INTERNATIONAL STANDARD

# ISO 19353

Second edition
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# Safety of machinery — Fire prevention and fire protection

*Sécurité des machines — Prévention et protection contre l'incendie*



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# Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 199, *Safety of machinery*.

This second edition cancels and replaces the first edition (ISO 19353:2005), which has been technically revised.

# Introduction

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

Annex E provides an overview on fire risk reduction measures. This International Standard deals with the measures shown in Figure 1.

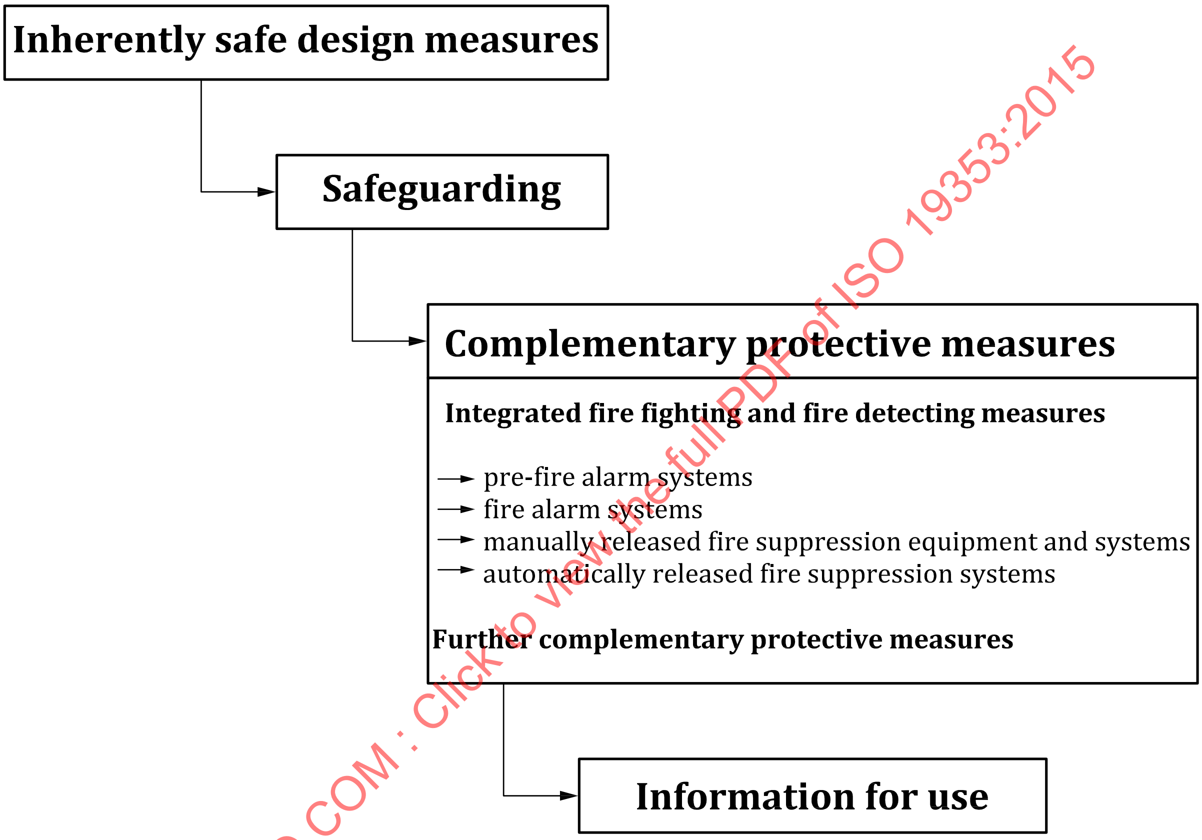



**Figure 1 — Protective measures dealt with in ISO 19353**

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

a) **type-A standards** (basis standards) giving 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-B1 standard as stated in ISO 12100.

This document is of relevance, in particular, for the following stakeholder groups representing the market players with regard to machinery safety:

— machine manufacturers (small, medium and large enterprises);

— health and safety bodies (regulators, accident prevention organisations, market surveillance, etc.);

— machine users/employers (small, medium and large enterprises);

— machine users/employees (e.g. trade unions, organizations for people with special needs);

— service providers, e.g. for maintenance (small, medium and large enterprises);

— consumers (in case of machinery intended for use by consumers).

The above-mentioned stakeholder groups have been given the possibility to participate at the drafting process of this document.

In addition, this document is intended for standardization bodies elaborating type-C standards.

The requirements of this document can be supplemented or modified by a type-C standard.

For machines that are covered by the scope of a type-C standard and that have been designed and built according to the requirements of that standard, the requirements of that type-C standard take precedence.



# Safety of machinery — Fire prevention and fire protection

## 1 Scope

This International Standard specifies methods for identifying fire hazards resulting from machinery and for performing a risk assessment.

It gives the basic concepts and methodology of protective measures for fire prevention and protection to be taken during the design and construction of machinery. The measures consider the intended use and reasonably foreseeable misuse of the machine.

It provides guidelines for consideration in reducing the risk of machinery fires to acceptable levels through machine design, risk assessment and operator instructions.

This International Standard is not applicable to

— mobile machinery,

— machinery designed to contain controlled combustion processes (e.g. internal combustion engines, furnaces), unless these processes can constitute the ignition source of a fire in other parts of the machinery or outside of this,

— machinery used in potentially explosive atmospheres and explosion prevention and protection, and

— fire detection and suppression systems that are integrated in building fire safety systems.

It is also not applicable to machinery or machinery components manufactured before the date of its publication.



## 2 Normative references

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

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

ISO 13849-1, *Safety of machinery — Safety-related parts of control systems — Part 1: General principles for design*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100 and the following apply.

**3.1**
**combustibility**
property of a material capable of burning

Note 1 to entry: Accurate assessment of the combustibility characteristics of a material will depend on the operating conditions of the machinery and the form and physical state of the material (e.g. gaseous, liquid or solid; solids chopped to form shavings or dust, or not).

Note 2 to entry: On the basis of their combustibility, materials can be classified into non-combustible, hardly combustible, combustible and easily combustible materials. It is important not to mix up combustibility on the one hand, and flammability or ignitability on the other. Consequently, flash points and ignition points do not represent quantitative measures of combustibility.

**3.2**
**combustible**
capable of being ignited or burned

[SOURCE: ISO 13943:2008, 4.43]

**3.3**
**combustion**
exothermic reaction of a substance with an oxidizing agent

Note 1 to entry: Combustion generally emits fire effluent accompanied by flames and/or glowing.

[SOURCE: ISO 13943:2008, 4.46]

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

**3.5**
**extinguishing opening**
port in the machine housing, closed with a plug or flap that can be safely accessed with an extinguishing device

Note 1 to entry: An extinguishing device, e.g. a hose or lance, can be used.

**3.6**
**fire**
<general> self-supporting combustion that can occur as controlled combustion or uncontrolled combustion

Note 1 to entry: Controlled combustion is deliberately arranged to provide an intended effect.

Note 2 to entry: Uncontrolled combustion is spreading uncontrolled in time and space.

