the machinery starts, an acoustic and/or visual warning signal must be given. The exposed persons must have time to leave the danger zone or prevent the machinery starting up.*
>
> . . .

§195 Visibility of danger zones during starting

In accordance with section 1.1.2 (b), the first measure should be the elimination or reduction of the risk, for example, by designing the machinery so that persons do not need to enter the danger zones of the machinery – see §239, comments on section 1.6.1 – or by fitting guards and/or protective devices to detect the presence of persons in the danger zone and prevent starting as long as persons are present. But such measures are not always possible.

If there is a risk that persons may enter the danger zones, the requirement set out in the fifth and sixth paragraphs of section 1.2.2 aim to enable the operator to ensure that no-one is in the danger zones of the machinery before starting the machinery. The persons concerned may be other production operators or other exposed persons such as maintenance operators. In the case of danger zones in the environment of the machinery, the possible exposed persons may include bystanders – see §165, comments on section 1.1.1 (b).

If it is not possible to design the machinery so that the operator controlling the start of the machinery has adequate direct vision of the danger zones from the control position, indirect vision aids can be provided, such as, for example, mirrors or close circuit television (CCTV).

In this respect, it should be noted that supplementary requirements relating to visibility from the driving position of mobile machinery are set out in section 3.2.1.

Where it is not possible to ensure direct or indirect visibility of the danger zones from the control positions, the starting of the machinery must be preceded by an acoustic or visual warning signal (or both) with sufficient time between the warning signal and the start or movement of the machinery to allow any exposed persons to leave the danger zones or, if that is not possible, exposed persons must have means to prevent the machinery from starting, such as, for example, an emergency stop control in the danger zone – see §202, comments on section 1.2.4.3.

Specifications for acoustic and visual warning signals are given in standard EN 981.[19]

When maintenance operations may be carried out in danger zones of machinery, specific means must be provided for preventing the unexpected start of the machinery or parts of the machinery – see §241, comments on section 1.6.3.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> *If necessary, means must be provided to ensure that the machinery can be controlled only from control positions located in one or more predetermined zones or locations.*
>
> . . .

§196 Location of control positions

The requirement set out in the seventh paragraph of section 1.2.2 aims to ensure that the position from which the operator controls the operation of the machinery is outside the danger zones of the machinery and located, as far as possible, so that the operator can ensure that other persons are not exposed to risks.

Particular attention should be given to this requirement when considering the use of moveable control devices such as pendant controls or remote controls. The risk assessment must take account of the risk that the operator may control the machinery from a hazardous position, such as, for example, a zone where there is a risk of being crushed or hit by falling or ejected objects.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> *Where there is more than one control position, the control system must be designed in such a way that the use of one of them precludes the use of the others, except for stop controls and emergency stops.*
>
> . . .

§197 Multiple control positions

The requirements set out in the eighth paragraph of section 1.2.2 concerns machinery provided with two or more control positions intended to be used in turn, either by a single operator or by two or more operators, to carry out different tasks or control the machinery during different phases of its operation. In order to avoid confusion or contradictory commands, the control devices at each control position must be linked to the control system in such a way that the use of one control position precludes the use of the others, except for stop controls and emergency stops.

[19] EN 981:1996 + A1:2008 – *Safety of machinery – System of auditory and visual danger and information signals*.

> ***1.2.2 Control devices (continued)***
>
> . . .
>
> *When machinery has two or more operating positions, each position must be provided with all the required control devices without the operators hindering or putting each other into a hazardous situation.*

§198 Multiple operating positions

The last paragraph of section 1.2.2 applies to machinery provided with two or more operating positions that can be used simultaneously. This is typically the case for assemblies of machinery where different constitutive elements of the assembly have their own operating position – see comments on the fourth indent of Article 2 (a). The overall control system of such an assembly and the attribution of control functions to the different operating positions must be designed so that commands given at one operating position do not hinder or create a hazardous situation for operators at other operating positions. Particular precautions must be taken if the operation of one element of the assembly automatically starts the operation of another element – see comments on section 1.2.3.

