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Safety of machinery — Fire prevention and protection

Sécurité des machines — Prévention et protection contre l'incendie

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 19353 was prepared by Technical Committee ISO/TC 199, *Safety of machinery*.

Introduction

The safety of machinery against fire involves fire prevention and protection and fire-fighting. In general, as shown in Figure 1, these include technical, structural, organizational, works and public fire-fighting measures. Effective fire safety of machinery can require the implementation of a single measure or a combination of measures.

ISO and IEC are producing a set of standards to assist designers, manufacturers and other interested bodies to interpret the essential safety requirements in order to achieve conformity with European legislation. Within this series of standards, the European Committee for Standardization (CEN) undertook to draw up a standard to give guidance in the field of fire prevention and protection, as hazards from fire are to be considered in accordance with ISO 12100-1:2003, 4.8.

ISO 19353 is based on EN 13478:2001, published by CEN.

The structure of safety standards in the field of machinery is as follows.

a) type-A standards (basis standards) give basic concepts, principle for design, and general aspects that can be applied to machinery;

b) type-B standards (generic safety standards) dealing with one or more safety aspect(s) or one or more type(s) of safeguards that can be used across a wide range of machinery:

   — type-B1 standards on particular safety aspects (e.g. safety distances, surface temperature, noise);

   — type-B2 standards on safeguards (e.g. two-hands controls, interlocking devices, pressure sensitive devices, guards);

c) type-C standards (machinery safety standards) dealing with detailed safety requirements for a particular machine or group of machines.

ISO 19353 is a type-B standard as stated in ISO 12100-1.

ISO/TC 199 has a mandate in this area to produce A-type and B-type standards, which will allow verification of conformity with the essential safety requirements.