Note 3 to entry: In the case of a combustion control failure, controlled combustion can lead to uncontrolled combustion.

[SOURCE: ISO 13943:2008, 4.96 to 4.98, modified.]

**3.7**
**fire alarm system**
system that, by the use of sensors, detects the onset of fire and initiates a response

Note 1 to entry: Sensors can be designed to detect smoke, combustion gases, heat or flames.

**3.8**
**fire-extinguishing agent**
agent which is appropriate to extinguish fire by cooling below ignition temperature and/or by reducing the oxidizer level

Note 1 to entry: The extinguishing agent can be gaseous, liquid or solid. Common extinguishing agents include water, carbon dioxide, nitrogen, argon, chemical powder or foam.

**3.9**
**fire hazard**
physical object or condition with a potential for an undesirable consequence from fire

[SOURCE: ISO 13943:2008, 4.112]



**3.10**
**fire load**
quantity of heat that can be released by the complete combustion of all the combustible materials in a volume, including the facings of all bounding surfaces

Note 1 to entry: Fire load can be based on effective heat of combustion, gross heat combustion or net heat combustion as required by the specifier.

Note 2 to entry: The word "load" can be used to denote force or power or energy. In this context, it is used to denote energy.

Note 3 to entry: The typical units are kilojoules (kJ) and megajoules (MJ).

[SOURCE: ISO 13943:2008, 4.114]

**3.11**
**fire prevention**
measures to prevent the outbreak of a fire and/or to limit its effects

[SOURCE: ISO 8421-1:1987, 1.21]

**3.12**
**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

[SOURCE: ISO 8421-1:1987, 1.23, modified — "measures such as" has been added to the original definition.]

**3.13**
**fire risk**
probability of a fire combined with a quantified measure of its consequence

[SOURCE: ISO 13943:2008, 4.124]

**3.14**
**fire suppression system**
technical system to fight a fire and to reduce the damaging effects of flames and heat

Note 1 to entry: Additional devices might be required to extinguish the fire.

**3.15**
**flame**
rapid, self-sustaining, sub-sonic propagation of combustion in a gaseous medium, usually with emission of light

[SOURCE: ISO 13943:2008, 4.133]

**3.16**
**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

[SOURCE: ISO 13943:2008, 4.139, modified — The note has been deleted and "the flame-spread rate" replaced with "its propagation rate".]

**3.17**
**flammability**
ability of a material or product to burn with a flame under specified conditions

Note 1 to entry: Accurate assessment of the ignition characteristics of material will depend on the operating conditions of the machinery.

[SOURCE: ISO 13943:2008, 4.151, modified — Note 1 to entry has been added.]

**3.18**
**glow**
glowing combustion
combustion of a material in the solid phase without flame but with emission of light from the combustion zone

[SOURCE: ISO 13943:2008, 4.169, modified — “glow” has been introduced as the preferred term.]

**3.19**
**ignitability**
ease of ignition
measure of the ease with which a test specimen can be ignited, under specified conditions

[SOURCE: ISO 13943:2008, 4.182, modified —Cross reference has been deleted.]

**3.20**
**ignition**
<general> initiation of combustion

[SOURCE: ISO 13943:2008, 4.187, modified — Deprecated synonymous term “sustained ignition” has been deleted.]

**3.21**
**ignition energy**
energy necessary to initiate combustion

**3.22**
**ignition source**
source of energy that initiates combustion

[SOURCE: ISO 13943:2008, 4.189]

**3.23**
**low-emission metalworking fluid**
metalworking fluid composed of low-evaporation base media and anti-mist additives

Note 1 to entry: Low-evaporation base media are base oils consisting of low-evaporation mineral oils, synthetic esters and/or special liquids.

**3.24**
**overheating**
uncontrolled temperature increase

**3.25**
**pre-fire alarm system**
system that detects conditions that can lead to the potential onset of fire and initiates a response

Note 1 to entry: A response can be a trigger of an alarm signal or can initiate an automatic reaction.

Note 2 to entry: Sensors for these systems can detect heat due to friction, hot surfaces, loss of inerting, abnormal changes of gas concentrations, failure of lubrication or cooling supply, etc.

**3.26**
**required performance level**
PLr
performance level (PL) applied in order to achieve the required risk reduction for each safety function

[SOURCE: ISO 13849-1:2006, 3.1.24, modified — Cross references have been deleted.]

**3.27**
**self-heating**
<chemical> rise in temperature in a material resulting from an exothermic reaction within the material

[SOURCE: ISO 13943:2008, 4.287]

**3.28**
**self-ignition**
spontaneous ignition resulting from self-heating

**3.29**
**smoke**
visible part of fire effluent

Note 1 to entry: For definition of fire effluent see ISO 13943:2008, 4.105.

[SOURCE: ISO 13943:2008, 4.2693, modified — Note 1 to entry has been added.]

## 4 Fire hazards

### 4.1 General

A fire hazard occurs if combustible materials (fuel), oxidizer (oxygen) and ignition energy (heat) are available in sufficient quantities at the same place and at the same time. A fire is an interaction of these three components in the form of an uninhibited chemical reaction (see Figure 2).

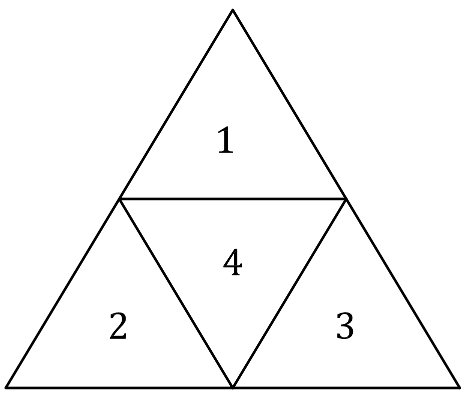
A fire can be prevented or suppressed by controlling or removing one or more of the components of the fire tetrahedron.

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 affect the fire hazard.

The fire hazard can arise from the material 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.

NOTE An explosion hazard can exist in addition to the fire hazard.




**Key**

1 heat
2 oxygen
3 fuel
4 uninhibited chemical chain reaction

**Figure 2 — Fire tetrahedron**

### 4.2 Combustible materials

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

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 that 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 that support combustion, e.g. potassium nitrate ($KNO_3$), potassium permanganate ($KMnO_4$), perchloric acid ($HClO_4$), hydrogen peroxide ($H_2O_2$) and 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.

NOTE See Annex A for examples of ignition sources and Annex B for examples of machines and their typical fire related hazards.

## 5 Strategy for fire risk assessment and risk reduction

### 5.1 General

Fire risk assessment comprises a series of logical steps that allow systematic examination of fire hazards according to the procedures outlined in ISO 12100. Fire risk assessment includes the following sequential phases:

a) fire risk analysis, comprising

   1) determination of the limits of the machinery (see 5.2),

   2) identification of fire hazards (see 5.3), and

   3) risk estimation (see 5.4), and

b) risk evaluation.