> ***1.2.3 Starting***
>
> *It must be possible to start machinery only by voluntary actuation of a control device provided for the purpose.*
>
> *The same requirement applies:*
>
> – *when restarting the machinery after a stoppage, whatever the cause,*
>
> – *when effecting a significant change in the operating conditions.*
>
> *However, the restarting of the machinery or a change in operating conditions may be effected by voluntary actuation of a device other than the control device provided for the purpose, on condition that this does not lead to a hazardous situation.*
>
> *For machinery functioning in automatic mode, the starting of the machinery, restarting after a stoppage, or a change in operating conditions may be possible without intervention, provided this does not lead to a hazardous situation.*
>
> *Where machinery has several starting control devices and the operators can therefore put each other in danger, additional devices must be fitted to rule out such risks. If safety requires that starting and/or stopping must be performed in a specific sequence, there must be devices which ensure that these operations are performed in the correct order.*

§199 Control of starting

The requirements set out in section 1.2.3 aim to prevent unintended or unexpected starting, which are common causes of serious accidents involving machinery.

The basic requirement, set out in the first paragraph of section 1.2.3, is that machinery shall only start when the operator gives a start command by using a specific start control device. This requirement applies to the initial start of machinery at the beginning of a period of operation.

According to the second paragraph of section 1.2.3 the basic requirement also applies when restarting the machinery after a stoppage or when effecting a significant change in the operating conditions such as, for example, the adjustment of the speed of the machinery.

Thus, for example, as a general rule, starting must not be initiated by the closing of an interlocking moveable guard, by the release of a stop control or by the release of an emergency stop control – see §200 to §202, comments on section 1.2.4.

However, according to the third paragraph of section 1.2.3, the requirement for a specific start or restart control device does not apply to restarting or changing the operating conditions if the use of another device than the specific start control device does not lead to a hazardous situation.

Thus, for example, it is exceptionally possible to control the initiation of certain functions of machinery by the closure of an interlocked guard (control guard) or by the withdrawal of a person or of the detected part of a person from the sensing field of a protective device. This feature can be useful for ergonomic reasons, in order to avoid the need for repeated action on the start control device on machinery with a short work cycle. However these exceptional solutions can only be applied if the machinery is designed and constructed with adequate compensatory protective measures to prevent the risk of unintended or unexpected starting.

Specifications for the exceptional recourse to control guards or of protective devices used for cycle initiation are given in standard EN ISO 12100-2.[20]

The fourth paragraph of section 1.2.3 permits a second exception to the general rule set out in the first paragraph, in cases where the starting of the machinery, the restarting after a stoppage or after a change in operating conditions is triggered automatically, providing that this does not lead to a hazardous situation. This requirement implies that automatic starting and restarting must be possible only when the necessary means to protect persons against the risks associated with the automatically controlled functions are in place and operating correctly.

The requirements set out in the fifth paragraph of section 1.2.3 are supplementary to the requirements set out in the eighth and ninth paragraphs of section 1.2.2.

Machinery may be fitted with several start control devices because it is provided with several control positions intended to be used at different times or for different tasks. In such cases, the control system must be designed to ensure that only one start control can be used at a time, in accordance with the eighth paragraph of section 1.2.2.

Several starting control devices may also be provided on machinery, especially assemblies of machinery, having several operating positions for different constitutive elements. In that case the overall control system of the assembly must be designed to ensure that use of one of the start control devices does not give rise to a hazardous situation for the other operators. Similarly, the overall control system must be designed to ensure that elements of the machinery that must be started or stopped in a given order can only be started or stopped in that order and that incorrect start or stop control signals are ineffective.

[20] EN ISO 12100-2:2003 – *Safety of machinery – Basic concepts, general principles for design* – Part 2: *Technical principles* (ISO 12100-2:2003) – see clauses 5.2.5.3 and 5.3.2.5.

Specifications for preventing unexpected start-up of machinery are given in standard EN 1037.[21]

It should be noted that, in addition to the general requirements relating to starting set out in section 1.2.3, supplementary requirements for starting relating to the mobility of machinery are set out in section 3.3.2.