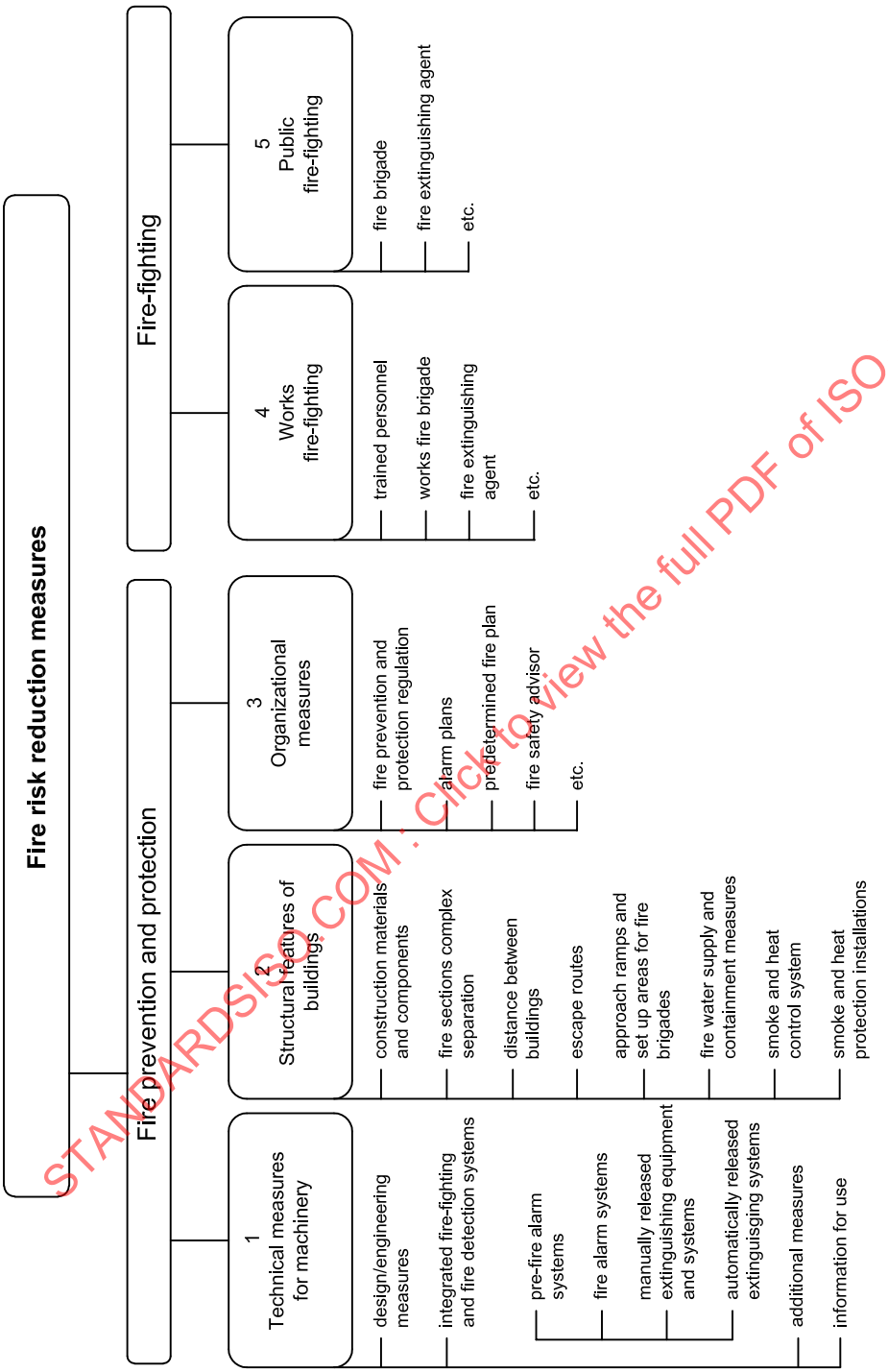


Figure 1 — Fire risk reduction measures

Safety of machinery — Fire prevention and protection

1 Scope

This International Standard specifies methods for identifying fire hazards resulting from machinery and performing a corresponding risk assessment. It gives the basic concepts and methodology of technical fire prevention and protection measures to be taken during the machinery's design and construction. Its purpose is the attainment of the required safety level according to the intended use of the machinery by application of technical measures for machinery-such measures being mainly integrated in the machinery and preferably implemented by the use of safety components. It does not cover machinery designed to contain controlled combustion processes (e.g. internal combustion engines, furnaces), unless those processes could constitute the ignition source of a fire in other parts of the machinery or outside the machine.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

ISO 14121, *Safety of machinery — Principles of risk assessment*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
combustibility
property of a material capable of burning

NOTE Accurate assessment of the combustibility characteristics of a material will depend on the operational conditions of the machinery and the form of the material (e.g. shavings, dusts).

3.2
combustible
capable of burning with or without flame

[ISO 13943:2000]

3.3
combustion
exothermic reaction of a substance with an oxidizer, generally accompanied by flames and/or glowing and/or emission of smoke

[ISO 13943:2000]

3.4
damaging fire
fire which causes harm to people, buildings, machinery and/or environment

3.5
fire-extinguishing agent
agent which is appropriate to extinguish fire

3.6
fire protection
measures such as design features, systems, equipment, buildings, or other structures to reduce danger to persons and property by detecting, extinguishing or containing fires

[ISO 8421-1:1987]

3.7
fire prevention
measures to prevent the outbreak of a fire and/or to limit its effects

[ISO 8421-1:1987]

3.8
fire load
sum of the calorific energies which could be released by the complete combustion of all the combustible materials involved in the machine and process, including raw and process materials

[ISO 13943:2000]

3.9
fire hazard
potential for loss of life (or injury) and/or damage to property and/or environment by fire

[ISO 13943:2000]

3.10
fire
general term for intended combustion (useful fire) as well as for uncontrolled combustion (damaging fire)

3.11
fire alarm system
system which detects the onset of fire and initiates an emergency response

3.12
fire risk
combination of the probability of occurrence of harm from fire and the severity of that harm

3.13
fire safety advisor
employee or consultant who assesses the fire prevention and protection measures for all or parts of business undertaking

3.14
flame retardant
substance added or treatment applied to a material in order to suppress or delay the appearance of a flame and/or reduce its propagation rate

3.15
flame
zone of combustion in the gaseous phase from which light is emitted

[ISO 13943:2000]

3.16
flammability
ability of a material or product to burn with a flame under specified conditions

[ISO 13943:2000]

NOTE Accurate assessment of the ignition characteristics of material will depend on the operational conditions of the machinery.

3.17
glow
combustion of a material in the solid phase without flame but with emission of light from the combustion zone

3.18
harm
physical injury and/or damage to health or property

[ISO 14121:1999]

3.19
ignition source
source of energy that initiates combustion

3.20
ignition
initiation of combustion

[ISO 13943:2000]

3.21
ignition energy
energy necessary to initiate ignition

3.22
organizational measures
all fire prevention and protection measures applied to assign tasks and responsibilities, to manage the emergency plan in case of fire, and assist the fire brigade in developing and implementing its own fire-fighting procedures

3.23
overheating
uncontrolled temperature increase

3.24
pre-fire alarm system
system which detects the potential onset of fire and initiates an emergency response in respect of this

3.25
public fire-fighting
all measures implemented by a community to fight fires by means of the fire brigades with capacities in accordance with the local conditions

[ISO 13943:2000]

3.26
safety component
component of the machinery, provided that it is not interchangeable equipment, which fulfils a safety function when in use, and the failure or malfunctioning of which endangers the safety or health of exposed persons

3.27
self-ignition
ignition resulting from self-heating

[ISO 13943:2000]

3.28
self-heating
exothermic reaction within a material resulting in a rise in temperature in the material

[ISO 13943:2000]

3.29
smoke
visible suspension of solid and/or liquid particles in gases resulting from combustion or pyrolysis

[ISO 13943:2000]

3.30
structural features of buildings
all fire prevention and protection measures related to the design, construction and functional planning of a building to reduce fire spread, facilitate escape of occupants, provide access to the fire brigade and safe fire-fighting conditions, and reduce damage to the building, its contents and the environment

3.31
works fire-fighting
all measures implemented by plant management for the user of the machinery to fight any outbreak of fire using own personnel

