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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This third edition cancels and replaces the second edition (ISO 19353:2015), which has been technically revised. It also incorporates the Amendment ISO 19353:2015/DAM 1:2017. The main changes compared to the previous edition are as follows:

— old Annexes A and B have become Annexes D and A, respectively;

— an example of methodology for selecting and qualifying a fire detection and fire suppression system has been added as new Annex B;

— old Annex D has been improved editorially and it has become Annex E;

— old Annex E on fire risk reduction measures has been deleted as well as references to it.

Introduction

The safety of machinery against fire involves fire prevention and fire protection and fire-fighting. In general, 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.

This document deals with the measures shown in Figure 1.

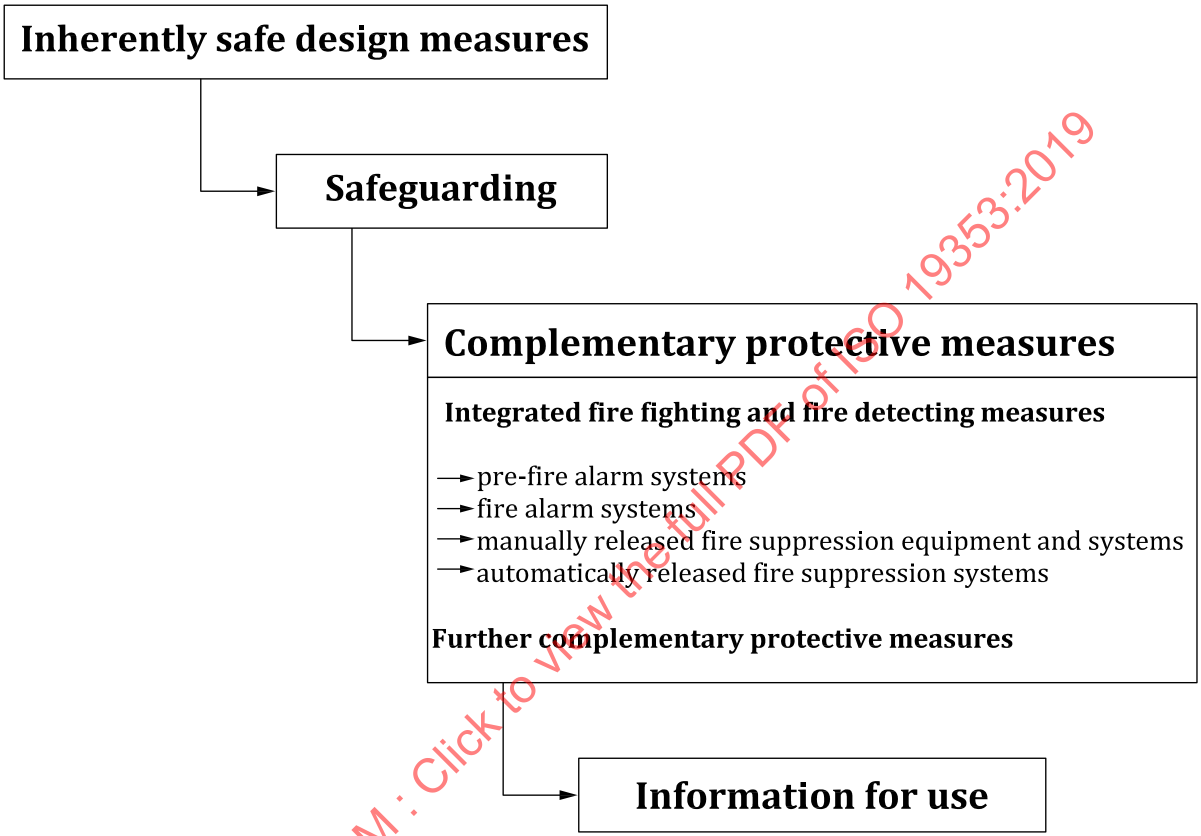


Figure 1 — Protective measures dealt with in ISO 19353

This document is a type-B 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 organizations, market surveillance etc.).

Others can be affected by the level of machinery safety achieved with the means of the document by the above-mentioned stakeholder groups:

— 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 which are covered by the scope of a type-C standard and which 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 document 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 document 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 are referred to in the text in such a way that some or all of their content constitutes requirements 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 12100:2010, *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*

ISO 13943, *Fire safety — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12100, ISO 13943 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
combustibility
property of a material capable of burning

Note 1 to entry: Accurate assessment of the combustibility characteristics of a material depends 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
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.

3.3
fire
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.

3.4
fire-extinguishing agent
agent which is appropriate to extinguish *fire* (3.3) 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.

3.5
fire prevention
set of measures to prevent the outbreak of a *fire* (3.3) and/or to limit its effects

[SOURCE: ISO 8421-1:1987, 1.21, modified — The words “set of” has been added to the definition.]

3.6
fire protection
set of measures such as design features, systems, equipment, buildings or other structures to reduce danger to persons and property by detecting, extinguishing or containing *fires* (3.3)

[SOURCE: ISO 8421-1:1987, 1.23, modified — The words “set of measures such as” have been added to the definition.]

3.7
fire suppression system
technical system to fight a *fire* (3.3) and to reduce the damaging effects of flames and heat

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

3.8
ignition energy
energy necessary to initiate combustion

3.9
low evaporation metalworking fluid
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.

3.10
overheating
uncontrolled temperature increase

3.11
pre-fire alarm system
pre-fire detection
system that detects conditions that can lead to the potential onset of *fire* (3.3) 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.