> ***1.2.4 Stopping***
>
> ***1.2.4.1 Normal stop***
>
> *Machinery must be fitted with a control device whereby the machinery can be brought safely to a complete stop.*
>
> *Each workstation must be fitted with a control device to stop some or all of the functions of the machinery, depending on the existing hazards, so that the machinery is rendered safe.*
>
> *The machinery's stop control must have priority over the start controls.*
>
> *Once the machinery or its hazardous functions have stopped, the energy supply to the actuators concerned must be cut off.*

§200 Normal stop control devices

The requirement set out in section 1.2.4.1 aims to ensure that operators can stop machinery safely at all times. Apart from the need to stop the machinery safely for operational reasons, it is also essential for operators to be able to stop machinery in case of malfunctioning that might lead to a hazardous situation.

The second paragraph applies to machinery with two or more workstations. In some cases, a single operator may control the whole of the machinery from different control positions, depending on his tasks and on the phase of operation. In other cases, different parts of the machinery may be controlled by different operators. The stop control device provided at each workstation may stop all of the machinery or only a part of the machinery where this can be done without risk – see §203, comments on section 1.2.4.4. If necessary, the stop control device shall stop the relevant parts of the complex machinery in a sequential procedure – see §199, comments on section 1.2.3.

The requirement set out in the third paragraph of section 1.2.4.1 is a requirement for the design of the control system that is particularly important in the case of machinery with several workstations, since it prevents a start command given by one operator from overriding a stop command given by another operator. It also aims to ensure that a stop command can be given, even in case of a failure of the start control in the sense of maintained start command.

The requirement, set out in the last paragraph of section 1.2.4.1, that once the machinery or its hazardous functions have stopped, the energy supply to the actuators concerned must be cut off, aims to prevent the risk of unintended starting following a stop command that might be caused by a fault or failure in the control system. This means that stopping can either be achieved by immediate removal of power to the machine actuators, or with power available to the machine actuators to achieve the stop and then removal of power once the stop has been achieved.

[21] EN 1037:1995+A1:2008- *Safety of machinery - Prevention of unexpected start-up*.

It should be noted that, in addition to the general requirements for stopping set out in section 1.2.4.1, supplementary requirements for stopping for the travelling function of mobile machinery are set out in section 3.3.3.

> ***1.2.4.2 Operational stop***
>
> *Where, for operational reasons, a stop control that does not cut off the energy supply to the actuators is required, the stop condition must be monitored and maintained.*

§201 Operational stop

Section 1.2.4.2 recognises that, for operational reasons, for example, in order to permit an easier or more rapid restart of the machinery, it may be necessary to provide, in addition to the normal stop control required by section 1.2.4.1, a stop control that does not cut off the energy supply to the actuators. However, since in that case a failure in the control system could lead to an unintended start, the control system must include the means of monitoring the stop condition in order to ensure that the machinery remains at a stop until it is intentionally restarted using the start control device. The part of the control system relative to the monitoring is to be considered as a safety related part of the control system that must have an adequate level of performance – see §184, comments on section 1.2.1.

> ***1.2.4.3 Emergency stop***
>
> *Machinery must be fitted with one or more emergency stop devices to enable actual or impending danger to be averted.*
>
> *The following exceptions apply:*
>
> – *machinery in which an emergency stop device would not lessen the risk, either because it would not reduce the stopping time or because it would not enable the special measures required to deal with the risk to be taken,*
>
> – *portable hand-held and/or hand-guided machinery.*
>
> *The device must:*
>
> – *have clearly identifiable, clearly visible and quickly accessible control devices,*
>
> – *stop the hazardous process as quickly as possible, without creating additional risks,*
>
> – *where necessary, trigger or permit the triggering of certain safeguard movements.*
>
> *Once active operation of the emergency stop device has ceased following a stop command, that command must be sustained by engagement of the emergency stop device until that engagement is specifically overridden; it must not be possible to engage the device without triggering a stop command; it must be possible to disengage the device only by an appropriate operation, and disengaging the device must not restart the machinery but only permit restarting.*
>
> *The emergency stop function must be available and operational at all times, regardless of the operating mode.*
>
> *Emergency stop devices must be a back-up to other safeguarding measures and not a*

substitute for them.

§202 Emergency stop devices

An emergency stop device comprises a specific control device linked to the control system that gives a stop command and the components or systems necessary to stop the hazardous functions of machinery as quickly as possible, without creating any further risks.

