TECHNICAL SPECIFICATION

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Lifts (elevators), escalators and passenger conveyors — Risk analysis methodology

Ascenseurs, escaliers mécaniques et trottoirs roulants — Méthodologie de l'analyse du risque

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Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed every three years with a view to deciding whether it can be transformed into an International Standard.

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

ISO/TS 14798 was prepared by Technical Committee ISO/TC 178, *Lifts (elevators), escalators and passenger conveyors*.

This document is being issued in the Technical Specification series of publications as a “prospective standard for provisional application” in the field of risk analysis for lifts (elevators), escalators and passenger conveyors because there is an urgent need for guidance on how safety requirements contained in standards for lifts, escalators and passenger conveyors should be evaluated.

This document is not to be regarded as an “International Standard”. It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO/TC 178 Secretariat.

A review of this Technical Specification will be carried out no later than three years after its publication with the options of extension for another three years, conversion into an International Standard or withdrawal.

Annexes A, B, C and D form a normative part of this Technical Specification. Annex E is for information only.

Introduction

This Technical Specification has been prepared in response to ISO/TC 178 Resolution 104/1994, in which the Technical Committee requested that WG 4 undertake a method of analysis to review the fundamentals of safety requirements, based upon ISO/IEC Guide 51. Furthermore, in its Resolution 131/1996, the Technical Committee requested WG 4 to “develop and formulate a report on risk analysis methodology as applicable to lifts and similar devices”.

Adherence to this Technical Specification will provide an orderly means to identify hazards, assess the risks, and recommend appropriate risk reduction measures.

Any amendments and additions to this Technical Specification will be handled by ISO/TC 178/WG 4 through the use of a database maintained by the Working Group.

Lifts (elevators), escalators and passenger conveyors — Risk analysis methodology

1 Scope

This Technical Specification establishes requirements and procedures for carrying out risk analysis for lifts (elevators), escalators and passenger conveyors.

It is intended for use by experts, trained in this methodology, to determine equipment safety and performance or to develop codes and standards.

2 Normative reference

The following normative document contains provisions which, through reference in this text, constitute provisions of this Technical Specification. For dated references, subsequent amendments to, or revisions of, this publication does not apply. However, parties to agreements based on this Technical Specification are encouraged to investigate the possibility of applying the most recent edition of the normative document indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC Guide 51:1999, *Safety aspects — Guidelines for their inclusion in standards*.

3 Terms and definitions

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

3.1
cause
trigger mechanism to the hazard, which will cause the incident or effect

3.2
frequency
probability of occurrence of an incident

3.3
harm
physical injury or damage to the health of people, or damage to property or the environment

[ISO/IEC Guide 51:1999, definition 3.3]

3.4
hazard
potential source of harm

NOTE The term hazard can be qualified in order to define its origin or the nature of the expected harm (e.g. electric shock hazard, crushing hazard, cutting hazard, toxic hazard, fire hazard, drowning hazard).

[ISO/IEC Guide 51:1999, definition 3.5]

3.5
harmful event
occurrence in which a hazardous situation results in harm

[ISO/IEC Guide 51:1999,definition 3.4]

3.6
hazardous situation
circumstance in which people, property or the environment are exposed to one or more hazards

[ISO/IEC Guide 51:1999, definition 3.6]

3.7
incident (effect)
unforeseen event or occurrence which can, but does not necessarily result in harm, i.e. death, injury, property or damage to the environment

3.8
major damage
harm that cannot be reversed without repair or replacement of a major system component

3.9
minor damage
harm that can be reversed with repair or replacement of a non-major system component

3.10
minor injury
impairment that can be reversed

3.11
minor illness
disease that can be reversed

3.12
severe injury
impairment that cannot be reversed

3.13
severe illness
disease that cannot be reversed

3.14
severity
qualitative measure of the worst possible incident (effect) that could be caused by a specific hazard

3.15
risk
combination of the probability of occurrence of harm and the severity of that harm

[ISO/IEC Guide 51:1999, definition 3.2]

3.16
residual risk
risk remaining after protective measures have been taken

[ISO/IEC Guide 51:1999, definition 3.9]

3.17
tolerable risk
risk which is accepted in a given context based on the current values of society

[ISO/IEC Guide 51:1999, definition 3.7]

3.18
risk analysis
systematic use of available information to identify hazards and to estimate the risk

[ISO/IEC Guide 51:1999, definition 3.10]

NOTE This method aims at systematically identifying and assessing hazards, evaluating risks and recommending risk reduction measures.

3.19
risk evaluation
procedure based on the risk analysis to determine whether the tolerable risk has been achieved

[ISO/IEC Guide 51:1999, definition 3.11]

3.20
risk assessment
overall process comprising a risk analysis and a risk evaluation

[ISO/IEC Guide 51:1999, definition 3.12]

3.21
risk profile
decision tool consisting of an x-y matrix used to visualize the assessed hazards

3.22
protective measure
means used to reduce risk

NOTE Protective measures include risk reduction by inherently safe design, protective devices, personal protective equipment, information for use and installation, and training.

[ISO/IEC Guide 51:1999, definition 3.8]

3.23
system
machine
combination of people, procedures, facilities and/or equipment that are integrated to perform a specific operational task or function within a specific environment

4 Risk analysis

4.1 Basic concept

Risk analysis is a series of logical steps that enable a systematic study of hazards and their corresponding causes and effects. In this Technical Specification, risk analysis is applied to lifts (elevators), escalators and passenger conveyors.