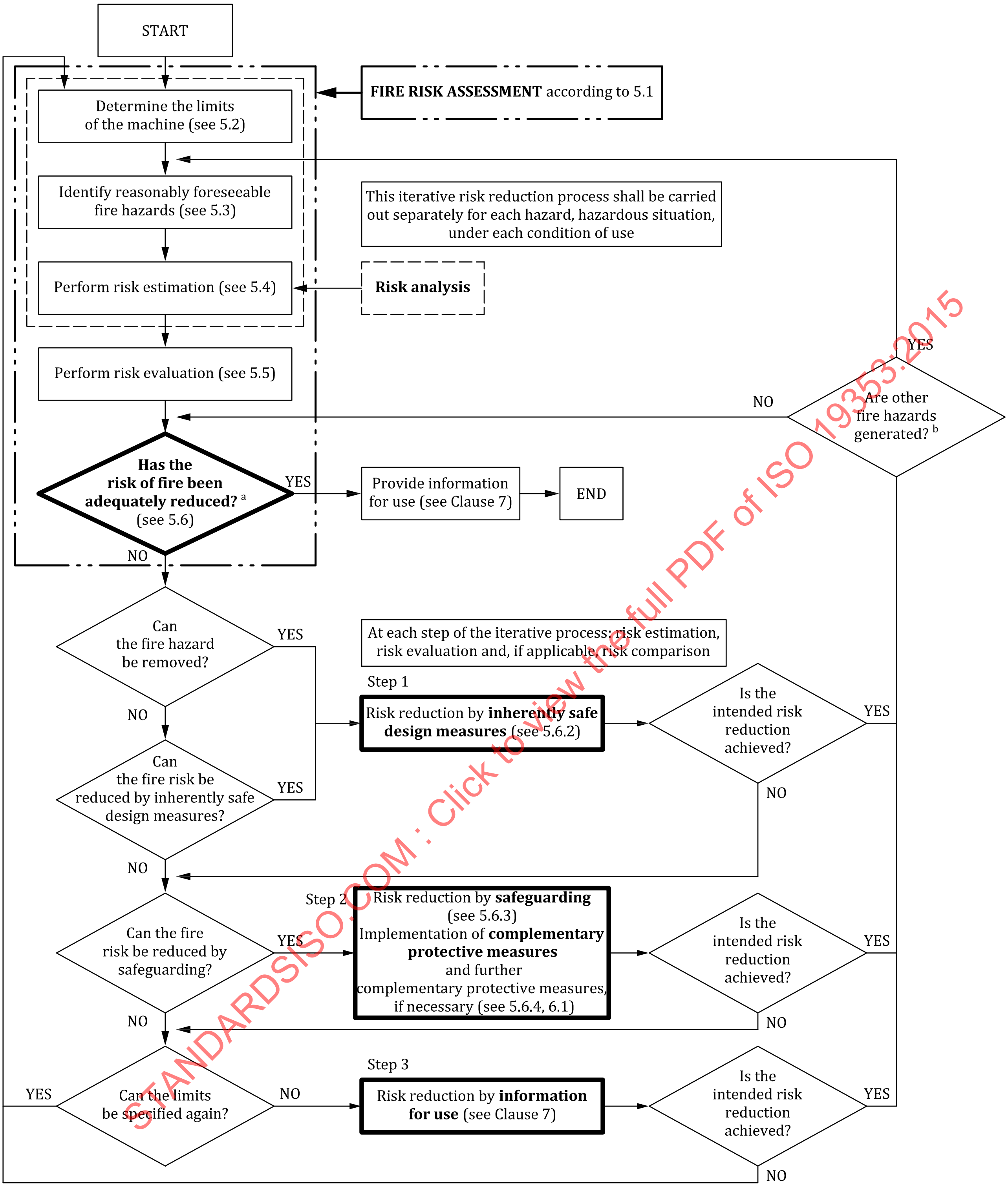
When deemed necessary risk evaluation is followed by risk reduction.



In planning fire prevention and protection measures, normal operating conditions – including start-up and standstill procedures, possible technical failures and reasonably foreseeable misuse – shall be taken into account.

The fire risk assessment and risk reduction shall be repeated as an iterative process until the risk of a fire occurrence has been adequately reduced. Risk analysis judgements shall be supported by a qualitative or, where appropriate, quantitative estimate of the risk associated with the hazards present on the machinery. See Figure 3.




**Key**

a The first time the question is asked, it is answered by the result of the initial risk assessment.

b If the applied risk reduction generates other hazards than fire hazards, risk reduction methods according to ISO 12100 shall be applied.

**Figure 3 — Schematic representation of fire risk reduction process including iterative three-step method (adopted from ISO 12100)**

## 5.2 Determination of the limits of the machinery

Risk assessment shall include determination of the limits of the machinery, taking into account the phases of the machinery life that can involve fire hazards.

Examples of machine limits that are useful in fire risk assessment are as follows:

— intended use and reasonably foreseeable misuse of the machine;

— properties of materials processed by the machine;

— machine operating modes;

— anticipated levels of training, experience or ability of the machine operators, maintenance personnel, and where appropriate the general public;

— the level of awareness of fire hazards by those persons likely to be exposed to the fire hazards;

— the anticipated life of the machine and its components and the impact of aging with respect to creation of fire hazards;

— recommended service intervals;

— housekeeping and level of cleanliness as potential contributors to a fire hazard;

— the environment in which the machine is expected to be operated (e.g. dry, dusty, humid, hot, cold conditions).

## 5.3 Identification of fire hazards

Following the determination of the limits of the machinery, reasonably foreseeable fire hazards shall be identified, taking into consideration the phases of machinery life in which a fire hazard can be present.

NOTE See Clause 4 for a general discussion on the nature of fire hazards.

All reasonably foreseeable fire hazards associated with the various uses of the machine shall be identified. The hazard can be identified according to the fire loads and ignition sources (see Figure 4).

For the determination of fire scenarios according to fire loads and ignition sources and for an estimation of the fire risk, the procedures outlined in ISO 12100 shall be followed. The procedure provides a sequence of logical steps allowing systematic examination of the fire hazards arising from the machinery and/or the work process, see Figure 3.

Identification of fire hazards shall include the following steps:

— identification of intended and reasonably foreseeable operating conditions;

— identification of combustible and/or flammable materials that are related to the fire hazard (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;

— estimation of the fire load based on the main combustible materials (fuel);

— identification of all possible ignition sources (e.g. heat) that can contribute to an ignition event;

— identification of fire scenarios according to fire loads and ignition sources: all reasonably foreseeable scenarios that can lead to an ignition of the combustible and flammable materials, including scenarios brought about by human errors such as exchange of substances, improper operation of the machine, or improper maintenance.