Emergency stop devices are intended to enable operators to stop the hazardous functions of machinery as quickly as possible if, despite the other protective measures provided, a hazardous situation or event arises. The emergency stop does not itself provide protection, which is why the last sentence of section 1.2.4.3 stresses that fitting an emergency stop device is a back-up to other safeguarding measures such as guards and protective devices and not a substitute for them. However, an emergency stop can enable operators to prevent a dangerous situation from resulting in an accident or at least reduce the severity of the consequences of an accident. Furthermore, an emergency stop may also enable operators to prevent malfunctioning of the machinery from damaging the machinery.

The first paragraph of section 1.2.4.3 requires machinery to be fitted, as a general rule, with one or more emergency stop devices. The second paragraph of section 1.2.4.3 sets out two exceptions where emergency stop devices are not required. The first exception is where an emergency stop device would not reduce the risk compared with the normal stop control. This may be the case, for example, if it is not possible to obtain a significantly quicker stop than is obtained by the normal stop control without creating further risks, such as, for example, the loss of stability or the risk of break up of parts of the machinery. In cases where an emergency stop control is not provided, the normal stop control device must be clearly identifiable, clearly visible and quickly accessible so that it can be used to stop the machinery in an emergency. The second exception concerns hand-held and/or hand-guided machinery – see comments on section 2.2.1.

The third and fourth paragraphs of section 1.2.4.3 set out requirements for the design of emergency stop devices:

- Firstly, the emergency stop control devices must be clearly identifiable and clearly visible. This is important because, in an emergency situation, a split-second reaction may be crucial. Usually, emergency stop control devices are red against a yellow background.
- Secondly, emergency stop control devices must be quickly accessible. This requirement has consequences for both the choice of the type of control device and the number and location of control devices to be fitted.

  Frequently, emergency stop control devices are hand-operated mushroom-type buttons. However, where there is a risk that the operator may have difficulty to reach the emergency stop, for example, if both of the operator's hands may be caught up, foot-operated emergency stop control devices, or bars that can be operated by other parts of the body may be preferable.

  On machinery where the danger zones extend over a long distance, for example, on continuous handling machinery such as conveyors, emergency stop controls can be activated by wires or ropes.

Since emergency stop control devices must be quickly accessible, the number and the location of the devices to be fitted must be decided taking account of the size and configuration of the machinery, the number of operators, the location of the danger zones and the location of the workstations and maintenance points. In particular, it may be necessary to fit emergency stop control devices within danger zones that are not visible to the operator starting the machinery or in areas of machinery where persons might be trapped, in order to enable any exposed persons to prevent starting if they cannot leave the danger zone in time – see §195, comments on the sixth paragraph of section 1.2.2.

- The second indent of the third paragraph specifies that the emergency stop device must stop the hazardous process as quickly as possible, without creating additional risks. The means to fulfil this requirement depend on the characteristics of the machinery. In some cases, an immediate cut-off of the energy supply to the actuators is sufficient. Where a controlled stop is necessary, the actuators may remain under power during the stopping process and the energy supply is cut off once stopping is achieved. In some cases, to avoid creating additional risks, it may be necessary to maintain the power supply to certain components even after stopping is achieved, for example, to prevent parts of the machinery from falling.
- The third indent of the third paragraph refers to cases where actions other than the stopping of the machinery may also be needed to avoid or remove the hazardous situation. For example, once the machinery has stopped, it may be necessary to open or to permit the opening of points where parts of the operator's body may be caught or trapped. In such cases, the emergency stop device must be designed to trigger such actions automatically or, at least, to permit such actions to be controlled. Where necessary for safety, certain functions of the machinery shall not be stopped (such as, for example cooling systems, or dust extractors).

The requirement set out in the fourth paragraph of section 1.2.4.3 aims to prevent the risk of inadvertent restarting of the machinery after the emergency stop device has been activated. This requirement can be met by fitting emergency stop devices of the 'lock-in' type needing a specific deliberate action to disengage them. The disengagement of the emergency control device must not restart the machinery but only permit the restarting of the machinery using the normal start control device – see §199, comments on section 1.2.3.

The fifth paragraph of section 1.2.4.3 requires the emergency stop function to be available and operational at all times, regardless of the operating mode – see §204, comments on section 1.2.5.

Specifications for emergency stops are given in standard EN ISO 13850.[22]

[22] EN ISO 13850:2008 – *Safety of machinery – Emergency stop – Principles for design* (ISO 13850:2006).