Note 3 to entry: A fire alarm system is understood to be a system that, by the use of sensors, detects the onset of fire and initiates a response. Sensors can be designed to detect smoke, combustion gases, heat or flames.

3.12
required performance level
PL_r
performance level (PL) applied in order to achieve the required risk reduction for each safety function

[SOURCE: ISO 13849-1:2015, 3.1.24, modified — Note 1 to entry has been deleted.]

3.13
self-ignition
spontaneous ignition resulting from self-heating

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).

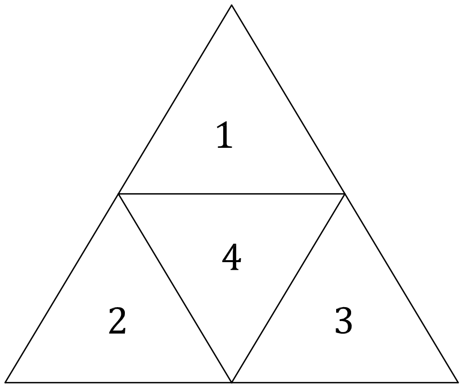
A fire can be prevented or suppressed by controlling or removing one or more of the components of the fire tetrahedron.

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 machines and their typical fire related hazards and Annex D for examples of ignition sources.

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);

   3) risk estimation (see 5.4);

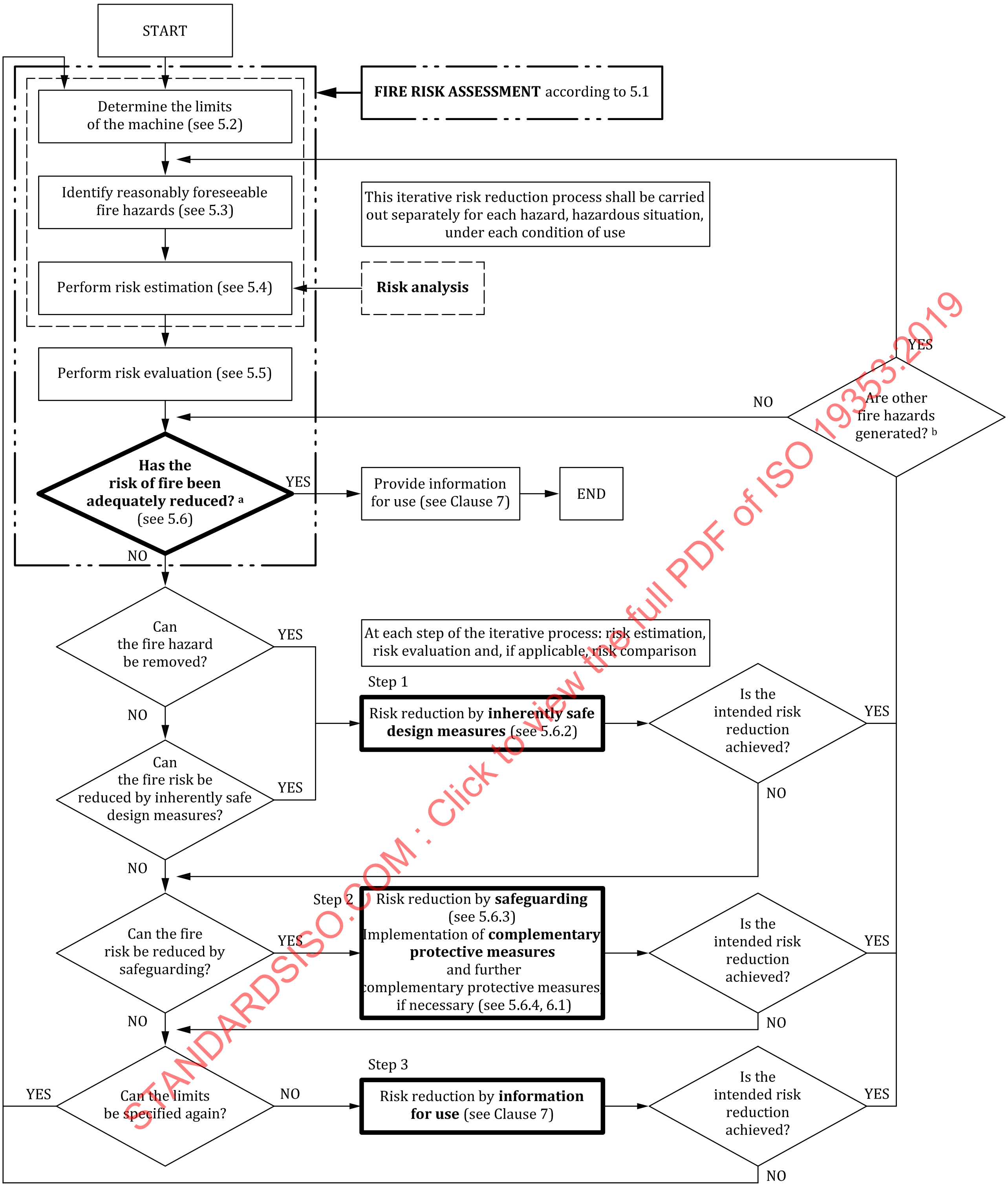
b) risk evaluation.

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.

NOTE See Annex E for an example for the risk assessment and risk reduction of a machining centre for the machining of metallic materials.



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 ageing 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.