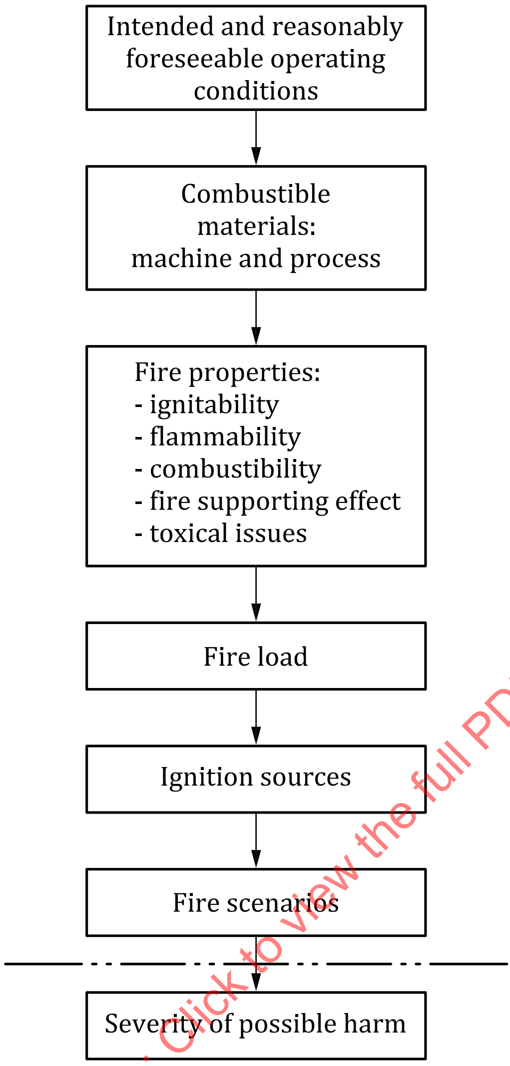


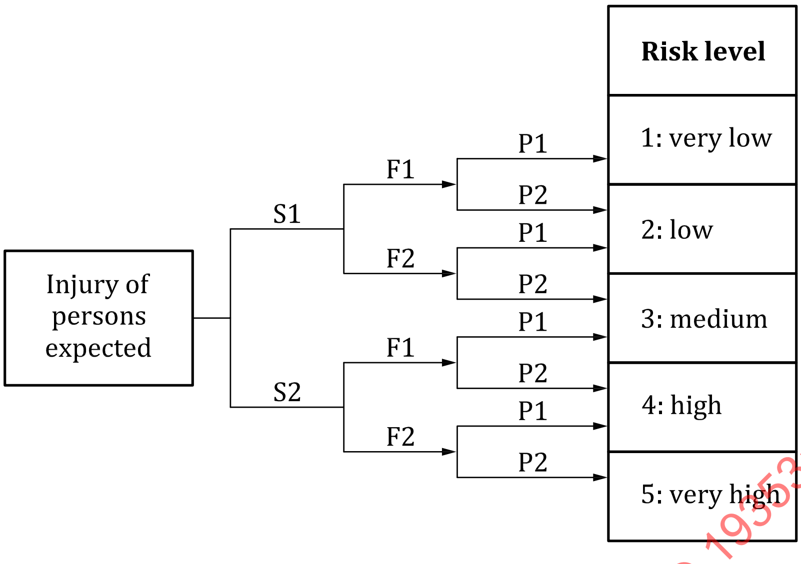

**Figure 4 — Identification of significant fire hazards**

## 5.4 Risk estimation

Once the fire hazards (fire scenarios) have been identified, the risk of occurrence of a fire shall be determined by estimation. Risk estimation provides information required for the risk evaluation, which in turn allows judgements to be made about whether or not risk reduction is required. Risk estimation depends on the existence of a fire hazard, the frequency at which the machine is exposed to the fire hazard, the probability of a fire occurring once exposure to hazard is present and the degree of possible harm.

The risk related to the fire hazard is a function of the severity of harm that can result from the fire hazard and the probability of occurrence of that harm. The risk graph given in Figure 5 provides guidance for risk estimation.

NOTE Methodology equivalent to Figure 5 can be used (see ISO/TR 14121-2).




**Key**

Risk parameters:

S1 slight severity of injury (normally reversible)

S2 serious severity of injury (normally irreversible or death)

F1 frequency: seldom to less often and/or short exposure time to hazard

F2 frequency: often to continuous and/or long exposure time to hazard

P1 possibility of avoiding hazard or limiting harm given under specific conditions

P2 avoiding hazard or limiting harm scarcely possible

**Figure 5 — Estimation of the risk level**



Analysis of fire risks shall include consideration of the following elements:

— the frequency that the machine is exposed to the fire hazard;

— information for use regarding fire preventive measures (e.g. operating instructions, signs on the machine);

— the likelihood that the machine operator will recognize a fire hazard and take intervention steps to eliminate or reduce the possibility of a fire;

— the likelihood that once an ignition takes place the fire can be detected by the operator or a sensor at an early stage;

— the extent of machine damage;

— the potential for operator or bystander injury and the most likely severity of such injury;

— the level of training of the operator with respect to fire hazard awareness and fire prevention practices.

## 5.5 Risk evaluation

After risk estimation has been completed, risk evaluation shall be carried out to determine if risk reduction is required. If risk reduction is required, then appropriate protective measures shall be selected and applied.

The adequacy of the risk reduction shall be determined after applying the technical fire prevention and protection measures stated in 5.6.

NOTE See also the “three-step method” given in ISO 12100:2010, Clause 6.

## 5.6 Risk reduction

### 5.6.1 General

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

After each protective measure is taken to reduce the risk of fire, a risk analysis shall be performed again until the machine is safe following the process given in ISO 12100.

Fire prevention and protection measures do not cover the overall risk at the machinery in question, and therefore care shall be taken to ensure that the protective measures applied do not create and/or increase other fire risks.



Adequate risk reduction is achieved when

— all operating conditions and intervention procedures have been considered,

— the risk of fire has been eliminated or reduced to the lowest acceptable level,

— any new fire risks introduced by the protective measures have been properly addressed,

— protective measures are compatible with one another, and

— the protective measures do not adversely affect the operator's working conditions or impede the function of the machine.

The objective of risk reduction can be achieved by applying fire prevention and protection measures as protective measures comprising, in order of priority, the following:

a) inherently safe design measures (see 5.6.2);

b) safeguarding (see 5.6.3);

c) complementary protective measures (see 5.6.4 and 6.1);

d) information for use (see Clause 7).

All protective measures to reach this objective shall be applied in the sequence given in 5.6.2 to 5.6.4, referred to as the "three-step method" (see also ISO 12100:2010, Clause 6).

### 5.6.2 Inherently safe design measures

**5.6.2.1** The elimination or reduction of the risk of fire shall be primarily achieved by inherently safe design measures, as shown in 5.6.2.2 to 5.6.2.6.

**5.6.2.2** Minimal use of combustible materials in the construction of a machine:

The selection of the materials shall be carried out according to the risk analysis (see 5.2 to 5.4). In case that non-combustible materials are not applicable self-extinguishing materials and fire-protected materials should be used.

NOTE Such materials can be classified in accordance with EN 13501–1 as class A1, class A2 or class B.

**5.6.2.3** Minimal use of flammable fluids or lubricants:

The selection of fluids shall be carried out according to the risk analysis (see 5.2 to 5.4) taking into account the combustion and ignition properties of the process fluids used.

NOTE Data for non-water-miscible metalworking fluids to perform risk analysis are shown in Table D.1 as an example.

**5.6.2.4** Competent ignition sources:

The risk analysis shall include machine operation or process deviations that might lead to the generation of competent ignition sources. It shall be identified how such deviations are detected and/or controlled.