4 Requirements for hazard identification

4.1 General

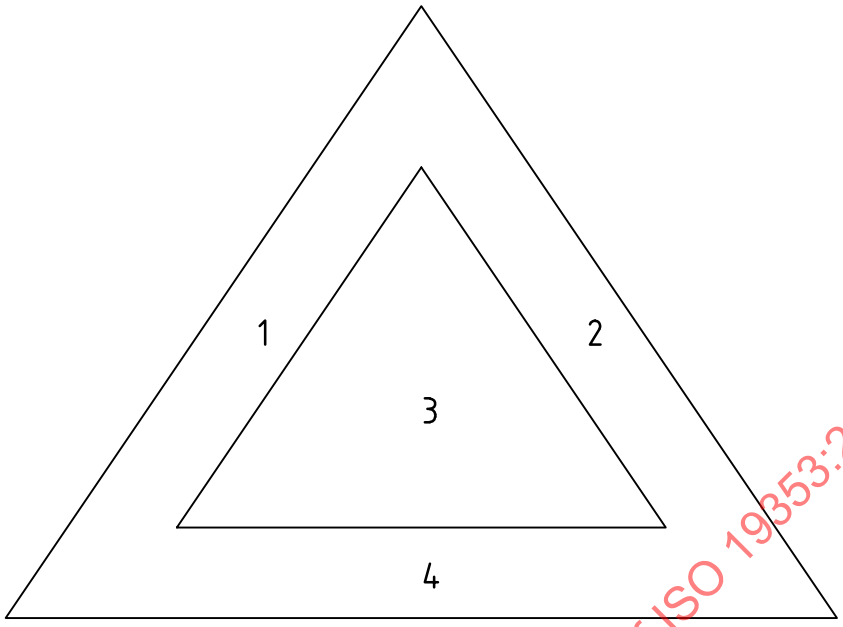
WARNING — An explosion hazard can exist in addition to the fire hazard (see EN 1127-1 and EN 1127-2).

A fire hazard occurs if combustible materials, oxidizer and ignition energy are available in sufficient quantities at the same place and at the same time The fire hazard depends on the interaction of these three items. See Figure 2.

Certain materials are inherently unstable, extraordinary oxidizers or capable of self-heating. This affects the fire hazard.

Variation in oxygen concentration (e.g. oxygen enrichment) can also significantly affect the fire hazard.

The fire hazard can arise from the materials processed, used or released by the machinery, from materials in the vicinity of the machinery, or from materials used in the construction of the machinery.



Key

1 combustible materials
2 ignition energy
3 fire
4 oxidizer

Figure 2 — Fire triangle

4.2 Combustible materials

Combustible materials can occur as solids, liquids or gases. It shall be determined whether combustible materials exist or can exist and in what quantity and distribution.

The ease of combustion of materials is affected by the size, shape and deposition of the materials. For example, small pieces of a material loosely collected together can be more easily ignited than a large piece of the same material. Also, the combination of materials can have an influence on the ignitability and the burning behaviour.

Consideration shall be given as to whether the properties of the materials can change over time or with use. Such changes can include the possibility of decomposition of the material releasing combustible gases and vapours. This can lead to an increased fire hazard.

4.3 Oxidizers

In assessing the fire hazard, the existence and quantity of fire-supporting substances, e.g. oxygen-producing substances, and the probability of their occurrence shall be determined. The most common oxidizer is air. But there are other oxidizers which support combustion e.g. potassium nitrate (KNO_3), potassium permanganate ($KMnO_4$), perchloric acid ($HClO_4$), hydrogen peroxide (H_2O_2), nitrous oxide (N_2O).

4.4 Ignition sources

It shall be determined which ignition sources exist or can occur.

Possible ignition sources can arise due to the influence of

a) heat energy,

b) electrical energy,

c) mechanical energy, and/or

d) chemical energy.

See Annex A for examples.

5 Requirements for risk assessment

5.1 General

Determination and evaluation of the fire risk requires a sequence of logical steps allowing systematic examination of the fire hazards arising from the machinery and/or the work process according to the procedures given in ISO 14121. It includes risk analysis and risk evaluation. The risk evaluation establishes if risk reduction measures are required.

5.2 Risk analysis

The risk of fire in machinery shall be determined by analysis. It depends on the existence of a fire hazard, the probability of its occurrence and the degree of the possible harm.

Analysis of fire risk shall include the following elements (see also Figure 3):

— list of all materials involved in the machine and process, including raw and process materials;

— evaluation of their ignitability, flammability, combustibility, fire-supporting effect and toxic issues;

— determination of the fire load;

— list of all possible ignition sources;

— determination of fire scenarios according to fire loads and ignition sources;

— evaluation of possible fire risks caused by human errors such as exchange of substances and wrong handling of controls.

Information on the fire properties of the materials or components used in a machine can often be found from the technical literature or the supplier. In some cases however, appropriate testing of the materials or components can be required.