1.2.4.4 Assembly of machinery

In the case of machinery or parts of machinery designed to work together, the machinery must be designed and constructed in such a way that the stop controls, including the emergency stop devices, can stop not only the machinery itself but also all related equipment, if its continued operation may be dangerous.

§203 Stop controls for assemblies of machinery

The requirement set out in section 1.2.4.4 must be applied according to the risk assessment carried out by the manufacturer responsible for constituting an assembly of machinery – see §38, comments on the fourth indent of Article 2 (a). The possibility of a normal stop control stopping only certain of the constitutive elements of an assembly of machinery permitted by section 1.2.4.2 does not apply if continued operation of other elements of the machinery may give rise to a hazardous situation. Similarly, where it is important for operators of one element of an assembly of machinery to be able to stop related elements of the assembly in an emergency, the emergency stop devices must act on all the related parts of the assembly.

If an assembly of machinery is divided into different zones controlled by different normal stop controls and emergency stop devices, these zones must be clearly defined and it must be clearly indicated which elements of the assembly of machinery belong to which zone. The interfaces between zones shall be designed in such a way that continued operation in one zone cannot give rise to hazardous situations in other zones which have been stopped.

1.2.5 Selection of control or operating modes

The control or operating mode selected must override all other control or operating modes, with the exception of the emergency stop.

If machinery has been designed and constructed to allow its use in several control or operating modes requiring different protective measures and/or work procedures, it must be fitted with a mode selector which can be locked in each position. Each position of the selector must be clearly identifiable and must correspond to a single operating or control mode.

The selector may be replaced by another selection method which restricts the use of certain functions of the machinery to certain categories of operator.

If, for certain operations, the machinery must be able to operate with a guard displaced or removed and/or a protective device disabled, the control or operating mode selector must simultaneously:

- *disable all other control or operating modes,*
- *permit operation of hazardous functions only by control devices requiring sustained action,*
- *permit the operation of hazardous functions only in reduced risk conditions while preventing hazards from linked sequences,*
- *prevent any operation of hazardous functions by voluntary or involuntary action on the machine's sensors.*

If these four conditions cannot be fulfilled simultaneously, the control or operating mode selector must activate other protective measures designed and constructed to ensure a safe intervention zone.

In addition, the operator must be able to control operation of the parts he is working on from the adjustment point.

§204 Mode selection

Section 1.2.5 deals with risks that may arise when machinery is designed with several control or operating modes. In some cases, machinery may be designed with specific control modes, for example, for setting or maintenance operations. In other cases, different operating modes are foreseen, for example, for operation with manual or automatic feeding of workpieces.

The first paragraph of section 1.2.5 applies in all such cases and requires the different control or operating modes to be exclusive of each other, except for the emergency stop function, which must be available whichever control or operating mode is selected.

The second paragraph of section 1.2.5 applies to operating modes requiring different protective measures and work procedures having a different impact on safety. For example, for an operating mode with manual feeding of workpieces, safeguarding with interlocking moveable guards or with protective devices, such as optoelectronic protective devices or two-hand control devices, may be appropriate. For an operating mode with automatic feeding, the use of a two-hand control device as the main means of safeguarding will probably not be acceptable.

Setting or maintenance modes may enable certain functions of the machinery to be controlled with guards open or with protective devices muted or by means of a special control device such as a pendant control or a remote control device, instead of the control devices used for normal operation.

In these cases, each position of the mode selector must correspond to a single control or operating mode and it must be possible to lock the mode selector device in each position, while the device must be provided with the necessary indicators to make it clear to operators which control or operating mode has been selected – see§194, comments on the fourth paragraph of section 1.2.2.

The third paragraph of section 1.2.5 permits, as an alternative to a physically lockable selector, that selection of a control or operating mode such as, for example, a setting or maintenance mode, may be restricted to specially trained and authorised operators by other means, such as, for example, an access code.

The fourth paragraph of section 1.2.5 sets out four conditions that must be simultaneously fulfilled for machinery to be provided with a control or operating mode where the guards are open or protective devices are muted:

- The first condition aims to rule out any use of the other control or operating modes during use of this mode;
- The second condition aims to ensure that the operator retains full control of hazardous functions at all times;
- The third condition requires the disabling of the normal protective means to be compensated by other protective measures such as, for example, reduced speed and/or incremental operation of the moving parts.