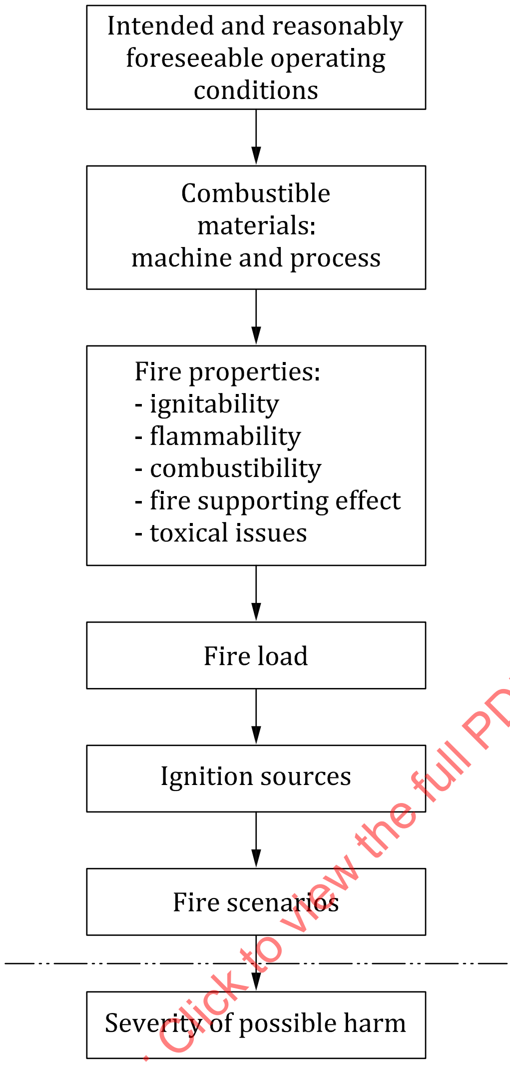


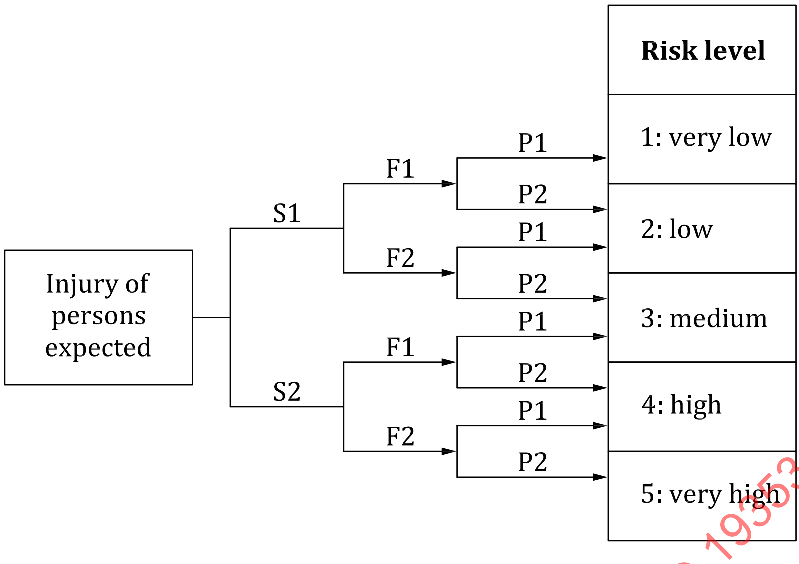
Figure 4 — Identification of significant fire hazards

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 non-combustible materials are not applicable, self-extinguishing materials and fire-protected materials should be used.

NOTE Such materials can be classified as per 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 E.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 E.3.8.1.2).

The required performance level (PL_r) 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 (PL_r) shall be defined.

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 E.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-extinguishing 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 (PL_r) 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.

Annex B gives an example of a methodology for selecting and qualifying a fire detection and fire suppression system.

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:

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

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

c) the 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 machines and their typical fire-related hazards

See Table A.1.

Table A.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 B
(informative)

Example of a methodology for selecting and qualifying a fire detection and fire suppression system

B.1 General

The selection and qualifying of a fire detection and fire suppression system is a complex procedure. Several considerations are needed to ensure a safe and reliable solution. A comprehensive understanding of the fire event as well as sufficient knowledge about ignition behaviour, fire detection and fire suppression possibilities is required. The primary goal is to ensure a safe working condition for the operator in the event of a fire incident.

This annex provides a methodology comprising a typical, but non-exclusive set of basic questions. These questions take into account the major aspects given in Figure B.1 which are normally considered when a fire detection and fire suppression system is selected and qualified.

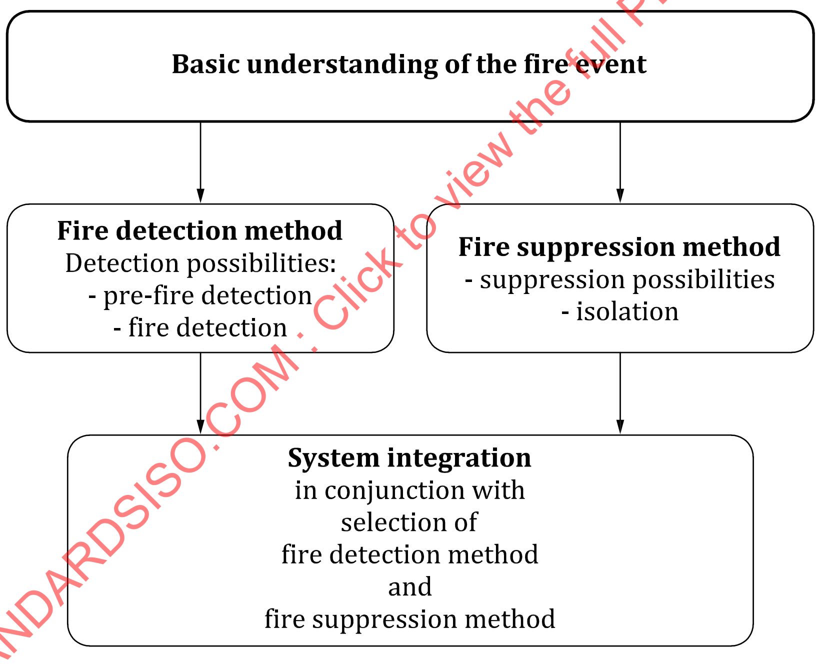


Figure B.1 — Example for fire detection and fire suppression methodology

Three machine examples are presented to illustrate the application of the given methodology (see Table B.1).