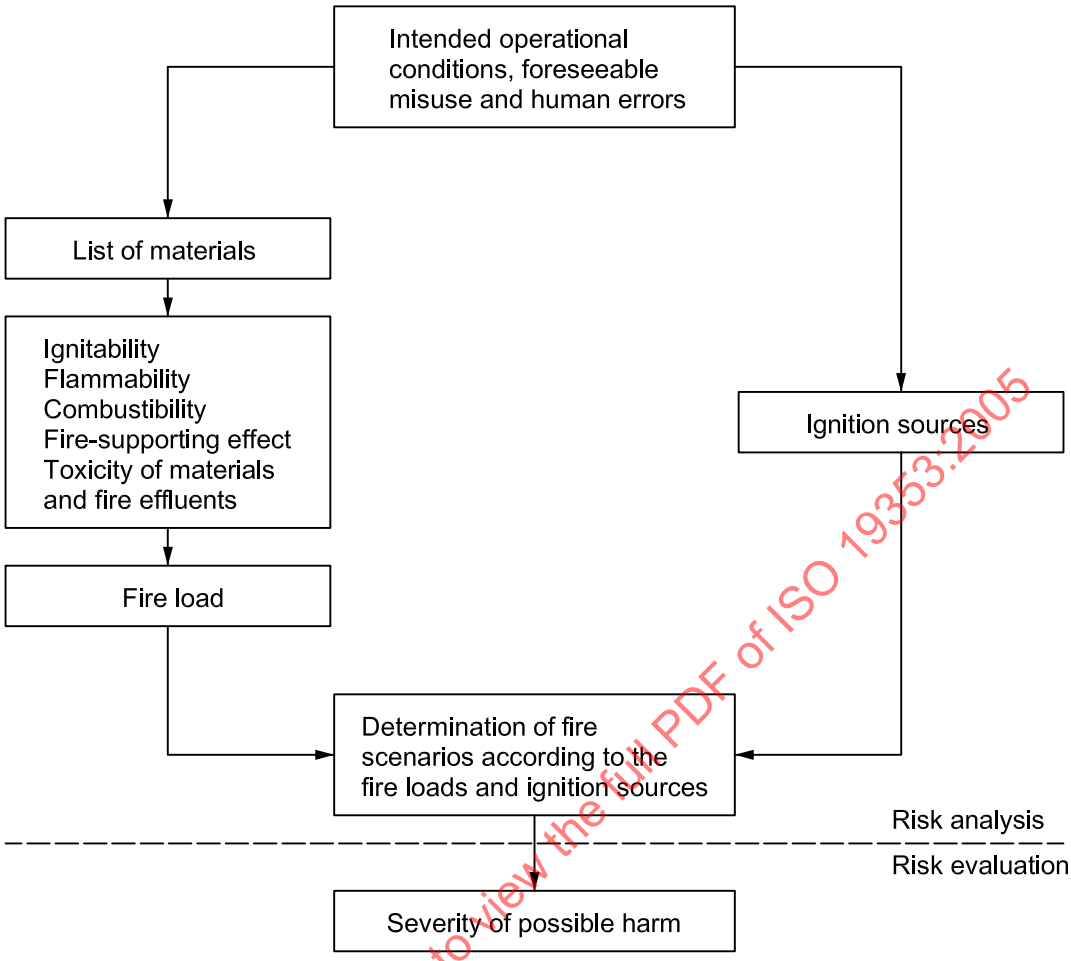


Figure 3 — Risk analysis and evaluation

5.3 Risk evaluation

After fire risk analysis, the fire risk shall be evaluated taking into account the expected harm. This can result, for example, from the fire itself, thermal radiation, the fire effluent, or escaping materials. If the evaluation of the fire risk results in the conclusion that the machine is not safe, risk reduction measures shall be implemented.

The evaluation of the level of damage to property or environment relies on economical, technical and regulatory factors. These factors shall be taken into account in deciding on the technical fire prevention and protection measures needed.

5.4 Risk reduction

If risk reduction measures are required, it shall be decided whether and which technical measures shall be taken to reduce the risk of fire and/or to limit the effects of a fire.

After each technical measure taken to reduce the risk of fire, a risk analysis shall be performed again until the machine is safe following the process defined in ISO 14121. Technical fire prevention and protection measures do not cover the overall risk at the machinery in question, and therefore care shall be taken that the measures applied do not increase other risks.

6 Technical fire prevention and protection measures for machinery

6.1 General

Technical fire prevention and protection measures (see Figure 1) comprise

— design and/or engineering measures,

— integrated fire-detection and fire-fighting systems,

— additional measures, and

— information for use.

The measures shall be applied in the above order of priority and in accordance with the procedures of ISO 12100-1:2003, Clause 5 (see 7.1 and Figure 4).

6.2 Design/engineering measures

Risk reduction shall be primarily achieved by design/engineering measures which eliminate or minimize the fire hazard. These comprise the following. The requirements of ISO 12100-1 shall also be applicable.

a) The use of materials in the construction of the machine which are non-combustible, non-flammable and/or have reduced combustibility/flammability, e.g. flame retardant materials.