**5.6.2.5** Use of materials in the construction of a machine that eliminate or minimize an adverse interaction with the materials produced by or used by the machine.

**5.6.2.6** Machine design that shall avoid aggregation of combustible or fire supporting concentrations, or accumulations of raw material, intermediate product or finished product that exceed the amount required for normal operation of the machine.

If applicable, inclusion of information in the instruction manual regarding steps to be taken by the user to reduce or prevent the onset of fire, see Clause 7.

### 5.6.3 Safeguarding

When it is not possible to eliminate hazards or sufficiently reduce risks by inherently safe design measures, consideration shall then be given to safeguarding to prevent persons from being exposed to the hazards.

Safeguarding comprises the following:

a) limitation of the effects of fire (e.g. flames, heat and smoke), for example by shielding or enclosure of the machine to eliminate or minimize the risk of injury to persons and/or damage to property;

b) containment or evacuation of hazardous components (e.g. dust, heat, smoke, toxicity);

c) installation of measures against flame ejection and hot gases through openings of the machine (e.g. labyrinths, door gaps, opening for workpiece loading, see D.3.8.1.2).

The required performance level (PLr) of a safety-related part of a control system necessary for a safety function shall be determined according to ISO 13849-1.

### 5.6.4 Complementary protective measures

#### 5.6.4.1 General

When inherently safe design measures and safeguarding do not reduce the risk of fire adequately, further risk reduction shall be achieved by applying complementary protective measures. The procedure to select the complementary protective measures is set out in detail in Clause 6.

Preference shall be given to integrated fire detection and fire suppression systems.

#### 5.6.4.2 Integrated fire detection and fire suppression systems

Integrated fire detection and fire suppression systems include devices for fire detection, control, alarm and extinguishing.

The control of the integrated fire detection and fire suppression systems shall be implemented according to ISO 13849-1.

The system shall include at least one safety function, for example, for

a) the detection of a fire,

b) the corresponding signal processing, and

c) the activation of adequate measures (e.g. activation of fire suppression and/or fire alarm).

Depending on the risk analysis, the necessary safety function(s) and corresponding required performance level (PLr) shall be defined. See Annex D for list of safety functions.

NOTE 1 An example for the design of a fire suppression system integrated in machinery is given in Annex C.

NOTE 2 An exemplary list of safety functions for machining centres for the machining of metallic materials is given in Table D.2.

The extent of fire damage essentially depends on the fire load, the fire spreading and duration of the fire. 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 by the use of a hazardous fire suppression agent (e.g. carbon dioxide, nitrogen) 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 is extinguished or limited as far as possible to the area of its occurrence.

#### 5.6.4.3 Further complementary protective measures

It can be necessary to provide further complementary protective measures for fire prevention and protection, examples are given below:

— automatic shut-down of the machinery and/or of auxiliary equipment, including blocking of all feeds to the machine, e.g. raw material, utilities and blocking of outgoing products;

  The functions that are still required (e.g. cooling, emergency power supply) shall stay in service.

— emergency stop of the machinery according to ISO 13850;

— extinguishing opening in combination with extinguishing lance or a fire extinguisher;

— connection coupling for the supply of extinguishing agent, e.g. water or inerting gas;

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

— installation of additional sensors and implementation of appropriate actions (that can detect smoke, combustion gases, heat or flames) at other locations with high fire risk.

The safety-related part of a control system required by a complementary protective measure shall comply with the required performance level (PLr) determined according to ISO 13849-1.

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



# 6 Procedure for the selection of complementary protective measures

## 6.1 General

### 6.1.1 Use of the procedure

When inherently safe design measures and safeguarding do not reduce the risk of fire adequately further risk reduction shall be achieved by complementary protective measures.

For the selection of complementary protective measures, the procedure shown in 6.1.2 to 6.1.7 shall be used.

### 6.1.2 Determination of the residual risk level

Determine the residual risk level based on the possible injury of persons (see Figure 4).

### 6.1.3 Specification of requirements for the choice of fire detection and fire suppression system

Specify the requirements for fire detection and fire suppression based on the determined residual risk level.

### 6.1.4 Specification of safety and performance requirements

Specify the safety and performance requirements for the detection, alarm and activation of the fire suppression system.

### 6.1.5 Selection of system parts and suitable fire-extinguishing agent

Select individual system parts in accordance with the safety and performance requirements specified in 6.1.4 regarding suitability and reliability as well as the type, number, location, distribution of the system components. At the same time, select the required type and quantity of fire-extinguishing agent.

### 6.1.6 Decision on the need for further complementary protective measures

Check if further complementary protective measures are required because the remaining risk level is not acceptable (see 5.6.4.3).

### 6.1.7 Validation

Compare the performance of the fire prevention and protection system with the requirements established in 6.1.2. If the risk of fire has not been adequately reduced, repeat items 6.1.3 to 6.1.5.

## 6.2 Selection of the fire prevention and protection system in relation to the expected risk level

### 6.2.1 General

When selecting appropriate fire prevention and protection equipment the solutions according to Table 1 shall be used based on the risk level.

**Table 1 — Fire detection and fire suppression solutions**

| Risk level according to Figure 5 | Automatic pre-fire detection | Automatic fire detection | Fixed manual discharge suppression system | Fixed automatic discharge suppression system |
|---|---|---|---|---|
| **1:** very low | Optional | Optional | Optional | Optional |
| **2:** low | Optional | Optional | Required | Optional |
| **3:** medium | Optional | Required | Optional | Required |
| **4:** high | Optional | Required | Optional | Required |
| **5:** very high | Required | Required | Optional | Required |

### 6.2.2 Injury to persons

Regarding injury to persons, a differentiation is required to establish the most likely severity of harm.

Five risk levels are defined analogous to ISO 13849-1 and shall be used to determine the suitable fire prevention and protection measures:

If risk level 1 is to be expected as a consequence of a fire at the machinery, all fire detection and fire suppression solutions given in Table 1 shall be provided optionally only.

If risk level 2 is to be expected as a consequence of a fire at the machinery, a fixed manual discharge suppression system shall be provided as a minimum.

If risk level 3 or 4 is to be expected as a consequence of a fire at the machinery, an automatic fire detection in combination with a fixed automatic discharge suppression system shall be provided.

If risk level 5 is to be expected as a consequence of a fire at the machinery, an automatic pre-fire detection and an automatic fire detection in combination with a fixed automatic discharge suppression system shall be provided.

Fire incidents that cause damage to property always involve hazards to persons because of gases, consequences of fire, fire spreading, extinguishing attempts, etc. Therefore, damages to property shall be taken into account since they represent a hazard to persons as well.

### 6.2.3 Safety considerations

When specifying the safety and performance requirements, the operating conditions for the use of the provided fire prevention and protection system shall be stated.

When manual systems are to be used in the event of an outbreak of a fire, procedures on how to properly and safely use the manual system, as well as other intervention procedures that should be taken by the equipment operator, should be included with the machine's information for use.

When automatic discharge suppression 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 machine control system and the fire detection and/or fire suppression system shall be capable of exchanging information to ensure that the functionality is not impaired. The machine control system shall support the functioning of the fire detection and/or fire suppression system and shall ensure that no new risks are generated. This can require "further complementary protective measures" (see 5.6.4.3).