B.2 Basic understanding of the fire event

For each particular type of machine under consideration, the following basic questions are asked at the beginning of the process for selecting and qualifying both a fire detection method and a fire suppression method:

a) What can burn?

b) What can cause the ignition?

c) Where can the fire spread?

d) How will the fire behave?

B.3 Fire detection method

B.3.1 Pre-fire detection possibilities

For each particular type of machine under consideration, the following questions are asked during the process with regard to pre-fire detection:

a) Which are the possible ignition criteria?

b) How and where can the criteria be detected?

c) At which stage/time can reliable and predictable pre-fire detection be made?

d) What environmental conditions is the detection equipment exposed to?

e) Are there any disturbance sources that can cause false detections?

B.3.2 Fire detection possibilities

For each particular type of machine under consideration, the following questions are asked during the process with regard to fire detection:

a) What are the fire criteria?

b) How can the fire criteria be detected?

c) Where and at which stage/time can reliable and predictable fire detection be made?

d) Is re-ignition possible and if so can the detection equipment reactivate?

e) What environmental conditions is the detection equipment exposed to?

f) Are there any disturbance sources that can cause false detections?

B.4 Fire suppression method

B.4.1 Suppression possibilities

For each particular type of machine under consideration, the following questions are asked during the process with regard to suppression possibilities:

a) What is the preferred fire suppression agent?

b) Can the suppression media be brought to all the places where it is needed?

c) Can the operator be exposed to the fire-suppression agent and, if so, can the exposure lead to a hazardous situation for the operator?

d) Which fire suppression agent is best compatible with the equipment protected?

e) Which fire suppression agent is the most effective?

f) Is the fire suppression solution suitable for the expected incident frequency?

g) Is re-ignition possible and if so can the fire suppression solution handle it?

B.4.2 Isolation

For each particular type of machine under consideration the following questions are asked during the process with regard to isolation needs:

a) Does the fire suppression solution require isolation to perform effectively?

b) Is isolation of the inlet and/or outlet of the machine necessary (to prevent fire propagation or damage from fire suppression agents)?

c) How fast does the isolation have to close (reaction time)?

d) Depending on the process design, does isolation create a secondary risk?

B.5 System integration in conjunction with selection of fire detection and fire suppression method

To determine a suitable system integration solution, the following questions are asked:

a) How shall the shutdown procedure of the equipment be designed?

b) How shall the fire suppression be activated?

c) What are the criteria for activation of fire suppression?

d) Is the system solution suitable for the incident frequency expected?

e) Is the system solution compatible with operation and maintenance of the equipment?

f) What needs to be monitored during operation and maintenance?

g) Which alarms shall be given?

h) How shall the alarms be given?

i) How will restart of the machine be implemented after a fire incident happened?

j) Will the reaction time for the total system solution be acceptable?

k) Does the fire protection system have to be operational in the event of a power failure and, if so, for how long time?

B.6 Example for application of the methodology

Table B.1 presents a mill, a turning machine and a paint booth as examples to demonstrate the application of the methodology for selecting and qualifying a fire detection and fire suppression system.

Tables B.2 to B.7 show the application of the given methodology on the machines exemplarily chosen in Table B.1 using the questions stated in B.2 to B.5.

Table B.1 — Types of machines used in the example

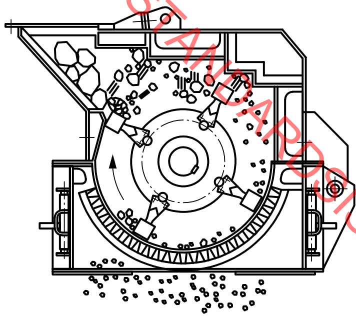
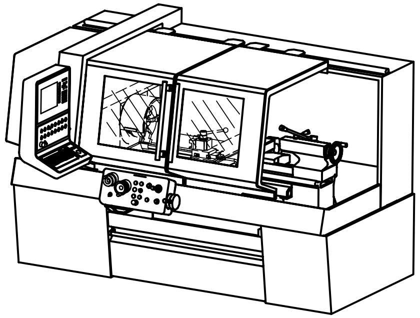
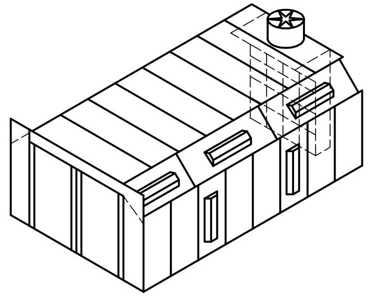
Parameter	Mill	Turning machine	Paint booth (wet)
Scheme of machine		 Adapted from ISO 23125:2015, Figure 4.	
Intended use	Shredding of pieces of wood for the production of wood chips	Turning of stainless steel stock bar for the production of turned parts, screws, nuts, screw connections	Painting of components
Combustible material and fire-related material characteristics	Wood: — minimum ignition energy (MIE): 100 mJ — minimum ignition temperature of a dust cloud (MIT dc): 460 °C — minimum ignition temperature of a dust layer with reference to a 5-mm-layer of dust (MIT dl5): 315 °C	Metalworking fluid (non-water-miscible cooling lubricant): — flashpoint CoC: 170 °C — evaporation loss Noack 250 °C, 1 h: 57 % — viscosity 40 °C: 10 mm^2/s — low evaporation metalworking fluid with anti-mist additives	Solvent based coatings: — flashpoint: 7 °C to 22 °C — LEL (Lower Explosion Limit): 1 % to 2 % — UEL (Upper Explosion Limit): 6 % to 15 % NOTE Refer to the manufacturer's Material Data Safety Sheet for the actual values associated with a specific product.