NOTE Suitable test methods for reacting to fire and a fire classification system for construction products and building elements are given e.g. in EN 13501-1.

b) Elimination or minimization of the risk of overheating, either of the machine itself, or of the materials, be they gases, liquids, solids, dusts or vapours, produced or used by the machine. The risk is analysed by consideration of the process deviations which might lead to overheating. Elimination or minimization of the risk is realized by identifying how such deviations are detected or controlled, and implementing the means to achieve this.

c) The choice of materials for the construction of the machine, in which their adverse interaction with the materials produced or used by the machine is eliminated or minimized.

d) The design of the machine to avoid combustible or fire-supporting concentrations, or accumulations of raw material, intermediate product, or product which exceed the required quantities for that machine.

e) Where the possibility of a fire cannot be eliminated, the effects of that fire (flames, heat and smoke, etc.) shall be limited, for example, by shielding or enclosure of the machine to eliminate or minimize the risk of injury to persons and/or damage to property and/or the environment.

6.3 Use of integrated fire-detection and fire-fighting systems

Risk reduction is achieved by appropriate use of integrated fire-detection and fire-fighting systems (safety components), which comprise devices for the detection, control, alarm and extinguishing functions. The requirements shall be determined according to Figure 5. An example of a safety component consisting of a detector, central alarm control unit, storage unit and discharge pipework and nozzles is given in Annex B.

The severity of harm is essentially determined by the rate of growth of the fire and its duration. The fire should be detected as soon as possible and the extinguishing procedure should be initiated with the minimum of delay following fire-detection. If persons can be endangered, e.g. where toxic extinguishants are used, due regard shall be given to the safety of persons in the area of the machine and/or in the machine itself. These measures should be taken to ensure that a fire (damaging fire) is extinguished or limited as far as possible to the area of its occurrence.

6.4 Additional measures

It can be appropriate to provide additional fire prevention and protection measures, for example:

— programmed shut-down of the machinery and/or of auxiliary equipment, including isolation of all non-essential raw materials and products;

— emergency stop of the machinery, isolation of non-essential power supplies, e.g. electrical supplies and fuel supplies;

— isolation of the protected area covered by the fire-fighting system, e.g. by an enclosure or water curtain.

If necessary, retention or collecting devices for the fire effluents and extinguishing agents used in the event of a fire shall be provided.

6.5 Information for use

Comprehensive and understandable documentation shall be provided to the user in order to ensure that he can keep the machinery, installations and the technical fire protection equipment in a proper condition and ready for operation and, where necessary, initiate the required fire-fighting measures.

Information of the commissioning, operation and maintenance of the technical fire prevention and protection measures with respect to the intended use of the machine, in accordance with ISO 12100-2:2003, Clause 6, and warnings of any residual fire risks, shall be provided. If a special requirement of the user is that the fire prevention and protection of the machinery be at least partly intended to rely on an existing fire-protection provision of the user, then the interfaces shall be defined and described in the operating instructions.

In determining the possible damage to property and the environment, the manufacturer of the machine shall state the installation requirements assumed for the machine, including its location. If the user does not follow these, it is for the user to assess the possible damage to his property and the environment caused by propagation of the fire beyond the confines of the machine, affecting the surrounding area, including other plant and/or buildings. This assessment can modify the determination of the level of damage (low, medium, high) (see 7.3.3) and can require corrective action by the user.

7 Selection and design of technical fire prevention and protection measures

7.1 Procedure

In selecting and designing technical fire prevention and protection measures with the aim of reducing the risk, the following steps shall be taken by the iterative process according to ISO 14121, and as shown in Figure 4.

Step 1: Risk assessment

— Perform a risk analysis with respect to fire at a machine in all operation modes and in each phase of its service life according to ISO 12100 and ISO 14121 (see also 5.2).

— Evaluate the risk arising through the fire hazards and decision on adequate risk reduction for this application in accordance with ISO 12100 and ISO 14121 (see also 5.3). If the machine is considered to be safe, the iterative process is finished and the information for use shall be completed.