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

### 6.2.4 Selection of system parts

The appropriate parts of the fire prevention and protection system shall be selected in accordance with 6.1.4. The designer shall demonstrate the reliability, compatibility and effectiveness of the parts used.

If necessary, dependent on the risk level, the whole or parts of the fire prevention and protection system shall be provided as a redundant system, based on the performance level specified in ISO 13849-1.

### 6.2.5 Selection of fire-extinguishing agent

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

— type of fire,

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

— location of the machinery,

— possible injury to persons, and

— possible damage to the environment.

The following four fire classes (see ISO 3941) shall be considered:

**A** fires involving solid materials, usually of an organic nature, in which combustion normally takes place with the formation of glowing embers, e.g. wood, paper, straw, coal, textiles, tyres;



**B** fires involving liquids or liquefiable solids, e.g. gasoline, grease, lacquer, resin, wax, tar, ether, alcohol;

**C** fires involving gases, e.g. methane, propane, hydrogen, town gas;

**D** fires involving metals, e.g. aluminium, magnesium, lithium, sodium, potassium and their alloys.

Taking into account these fire classes, appropriate fire-extinguishing agents shall be selected, such as

— water with or without additives, e.g. to change surface tension,

— foam,

— powder,

— fire-extinguishing gas, e.g. carbon dioxide, nitrogen, argon and mixtures of these,

— chemical fire-extinguishing agents, e.g. halon substitutes, and

— aerosols, e.g. fluids or solid substances in finely dispersed form.

The type and amount of distribution and discharge rate of the extinguishing agent shall be adapted to the expected fire, the machinery configuration and operating conditions, the spatial conditions and the extinguishing agent used. The quantity of extinguishing agent shall be sufficient to extinguish the expected fire or to keep it under control until other fire-fighting measures become effective (e.g. intervention of the fire brigade).

NOTE In some cases special approval can be necessary for the selected fire-extinguishing agent.

### 6.2.6 Validation

The purpose of validation is to check whether the safety and performance requirements as specified in 6.1.4 are met or complied with by the choice of the individual system components (fire detection and fire suppression systems and/or further complementary protective measures).

Furthermore, care shall be taken as to whether new hazards or risks are generated by the choice of the individual system components.

Finally, checks shall be made, using the risk analysis, as to whether the risk of a fire occurrence has been adequately reduced by the choice of the individual system components.

## 7 Information for use

Comprehensive documentation that is readily understandable and unambiguous shall be provided regarding the

a) responsibilities of the user to keep the machinery, installations and the fire protection equipment in a proper condition and ready for operation,

b) actions, inspections and verifications that shall be carried out after a fire incident, and

c) need for training, required experience or ability of the machine operators and maintenance personnel.

Information regarding the commissioning, operation and maintenance of the fire prevention and protection measures with respect to the intended use of the machine, in accordance with ISO 12100:2010, 6.4, and warnings of residual fire risks, shall be provided.

The manufacturer of the machine shall state the installation requirements assumed for the machine, including its installation site.



If it is intended that the fire prevention and protection of the machinery at least partly relies on the fire protection system of the user, the interface between the machine and the system shall be specified and described in the operating instructions.

If gases (e.g. an oxygen displacing gas or a gas that creates a chemical reaction) are used as extinguishing agent for walkable installations, the instructions shall state that the following devices need to be considered by the user:

— blocking device for deactivation of extinguishing gas supply prior to entering the installation for cleaning, setting and maintenance activities (e.g. non-electrical or electrical shut-off device);

— delay device in case of hazards to persons (e.g. small rooms or rooms situated below).

If it is foreseeable that portable fire-extinguishing devices will be used for fire-fighting the instructions shall include recommendations on suitable devices and their safe use.

# Annex A
(informative)

# Examples of ignition sources

## A.1 Heat energy

This category of ignition sources includes, for example,

— heating installations,

— internal combustion engines,

— open light or fire,

— hot surfaces,

— welding spatter, and

— intensive radiation sources (e.g. laser).

## A.2 Electrical energy

This category of ignition sources includes, for example,

— electrical lighting devices (e.g. lamps),

— electromagnetic radiation,

— short circuit,

— electrical arc,

— earth fault,

— conductor fault,

— lightning strike,

— discharges of static electricity,

— loose contact,

— excessive temperature rise due to overload,

— induction heating, and

— connection to inappropriate electrical supply.

## A.3 Mechanical energy

This category of ignition sources includes, for example,

— friction (e.g. overheating),

— ultrasonic,

— impact,

— grinding, and

— compression (including adiabatic compression).

## A.4 Chemical energy

This category of ignition sources includes, for example,

— self-heating,

— self-ignition such as pyrophoric materials, and

— runaway exothermic reaction.

# Annex B
(informative)

# Examples of machines and their typical fire-related hazards

See Table B.1.

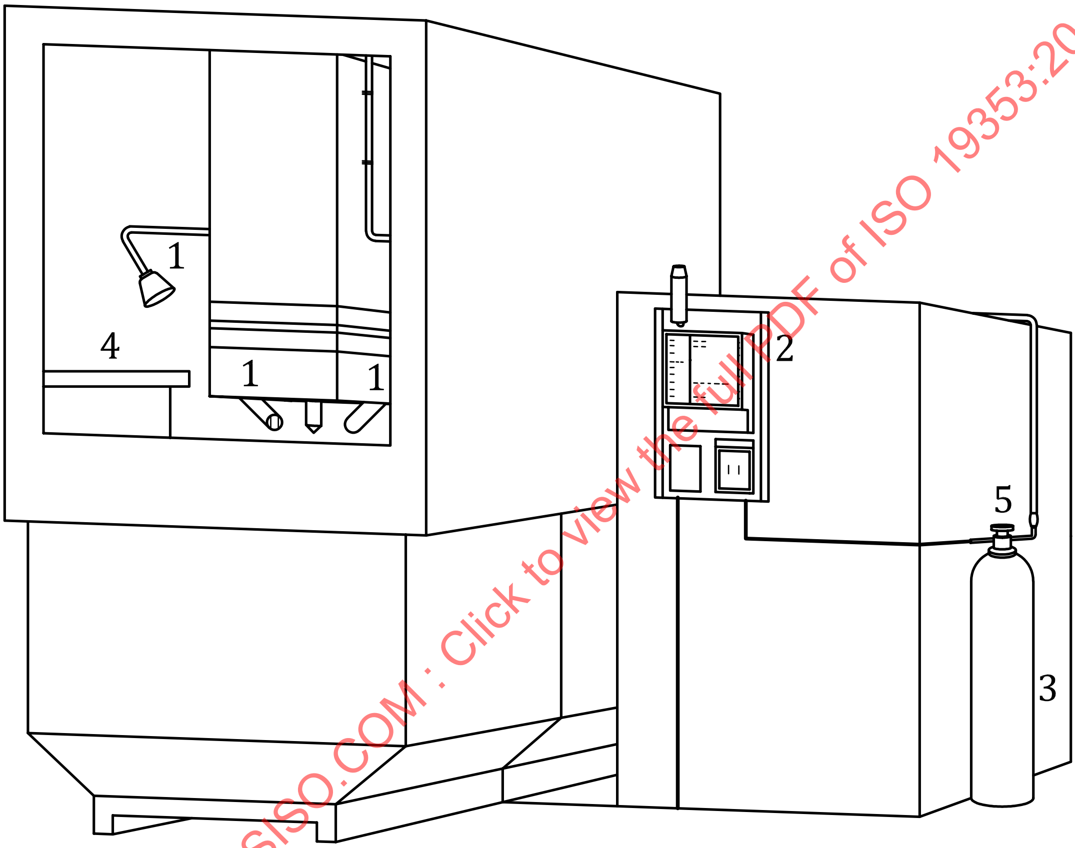
**Table B.1 — Examples of machines and their typical fire-related hazards**