Safeguarding shall be maintained for hazardous parts to which access is not required;

- The fourth condition requires the mode selector not only to disable all other control modes but also to disable any sensors on the machinery that might otherwise trigger movements or other hazardous functions of the machinery or parts of the machinery during the operation concerned.

The fifth paragraph of section 1.2.5 applies if it is necessary to provide an operational mode with certain of the normal protective means disabled and where one or more of the four conditions set out in the fourth paragraph cannot be fulfilled. In that case, the machinery must be provided with other protective means to ensure that the zone in which the operator is intended to intervene is safe. It should be underlined that these means must be integrated in the design and construction of the machinery and that it is not sufficient, in such a case, to rely on the manufacturer's instructions, on warnings on the machinery or on the training of the operators.

1.2.6 Failure of the power supply

The interruption, the re-establishment after an interruption or the fluctuation in whatever manner of the power supply to the machinery must not lead to dangerous situations.

Particular attention must be given to the following points:

- *the machinery must not start unexpectedly,*
- *the parameters of the machinery must not change in an uncontrolled way when such change can lead to hazardous situations,*
- *the machinery must not be prevented from stopping if the command has already been given,*
- *no moving part of the machinery or piece held by the machinery must fall or be ejected,*
- *automatic or manual stopping of the moving parts, whatever they may be, must be unimpeded,*
- *the protective devices must remain fully effective or give a stop command.*

§205 Failure of the power supply

Section 1.2.6 deals with hazardous situations that may arise in case of the failure of the power supply or following such a failure. The first paragraph sets out the basic requirement that the interruption of the power supply, the re-establishment of the power supply after an interruption or any fluctuation of the power supply must not lead to a dangerous situation. The power supply may be interrupted as a result of a local or general electricity power cut or as a result the failure of other power sources such as steam, compressed air, hydraulic fluid and so on. Fluctuations in the power supply may include variations in the voltage or frequency of the electricity supply, variations in the pressure of steam, compressed air, hydraulic fluid and so on.

In order to fulfil this requirement, the manufacturer's risk assessment must include an analysis of the possible behaviour of the machinery in such cases and the machinery must be designed and constructed to prevent hazardous situations

from resulting. The six indents of the second paragraph of section 1.2.6 draw attention to certain common hazardous situations which may occur in the event of the failure of the power supply. It must be underlined that this list is only indicative. It can also be noted that these hazardous situations are the same as those mentioned in the second paragraph of section 1.2.1 with respect to the safety and reliability of control systems, thus certain of the necessary design measures may be common to both requirements.

- The first indent refers to the risk of unexpected start of the machinery. This situation is most likely to occur when the power supply is re-established after an interruption. The control system must therefore be designed to ensure that the interruption of the power supply automatically prevents any start until the machinery is restarted using the start control device.
- The second indent refers to cases where a power supply is necessary to maintain certain parameters of the machinery such as, for example, pressure or temperature, within safe limits. In certain cases, it may be necessary to provide a reserve power supply for that purpose. In addition, related data may be saved for use when re-establishing the power supply.
- The third indent applies to the parts of the control system controlling stop and emergency stop functions. The control system must be designed so that, once a stop command has been given, it remains effective even if the power supply is interrupted.
- The fourth indent requires machinery to be designed so that moving parts or pieces held by the machinery do not fall or are not ejected in case of failure of the power supply. This may be achieved by clamps, brakes, locking devices, check valves and so on that operate by removal of power or, if that is not possible, by a source of stored energy such as, for example, a spring or a reservoir of compressed air.

  In this respect, it can be noted that a specific requirement applies to lifting operations – see comments on section 4.1.2.6 (c).
- The fifth indent requires the machinery to be designed so that the moving parts can be stopped safely in case of failure of the power supply. Where energy is required to stop the moving parts safely, it may be supplied from a source of stored energy. In certain cases, it may be necessary to provide a reserve power supply to enable the moving parts of the machinery to be stopped safely.
- The last indent requires protective devices to be designed so that they remain effective in the absence of the power supply or so that a stop command is automatically triggered if the power supply is interrupted.