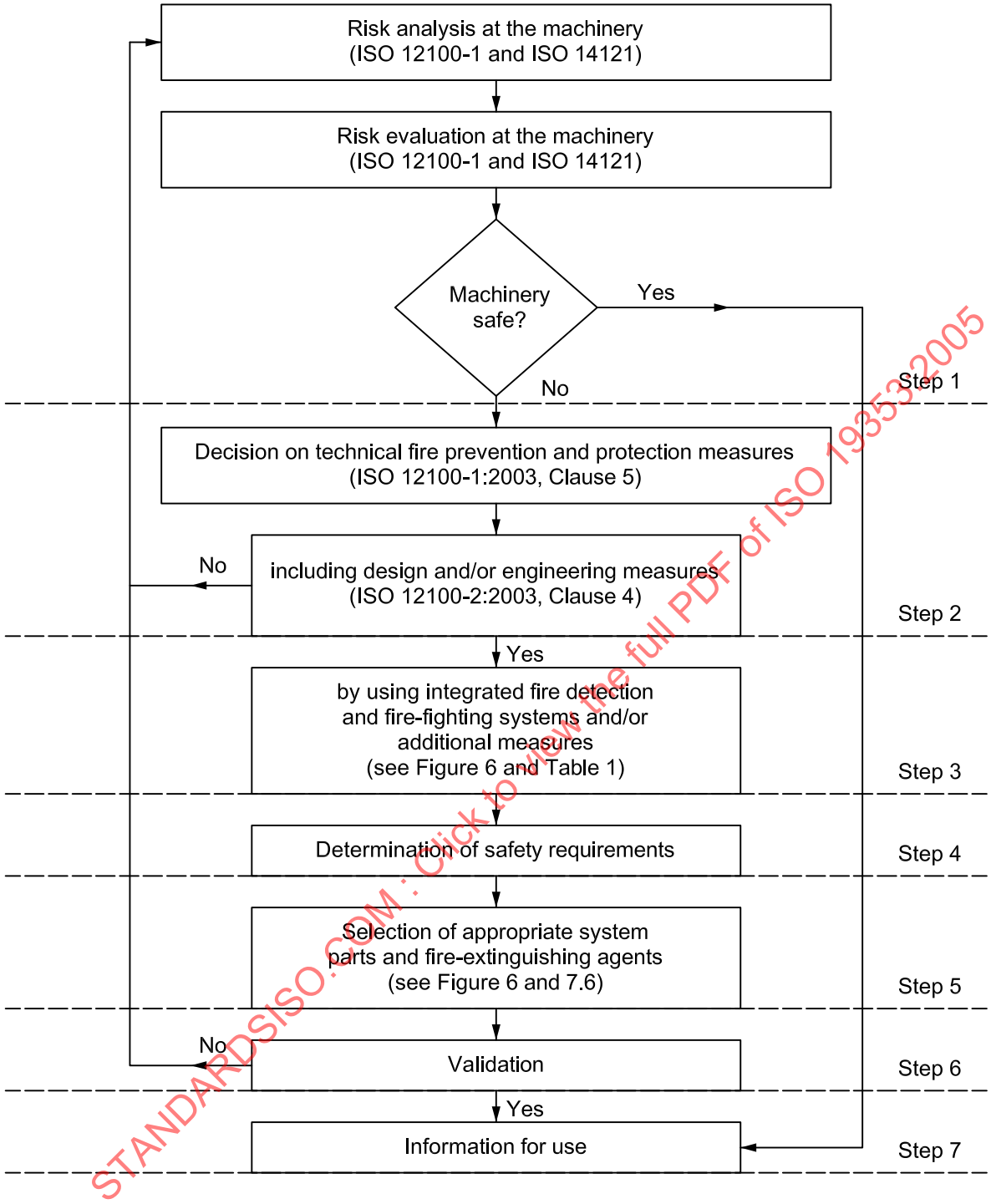


Figure 4 — Iterative process for the selection of technical fire prevention and protection measures

Steps 2 to 7: Decision on technical fire prevention and protection measures to achieve risk reduction

Step 2: Decision on design/engineering measures to be taken

Check the design and engineering measures have to be checked using step 1. If adequate safety of the finally designed machinery is not achieved, carry out step 3.

Step 3: Decision on integrated fire-detection and fire-fighting systems (safety components) and/or additional measures

Step 4: Determination of safety requirements with regard to fire prevention and protection measures

Determine the conditions for detection, alarm and initiation of fire protection equipment (e.g. emergency stop, isolation of power/fuel and/or release of fire extinguishing agent).

Step 5: Selection of appropriate system parts and fire extinguishing agents

Select individual system components in accordance with the requirements established in step 4 regarding suitability and reliability as well as the number, location, distribution and as appropriate quantity of the extinguishing agent.

Step 6: Validation

Validate the fire prevention and protection reached by selecting the individual system components in comparison with the requirements established in step 4. The final fire-fighting and fire detection systems and/or additional measures shall be checked using step 1. If the machine is still not considered to be safe, repeat steps 3 to 6.

Step 7: Completion of information for use

7.2 Decisions on technical fire prevention and protection measures

If a decision on technical fire prevention and protection measures is made to reduce the fire risk, design and/or engineering measures shall be given preference. If the risk is not reduced to the desired level by these measures, integrated fire-detection and fire-fighting systems shall be provided. These may include (see also Figure 6), for example,

— pre-fire alarm systems, and

— fire alarm systems with

1) manual discharge extinguishing systems, or

2) automatic discharge extinguishing systems.

The residual risk remaining shall be described in the information for use (see 6.5).