| Type of machine | Typical fire-related hazards |
|---|---|
| Machining centre | Tool breakage, shortage of metalworking fluid supply, short circuit |
| Drier | Hot surface |
| Conveying belt | Hot bearings, slip between belt and drive |
| Extruder | High temperature of fluid, high pressure |
| Paint booth | Generation of aerosols, electrostatic hazards |
| Mill | Friction, foreign material, overload |
| Pelletizer | Friction, overheating due to improper starting/stopping procedures, overloading |
| Wood-working machine | Friction, foreign material, overloading, tool breakage, inappropriate feed rate, overheating |
| Printing machine | Friction |
| Blasting unit | Sparks by foreign material, self-ignition |
| Textile machine | Friction, material build-up, overheating |
| Shredder | Friction, foreign material, overloading |

# Annex C
(informative)

## Example for the design of a fire suppression system integrated in machinery

**See Figure C.1.**






**Key**

1 detector

2 central alarm control unit

3 storage unit for extinguishing agent

4 discharge pipework and nozzles

5 release unit

**Figure C.1 — Example for the design of a fire suppression system integrated in machinery**

# Annex D
(informative)

# Example for the risk assessment and risk reduction of a machining centre for the machining of metallic materials

## D.1 General

This example is provided to show how this International Standard can be applied to a specific machine. The intention of this example is to provide guidance for the user in how to follow the logic of this International Standard. It is not intended to specify specific solutions.



## D.2 Operating conditions

The example describes an enclosed machining centre in industrial use for the chip-forming machining of metallic materials with non-water-miscible metalworking fluids (drilling, turning, grinding, milling).

The risk of fire depends on possible ignition sources and on the degree of emissions (concentration of flammable non-water-miscible metalworking fluids) in a machine (evaporation and mist formation). The degree of emissions is influenced by

— machining process, e.g. high-speed machining, high-speed cutting,

— machining parameters, e.g. feed, cutting speed ($m \cdot min^{-1}$),

— metalworking fluid supply, e.g. high pressure for deep hole drilling, and

— material characteristics, e.g. high alloyed steel that is difficult to machine, quality of material (strength, shrinking).

When planning protective measures for fire prevention and protection, normal operating conditions of the machine are determined, i.e. the usual intended operation including start-and-stop procedures as well as servicing and maintenance. In addition, possible technical failures and reasonably foreseeable misuse are included.

The chip-forming operation of light metals (e.g. magnesium) is not considered here since it requires specific measures. However, information on dealing with magnesium alloys is given.

## D.3 Risk assessment and risk reduction

### D.3.1 General

The risk assessment and risk reduction procedure is shown in Figure D.1.

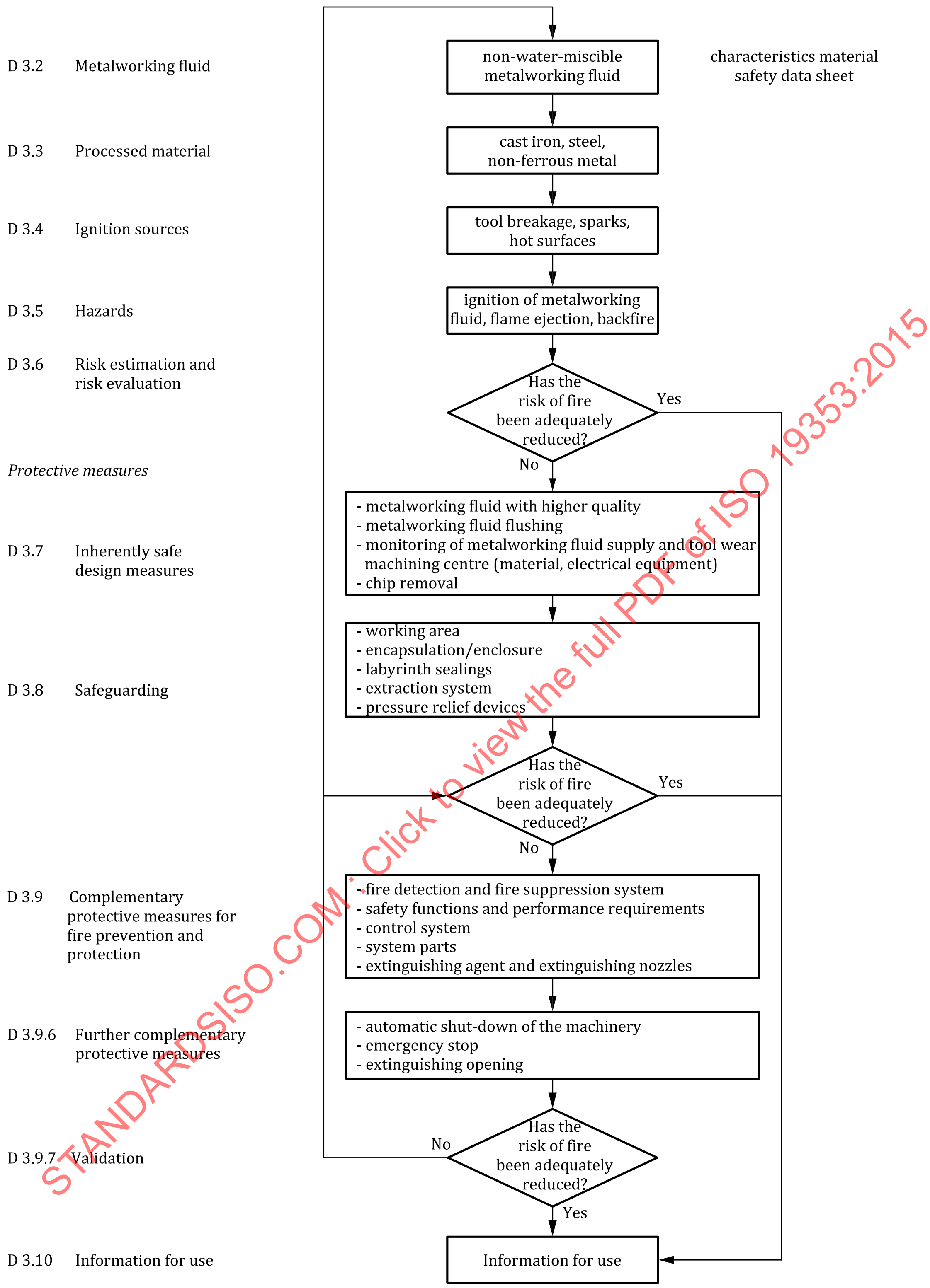



**Figure D.1 — Risk assessment and risk reduction for the example of a machining centre**

## D.3.2 Selection of non-water-miscible metalworking fluids

The fire risk of non-water-miscible metalworking fluids is determined by their properties as shown in Table D.1.