Table B.2 — Basic understanding of a fire event

Question	Mill	Turning machine	Paint booth (wet)
What can burn?	Wood chips and wood dust	— Aerosol/vapour/air mixture of flammable lubricant — Oil and oil-soaked chips and dust (e.g. residues in machines, chip accumulations)	— Flammable paint solvent vapour — Flammable paint solvent in containers — Paint residue on equipment, air duct walls, air plenums
What can cause the ignition?	— Friction heat — Foreign material (e.g stones, dust, metal or plastic objects) — Mechanical break-down (e.g bearings) — Hot surface (e.g. by heat transfer from the drive unit) — Electrical malfunction — Electrostatic discharge due to ungrounded components — Hot spots in the feed of wood chips and wood dust	— Tool breakage (e.g. by incorrect tool position, wear) — Dry running (e.g. insufficient lubricant supply, clogging) — Insufficient volume and/or distribution of cooling fluid — Collision (e.g. incorrect movement due to incorrect data input to the control system, wrong size or type of raw material) — Larger accumulation of oily chips and dust in the chip container (self-ignition) — Electrostatic discharge due to ungrounded components	— Sparks generated by electrical equipment — Overheated bearing on ventilation fans — Accumulations of booth debris (self-ignition) — Friction of fan blades against paint deposits on fan housing — Electrostatic discharge due to ungrounded components
Where can the fire spread?	— Throughout the machine — Through the air inlet, the material inlet and the material outlet	Throughout the machine, e.g. drive enclosure, extraction pipes and extraction system, chip conveyors and chip containers, and into the machine room	— Throughout the paint booth — Into the ventilation ductwork — Into the air plenum — Outside of the paint booth and possibly into its surrounding area

Table B.2 *(continued)*

Question	Mill	Turning machine	Paint booth (wet)
How will the fire behave?	— Quick fire propagation Typical scenarios: The fire starts inside the mill The fire spreads to or starts in subsequent process operations from an ignition source generated by the mill. Combination of above — Formation of smoke and generation of hazardous fire gases	— Quick fire propagation due to ignition of the aerosol-vapour-air mixture — Moderate fire propagation due to ignition of oily chip residues with subsequent fire and creation of hot surfaces — Formation of smoke and generation of hazardous fire gases	— Quick fire propagation in ventilation air ducts and in exhaust ducts — Moderate fire propagation due to ignition of booth debris NOTE An ignition of a vaporous atmosphere can result in an explosion and potentially followed by a widely dispersed fire. — Formation of smoke and generation of hazardous fire gases

Table B.3 — Pre-fire detection possibilities

Question	Mill	Turning machine	Paint booth (wet)
Which are the possible ignition criteria's?	— Friction heat — Hot surfaces — Foreign materials — Sparks — Hot particles — Out-gazing — Hot spots in the feed due to self ignition	— Friction heat — Hot surfaces — Contamination (e.g. tramp oil) — Sparks — Hot particles	— Friction heat caused by loss of clearance between fan blade and housing — Electrostatic discharge — Hot surfaces — Sparks — Hot particles

How and where can the criteria be detected?	— By temperature monitoring of bearings, motor and mill housing
	— By spark/hot particle detection on the mill outlet
	— By monitoring of power consumption at the main motor
		— By tool monitoring:
		  — power consumption
		  — temperature
		  — vibration
		— By monitoring of the flow rate and the temperature of the metal working fluid
			— By temperature monitoring of fan and motor bearings
			— By smoke detection in clean air ducts
			— By gas detection
			— By vibration monitoring of the fan
			— By heat detection
			— By spark/hot particle detection after fan

At which stage/time can reliable and predictable pre fire detection be made?	The following pre-fire indications can be done before the ignition takes place: — monitoring of power consumption; — temperature monitoring, if located close to the heat source; — spark/hot particle detection on the mill outlet.	The following pre-fire indications can be done before the ignition takes place: — monitoring of power consumption; — temperature monitoring; — vibration monitoring; — monitoring of the flow rate of the metal working fluid.	The following pre-fire indications can be done before the ignition takes place: — temperature monitoring, if located close to the heat source; — gas detection; — vibration monitoring; — spark detection.
What environmental conditions is the detection equipment exposed to?	Heavy industrial environment involving large quantities of wood chips and dust, normal wear and tear, vibrations and electromagnetic fields	Industrial environment involving metal working fluids and metal chips and dust	Industrial environment involving airborne paint overspray, paint solvent in the atmosphere, dry paint