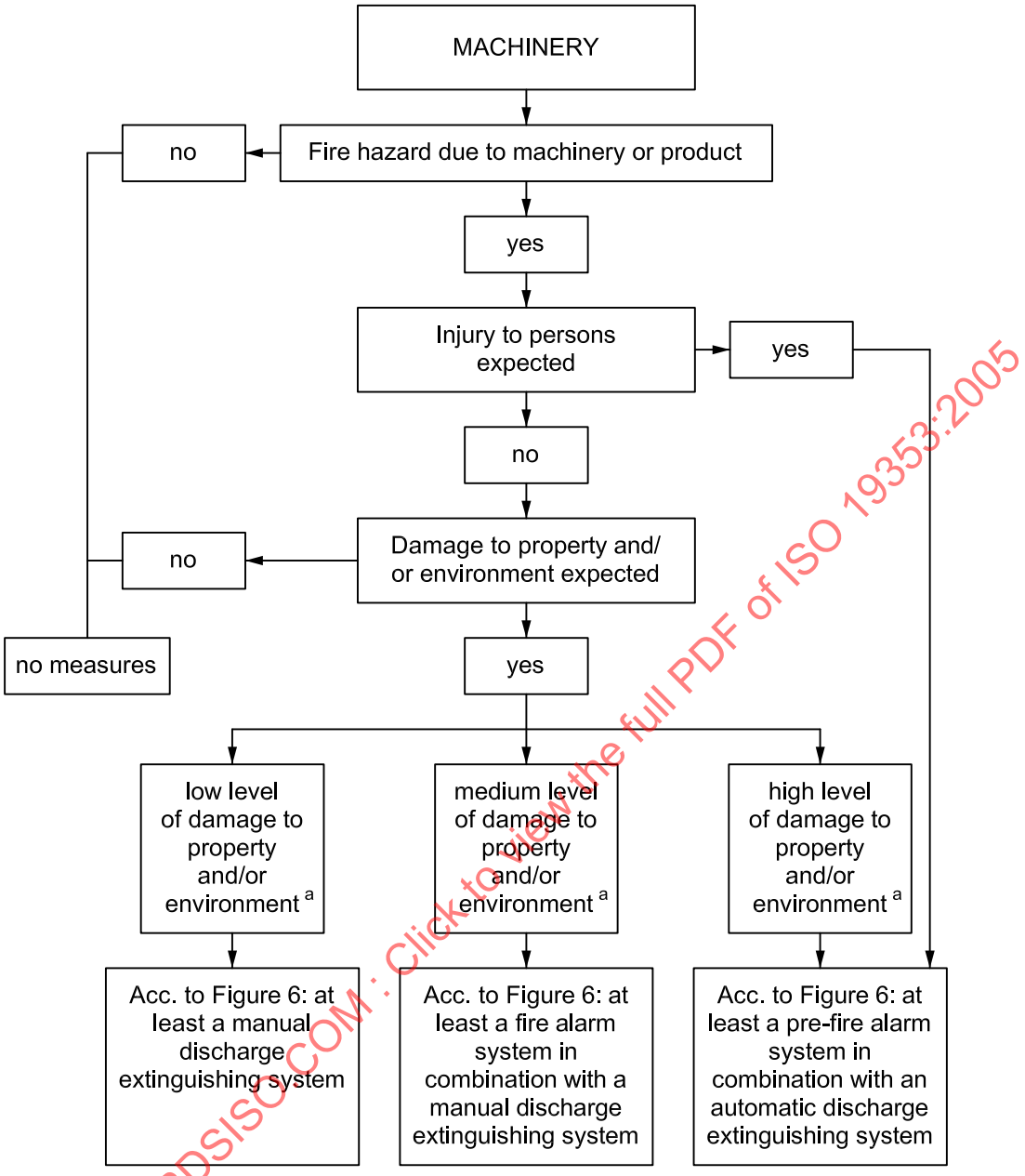
7.3 Selection of integrated fire-detection and fire-fighting systems in relation to expected harm

7.3.1 General

In determining the selection of the integrated fire-detection and fire-fighting systems (see 7.2 and Figure 6) in relation to the harm to be expected in the event of a fire, the following levels of severity of possible harm shall be considered (see also Figure 5).