**Table D.1 — Properties of non-water-miscible metalworking fluids**

| Tendency | Viscosity grade<br>in accordance with ISO 3448 | Viscosity at 40 °C<br>$mm^2 \cdot s^{-1}$ | Flashpoint<br>in accordance with ISO 2592<br>°C | Evaporation loss at 250 °C in 1 h<br>Noack procedure[a]<br>% |
|---|---|---|---|---|
| Decreasing fire and explosion hazard<br>↓ | ISO VG 5 | 4,14 to 5,06 | > 120 | < 85 |
| | ISO VG 7 | 6,12 to 7,48 | > 145 | < 80 |
| | ISO VG 10 | 9,0 to 11,0 | > 155 | < 60 |
| | ISO VG 15 | 13,5 to 16,5 | > 190 | < 25 |
| | ISO VG 22 | 19,8 to 24,2 | > 200 | < 15 |
| | ISO VG 32 | 28,8 to 35,2 | > 210 | < 13 |
| | ISO VG 46 | 41,4 to 50,6 | > 220 | < 11 |

[a] See, for example, DIN 51581-1.

Depending on the machining process, the most suitable metalworking fluid is selected by considering the following parameters:

— highest suitable viscosity for the intended machining process;

— lowest possible evaporation loss;

— highest possible flashpoint.

### D.3.3 Processed material

The fire risk of material residues within the machine is determined by

— their size (coarse or fine chips), and

— their condition (wet or dry).

For light metal chips, the fire characteristics, e.g. combustibility index, should be determined or provided by the supplier of the processed material.

In order to minimize the risk of fire or to limit the consequences of fire, it is important to keep the fire load in the interior of the machine as low as possible. This can be achieved by efficient chip removal, for example

— chip discharge through flushing with metalworking fluid,

— chip removal through chain or chip conveyors, and

— regular cleaning and disposal of deposits in the interior of the machine.

### D.3.4 Ignition sources

In most cases, machine fires are initiated by the following ignition sources:

— incorrect tool position leading to tool damage;

— incorrect process parameters (e.g. feed rate, tool speed);

— sparks with high energy (e.g. grinding sparks);

— overheated chips;

— hot surfaces (e.g. overheated tool or workpiece due to insufficient flow rate of metalworking fluid).

A reliable and sufficient cooling of the machining zone by metalworking fluid to avoid ignition sources can be ensured by the following measures:

— total wetting of the workpiece by metalworking fluid;

— selection of optimum metalworking fluid flow rate;

— monitoring of metalworking fluid flow rate and tool wear.

### D.3.5 Hazards

The properties of metalworking fluid, the materials used, the potential ignition sources and the operating conditions can create hazards, including ignition of an aerosol consisting of metalworking fluid and air in the interior of the machining centre. The following hazards can be created:

a) flame ejections through machine openings (e.g. door openings, gaps, loading and unloading openings or pressure relief openings);

b) flame ejections into the extraction system or chip removal system;

c) subsequent fire in the interior of the machine;

d) subsequent fire propagation to adjacent machine areas, e.g. drive room, workpiece magazines, chip conveyor, extraction system;

e) ignition of chips, in particular with light metals (e.g. magnesium, aluminium);

f) fire propagation to other parts of the plant;

g) formation of smoke and generation of hazardous combustion gases;

h) backdraft when opening the door of the machine enclosure;

i) re-ignition due to reintroduction of metalworking fluid when restarting the machine.

### D.3.6 Risk estimation and risk evaluation

For all fire hazards (fire scenarios) identified in D.3.5, depending on the operating conditions, the "risk level" is determined (see 5.4).

The risk level is estimated by means of a risk graph that examines the severity of injury, the frequency and/or exposure time of the fire hazard and the possibility of avoiding hazard (see Figure 5).

Example of risk estimation: For hazard D.3.5 a) "flame ejections through machine openings" in every case injury of persons can be expected. Assuming that the severity of injury is serious (S2), the frequency of occurrence is seldom to less often (F1) and avoidance of hazard or limiting the harm is scarcely possible (P2) a high risk level (risk level 4) results.

For hazards where the risk level is unacceptably high, fire prevention and protection measures are selected and applied to adequately reduce the risk of fire by using the three-step method (see 5.6.1), starting with inherently safe design measures followed by safeguarding and complementary protective measures.

### D.3.7 Inherently safe design measures

#### D.3.7.1 Hot surfaces and other ignition sources

##### D.3.7.1.1 Cooling by use of metalworking fluid

The metalworking fluid supply system (pipe and nozzle dimensioning, storage tank volume, pump capacity, sufficient heat dissipation, etc.) is designed in such a way that a sufficient amount of metalworking fluid is available to cool the cutting zone at all times by flushing.



Measures for the best possible cooling by use of metalworking fluid are

— total flushing with metalworking fluid at pressure and a velocity sufficiently low in the close vicinity of the cutting zone, and

— provision of more nozzles, if the waste material (chips and particles) generated is not sufficiently cooled at the point of generation.

The performance of the flushing nozzle (pressure, nozzle geometry and correct setting) is also relevant.

By the installation of additional nozzles and their arrangement as "metalworking fluid rinsing curtains", mist volumes can be further minimized. It is necessary to correctly adjust and direct the nozzles towards the workpiece/cutting zone area (see D.3.10).

In some cases, additional cooling outside the working zone is needed to obtain sufficient cooling, e.g. in the chip conveyor.

#### D.3.7.1.2 Monitoring of the metalworking fluid supply and tool wear

Flow control devices (or, alternatively, switches for high and low pressure) and monitoring of the metalworking fluid temperature are mainly used to monitor the metalworking fluid supply.

By means of process monitoring, the ignition sources due to tool wear are recognized, e.g. by means of monitoring of structure borne noise or monitoring of the cutting force.

### D.3.7.2 Chip removal

In order to avoid a fire or to limit its consequences, it is important to keep the "fire hazard" as low as possible, by means of, for example

a) design measures in the interior of the machine that include

   — draining-off of cutting fluids by slightly sloped machine tops, and

   — avoidance of horizontal surfaces (areas with pool formation or chip accumulation).

b) chip conveyance from the interior of the machine by

   — chip discharge through flushing with metalworking fluid, and

   — chip removal through chain or chip conveyors with motor monitoring.

c) storage of chips in chip container where the

   — container is closed, if possible,

   — container is integrated in an extraction system through an extraction cover, and

   — information on regular emptying of container is in the operating instructions.

## D.3.8 Safeguarding

### D.3.8.1 Machining centre

#### D.3.8.1.1 Working area encapsulation and enclosure of the machining centres

Measures against hazardous pressure increase and fire within the enclosure comprise

— enclosure and working area encapsulation (doors, other covers) consisting of non-flammable metal materials,