Table B.3 *(continued)*

Question	Mill	Turning machine	Paint booth (wet)
Are there any disturbance sources that can cause false detections?	Daylight can disturb spark/hot particle detectors if these are not daylight-insensitive	Monitoring of power consumption, temperature monitoring, vibration monitoring and monitoring of the flow rate of the metal working fluid can be disturbed by electromagnetic fields	— Fumes from external processes being introduced (e.g. combustion engine) can disturb gas detection — Improper air filtering (e.g. dust particles reaching the smoke detector) can disturb smoke detection — Daylight can disturb spark/hot particle detectors, if these are not daylight-insensitive

Table B.4 — Fire detection possibilities

Question	Mill	Turning machine	Paint booth (wet)
What are the fire criteria?	— Heat — Combustion gases — Smoke — Flames	— Heat — Combustion gases — Smoke — Flames	— Heat — Combustion gases — Smoke — Flames
How can the fire criteria be detected?	— *Heat*: Temperature sensor — *Combustion gases*: Gas detector — *Smoke*: Smoke detector — *Flames*: UV-, IR- or UV-IR- detector	— *Heat*: Temperature sensor — *Flames*: UV-, IR- or UV-IR- detector	— *Heat*: Temperature sensor — *Combustion gases*: Gas detector — *Flames*: UV-, IR- or UV-IR- detector
Where and at which stage/time can reliable and predictable fire detection be made?	— *Temperature sensor*: Can detect a fire at a relatively early stage if located close to the fire. In general, the reaction time for a temperature sensor is longer in comparison with flame detectors — *Gas detector*: Can detect the combustion gases from the fire if sufficient concentration reaches the detector. Generally quicker reaction time than a smoke detector, but longer reaction time in comparison with flame detectors — *Smoke detector*: Can detect the smoke from the fire if sufficient concentration reaches the detector. In general the reaction time is longer in comparison with flame detectors — *Flame detector*: Can detect a flame at an early stage, if it appears within the detectors field of vision	— *Temperature sensor:* Can detect a fire at a relatively early stage if located close to the fire. In general, the reaction time for a temperature sensor is longer in comparison with flame detectors — *Flame detector:* Can detect a flame at an early stage, if it appears within the detectors field of vision. Installation of flame detector is most suitable in the upper corners of the machine cover	— *Temperature sensor: Can* detect a fire at a relatively early stage in the paint booth and in the ventilation ductwork, if located close to the fire — *Gas detector:* Can detect the combustion gases from the fire in the paint booth if sufficient concentration reaches the detector. Generally quicker reaction time than a smoke detector, but longer reaction time in comparison with flame detectors — *Flame detector:* Can detect a flame at an early stage, if it appears within the detectors field of vision. UV/IR detectors in the paint booth can detect radiant energy originating from a fire

Table B.4 *(continued)*

Question	Mill	Turning machine	Paint booth (wet)
Is re-ignition possible and if so can the detection equipment reactivate?	Re-ignition is possible: — *Temperature sensor:* Can detect a reignited fire and being reactivated, if not damaged by the fire — *Gas detector:* Can detect a reignited fire and being reactivated, if not damaged by the fire — *Flame detector:* Can detect a reignited fire and being reactivated, if not damaged by the fire	— Re-ignition is possible, if there exist hot surfaces and/or burning/ glowing chip accumulations — Reactivation of temperature sensors or flame detectors is possible if not damaged by fire	— Re-ignition is possible, if the original source of ignition has not been eliminated — Reactivation of temperature sensors or flame detectors is possible if not damaged by fire
What environmental conditions is the detection equipment exposed to?	Heavy industrial environment involving large quantities of wood chips and dust, normal wear and tear, vibrations and electromagnetic fields	Industrial environment involving metal working fluids and metal chips and dust	Industrial environment involving airborne paint overspray, paint solvent in the atmosphere, dry paint
Are there any disturbance sources that can cause false detections?	— *Gas detector*: Combustion gases from other sources, electromagnetic interference — *Flame detector:* Non-fire radiant energy (e.g. sunlight, daylight, halogen light, strobe lights, vehicle lights, depending on the type of flame detector (UV, UV-IR, IR), electromagnetic interference	*Flame detector:* Non-fire radiant energy (e.g. sunlight, daylight, halogen light, strobe lights, vehicle lights, depending on the type of flame detector (UV, UV-IR, IR), electromagnetic interference	— *Gas detector:* Combustion gases from other sources, electromagnetic interference, influence of other gases — *Flame detector:* Non-fire radiant energy (e.g. sunlight, daylight, halogen light, strobe lights, vehicle lights, depending on the type of flame detector (UV, UV-IR, IR), electromagnetic interference

Table B.5 — Fire suppression possibilities

Question	Mill	Turning machine	Paint booth (wet)
What is the preferred fire suppression agent?	Water or inert gas	Inert gas or water mist	— Powder — Foam — Water mist — Inert gas NOTE The selection depends on the size of the paint booth and the objects being painted.
Can the suppression media be brought to all the places where it is needed?	Yes, under the assumption that the injection points are properly located Additionally, extinguishing openings for manual fire suppression can be foreseen	Yes, under the assumption that the injection points are properly located Additionally, extinguishing openings for manual fire suppression can be foreseen	Yes, under the assumption that the injection points are properly located Additionally, extinguishing openings for manual fire suppression can be foreseen
Can the operator be exposed to the fire-suppression agent and, if so, can the exposure lead to a hazardous situation for the operator?	Yes, if inert gas is used, e.g. CO_2, there is a risk of suffocation for the operator	Yes, if inert gas is used, e.g. CO_2, there is a risk of suffocation for the operator	Yes, if inert gas is used, e.g. CO_2, there is a risk of suffocation for the operator
Which fire suppression agent is best compatible with the equipment protected?	Both are compatible with the equipment protected	Inert gas (check in the individual case)	Inert gas and water mist are most compatible with the equipment protected