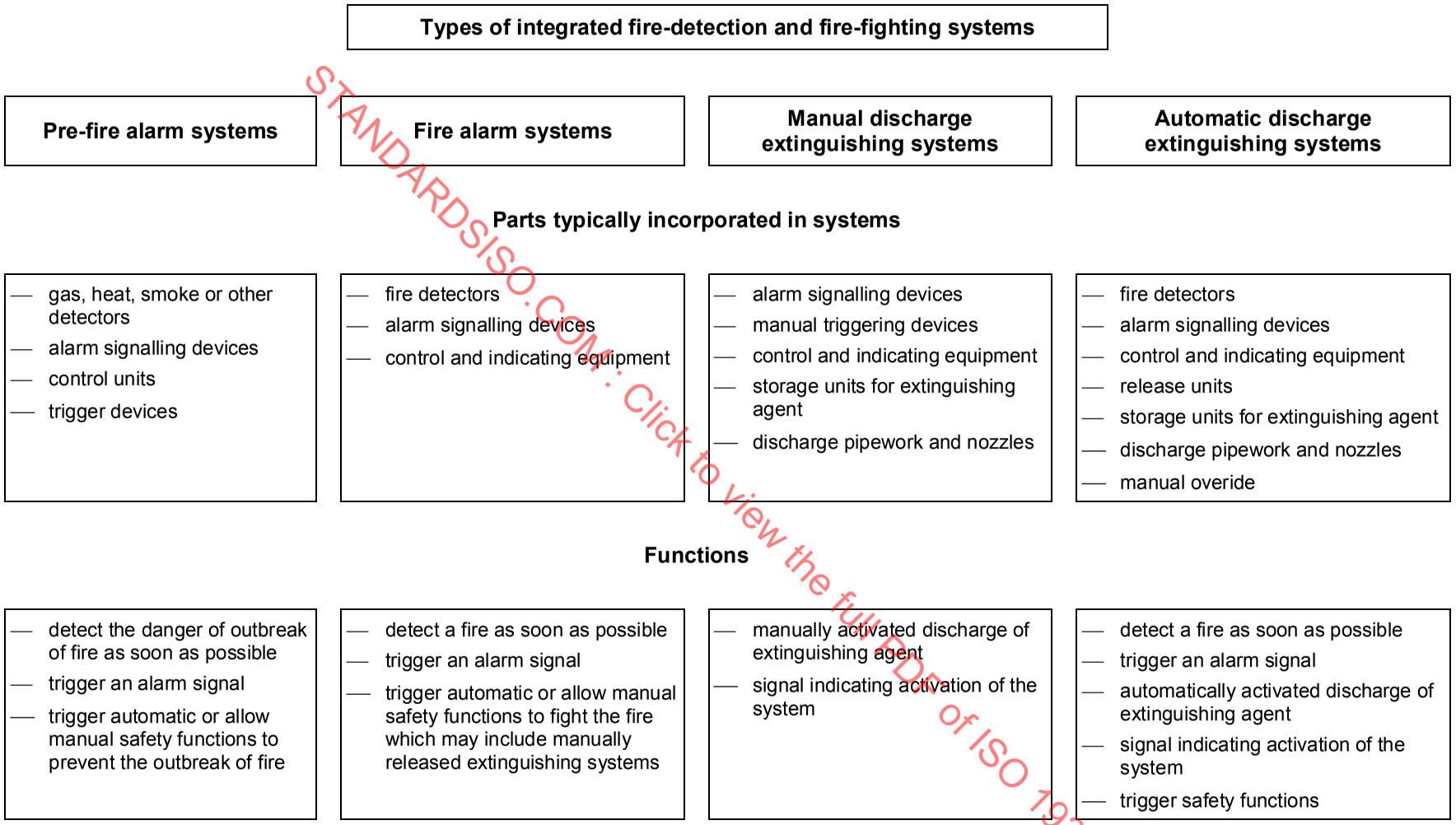
7.3.2 Injury to persons

If injury to persons is to be expected as a consequence of a fire at the machinery, a pre-fire alarm system in combination with an automatic discharge extinguishing system shall be provided as a minimum.



[a] The highest damage to be expected is considered here.

Figure 5 — Selection of fire prevention and protection equipment integrated, fire-detection and fire-fighting systems in relation to expected harm



These functions shall be the minimum considered necessary. Additional functions may be added, provided they are not detrimental to the list functions

For definitions of trigger, control and indicating equipment, fire detector, and fire-alarm signalling device, see EN 54.

Figure 6 — Integrated fire-detection and fire-fighting systems

7.3.3 Damage to property/environment

7.3.3.1 Low level of damage

If a low level of damage to property and/or environment is to be expected as a consequence of a fire at machinery, a manual discharge extinguishing system shall be provided as a minimum.

7.3.3.2 Medium level of damage

If a medium level of damage to property and/or environment is to be expected as a consequence of a fire at machinery, a fire alarm system in connection with a manual discharge extinguishing system shall be provided as a minimum.

7.3.3.3 High level of damage

If a high level of damage to property and/or environment is to be expected as a consequence of a fire at machinery, a pre-fire alarm system in combination with an automatic-discharge extinguishing system shall be provided as a minimum.

7.4 Safety considerations

At step 3, the operating conditions for the use of the provided integrated fire-detection and fire-fighting systems shall be specified.

If manual systems are used, in the event of the outbreak of a fire trained persons shall be present who can intervene in time (trigger alarm, stop machinery, attempt to extinguish the fire). This shall be included in the information for use.

If automatic discharge extinguishing systems are used, their proper functioning shall be ensured for all foreseeable operating conditions (e.g. climatic conditions, smoke development, disturbances in energy supply, electromagnetic compatibility, device failures).

The control systems of the protected machinery and the extinguishing system belonging to it shall be matched to each other to ensure that the extinguishing action is not impaired. The control system for the machinery shall support the functioning of the extinguishing system and ensure that no new risks are generated.

Alarm systems on machinery connected to a central alarm unit shall be compatible. The interface shall be described in the information for use.

7.5 System parts

The appropriate parts of the integrated fire-detection and fire-fighting systems shall be selected in accordance with step 3. The designer shall demonstrate the reliability, compatibility and effectiveness of the parts used.

If it is necessary, dependent on the risk level, the whole or parts of the integrated fire-detection and fire-fighting system shall be provided as a redundant system.

7.6 Fire-extinguishing agents

The selection of the appropriate fire-extinguishing agent shall take into consideration factors such as the following:

— type of fire;

— combustible materials, belonging to the machinery or processed by the machinery;

— location of the machinery;