Table B.5 *(continued)*

Question	Mill	Turning machine	Paint booth (wet)
Which fire suppression agent is the most effective?	Water will be the most effective fire suppression agent because it spreads well in the mill housing, it has a fire cooling effect and it wets the material	Inert gas is most effective due to its high suppression efficiency in a closed/encapsulated machine	Inert gas and water mist are the most effective ones
Is the fire suppression solution suitable for the expected incident frequency?	Yes. The incident frequency of a mill is expected to be high. It is possible that the fire suppression system can activate multiple times per day	Yes, fire incidents happen rather infrequent. Normally, these occur only at simultaneous occurrence of several failures, e.g. tool breakage, dry running	Yes. Paint booth fires are expected to be of low incident rate
Is re-ignition possible and if so can the fire suppression solution handle it?	Re-ignition is possible, but very unlikely when water is used as fire suppression agent Reactivation of fire suppression is possible as long as the required volume of water and the required water pressure is available	Yes, re-ignition is possible but not very likely Reactivation of the fire suppression system can only be done if additional gas bottles are installed and can be triggered by the fire suppression system	Re-ignition is not likely

Table B.6 — Isolation

Question	Mill	Turning machine	Paint booth (wet)
Does the fire suppression solution require isolation to perform effectively?	No	Yes	Yes, in the case of inert gas.
Is isolation of the inlet and/or outlet of the machine necessary (to prevent fire propagation or damage from fire suppression agents)?	In order to avoid collateral damage, isolation can be needed depending on the design of the process upstream and downstream.	Yes, if a central extraction system is used. A shut-off valve against fire propagation should be installed. Extraction should be stopped.	Yes, by designing the detection system in a manner that all power to the paint delivery system and extraction/ventilation fan are stopped. The use of a shut-off valve against fire propagation with extraction system is useful.
How fast does the isolation have to close (reaction time)?	This depends on the design of the process upstream and downstream.	For shut-off valves, for example, 500 ms are sufficient.	For example, within 500 ms.
Depending on the process design, does isolation create a secondary risk?	Not applicable.	No	No

Table B.7 — System integration solution

Question	Mill	Turning machine	Paint booth (wet)
How shall the shutdown procedure of the equipment be designed?	Alarm and shut down should be initiated and maintained automatically by signals from the fire protection system — Prealarm Activation when a temperature monitoring device or when a temperature/energy detector exceeds a pre-set value. Notification of the operators without stopping the process at this stage. — Alarm with activation of fire suppression system Activation when a temperature/energy detector momentarily exceeds a pre-set value higher than the pre-alarm that activates the fire suppression at the mill outlet. Notification of the operators without stopping the process at this stage to avoid unnecessary tripping.	— Emergency-stop, shut-down of external power sources — Shut-down of metalworking fluid supply — Closing of shut-off valves when central extraction system is used — Shut-down of extraction system when local extraction system is used — Machine door interlocked closed — Shut-down of chip conveyor	— Immediate shut down of all paint delivery systems upon detection of a fire — Immediate cut off all power to the ventilation/exhaust system and closure of ventilation system with shut-off valves — Shut-down of all external power sources, e.g. heater, excluding lights

Table B.7 *(continued)*

Question	Mill	Turning machine	Paint booth (wet)
	— Alarm with activation of fire suppression system and shutdown Initiation of alarm and shutdown of machine when a temperature monitoring device detects a temperature exceeding a pre-set high risk of sustained fire value or when a temperature/energy sensor detects a specified number of sustainable fire conditions within a pre-set time. Stopping of infeed to the mill, the mill and conveying components. Stopping of extraction fans, if applicable, as soon as possible in order to limit the addition of oxygen and to avoid hot particles/sparks from following the air flow through the extraction ductwork		
How shall the fire suppression be activated?	Automatically Manual activation of the fire suppression system can also be available	Automatically Manual activation of the fire suppression system can also be available	Either automatically and/or manually
What are the criteria for activation of fire suppression?	Alarm signal from a monitoring/detection device, or manual release	Alarm signal from a monitoring/detection device, or manual release	Alarm signal from a monitoring/detection device and a completed delay time to allow the operator to leave the hazard zone, or manual release
Is the system solution suitable for the incident frequency expected?	Yes, due to continuously available supply of suppression agent when operating	Yes. Manual refilling of suppression agent from a safe position is acceptable	Yes. Manual refilling of suppression agent from a safe position is acceptable
Is the system solution compatible with operation and maintenance of the equipment?	Yes, if the equipment included in the fire protection solution is accessible for maintenance and does not interfere with operation and maintenance of the mill	Yes, if the equipment included in the fire protection solution is accessible for maintenance and does not interfere with operation and maintenance of the turning machine	Yes, if the equipment included in the fire protection solution is accessible for maintenance and does not interfere with operation and maintenance of the paint booth

Table B.7 *(continued)*

Question	Mill	Turning machine	Paint booth (wet)
What needs to be monitored during operation and maintenance?	— Electrical equipment within the fire protection system, such as detectors, suppression and control equipment — Water pressure — Temperature	— Readiness for operation of the fire suppression system — Readiness for operation of sensor (e.g. cable breakage monitoring) — Quantity of fire suppression agent (e.g. automatic monitoring or manual verification)	— Flame detectors by automatic self-testing, e.g. for paint residues — Readiness for operation of the fire suppression system — Readiness for operation of sensor (e.g. cable breakage monitoring) — Quantity of fire suppression agent (e.g. automatic monitoring or manual verification)
Which alarms shall be given?	— Pre-fire — Fire — Fault — Process stop	— Fire — Fault — Process stop	— Pre-fire (e.g. overheated bearing) — Fire — Fault — Process stop
How shall the alarms be given?	— Audible alarm — Visible alarm — Alarm outputs from the fire protection system suitable for the control system of the mill	— Audible alarm — Visible alarm — Alarm outputs from the fire protection system suitable for the control system of the turning machine	— Audible alarm — Visible alarm — Alarm outputs from the fire protection system suitable for the control system of the paint booth
How will restart of the machine be implemented after a fire incident happened?	The machine is not ready for restart unless any faults are eliminated and the alarms are acknowledged in the fire protection system	The machine is not ready for restart unless: — the fire suppression system is refilled and checked for readiness (including all sensors, cables etc.); — the shut-off valve is checked for readiness	The machine is not ready for restart unless: — the fire suppression system is refilled and checked for readiness (including all sensors, cables etc.); — the shut-off valve is checked for readiness
Will the reaction time for the total system solution be acceptable?	Yes, with a total time of less than 100 ms until the release of the fire-extinguishing agent	Yes, with a total time of less than 1 s until the release of the fire-extinguishing agent	Yes, with a total time of less than 1 s until the release of the fire-extinguishing agent (excluding a possible delay time to allow the operator to leave the hazard zone)

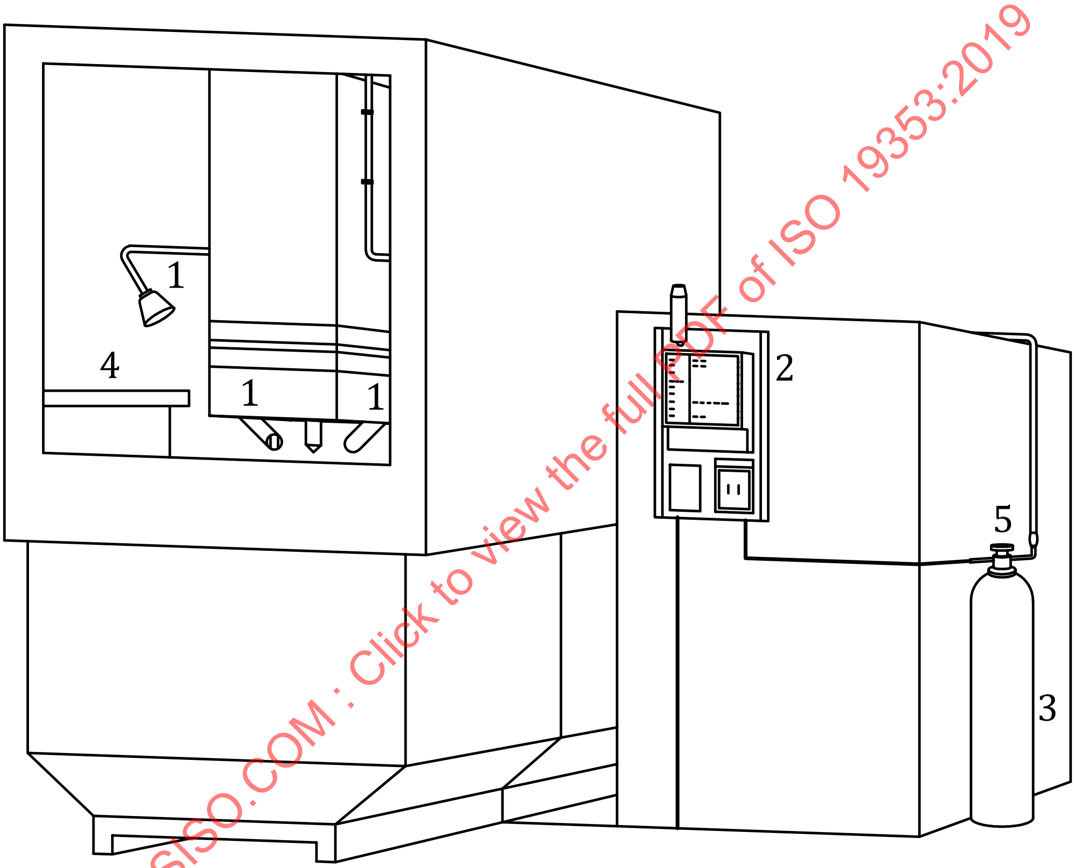
Table B.7 *(continued)*

Question	Mill	Turning machine	Paint booth (wet)
Does the fire protection system have to be operational in the event of a power failure? **If yes for how long time?**	Yes, for one hour as a minimum	Yes, for one hour as a minimum	Yes, for one hour as a minimum

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)

Examples of ignition sources

D.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).

D.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.

D.3 Mechanical energy

This category of ignition sources includes, for example:

— friction (e.g. overheating);

— ultrasonic;

— impact;

— grinding; and

— compression (including adiabatic compression).

D.4 Chemical energy

This category of ignition sources includes, for example:

— self-heating;

— self-ignition such as pyrophoric materials; and

— runaway exothermic reaction.

Annex E
(informative)

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

E.1 General

This example is provided to show how this document 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 document. It is not intended to specify specific solutions.

E.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.

E.3 Risk assessment and risk reduction

E.3.1 General

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