The identification of hazards, when followed by an assessment of their severity and frequence (probability of occurrence), yields a measure of the risk associated with the individual hazards. Through the use of an iterative process, each hazard and effect is evaluated and either eliminated or, if necessary, controlled by means of appropriate protective measures that reduce the corresponding risk to a tolerable level.

The step-by-step procedure shown in Figure 1 is based largely on the definitions, requirements and processes described in ISO/IEC Guide 51 and the documents listed in the bibliography.

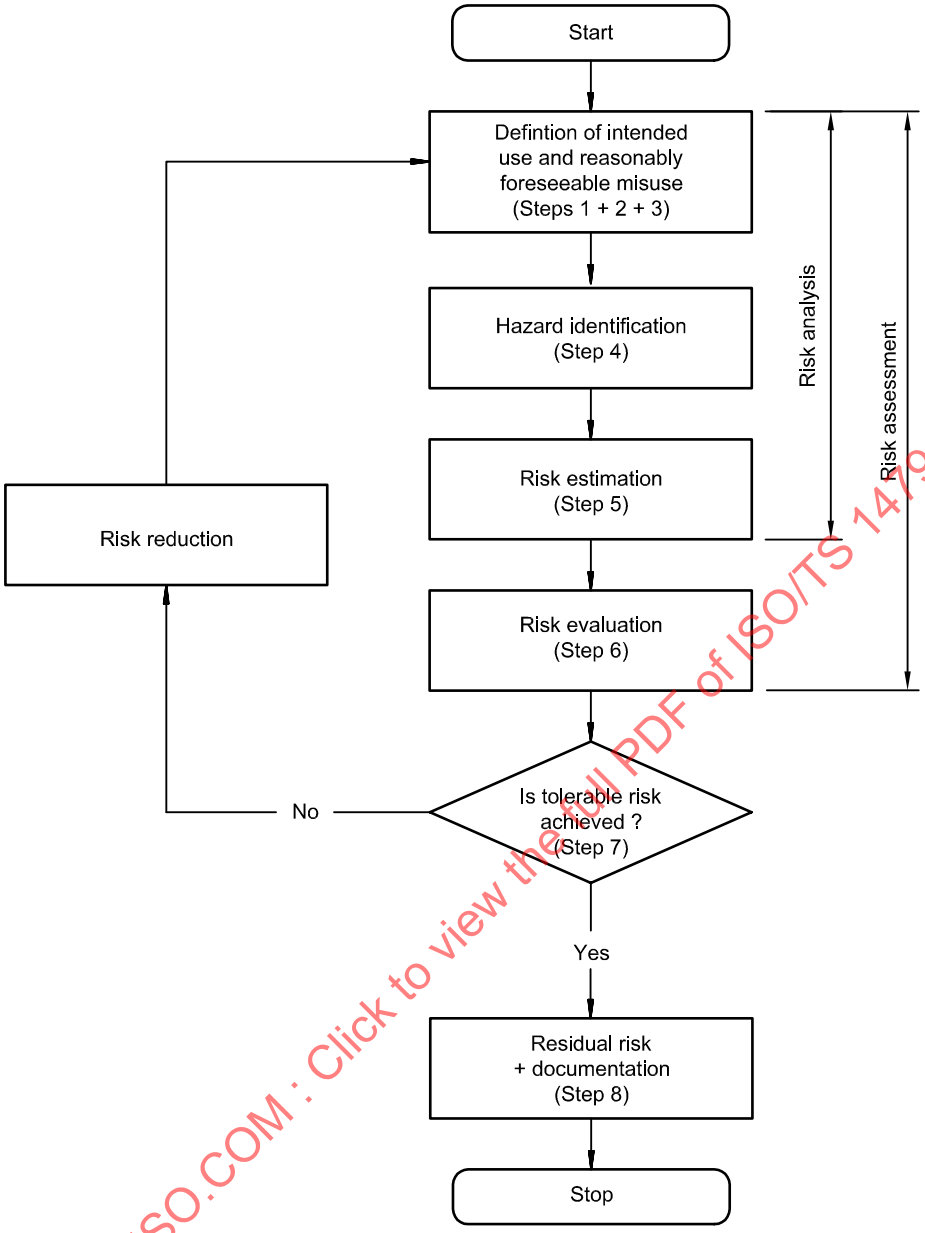


Figure 1 — Overview of risk analysis

4.2 Risk analysis process

4.2.1 Step 1: Define the reasons for risk analysis

This risk analysis process is intended to be used for the following purposes:

a) the writing of safety requirements/standards;

b) review and assessment of the efficiency of safety requirements/standards;

c) the design of safety-related components in instances where safety standards do not exist or are not applicable;

d) verification that the risk associated with some equipment and/or an installation is tolerable.

4.2.2 Step 2: Form a risk analysis team

Select the members of the analysis team and choose a team leader/moderator.

The members of the team and the team leader/moderator should, as a minimum, have a working knowledge of the product or process being analysed.

4.2.3 Step 3: Define the products, processes and applications to be analysed

The following should be considered:

a) products/processes

   1) codes and standards,

   2) electrical, hydraulic, and mechanical equipment,

   3) hardware and software,

   4) operating procedures,

   5) performance parameters, e.g. duty cycle, load limits, environment;

b) aspects

   1) design,

   2) manufacturing,

   3) transport,

   4) installation,

   5) type of use,

   6) maintenance,

   7) dismantling and disposal,

   8) modernization,

   9) training,

   10) documentation;

c) applications

   1) transport of passengers,

   2) transport of goods (freight).

4.2.4 Step 4: Identify hazards

4.2.4.1 Identify the hazardous situation by defining the hazard, cause and effect.

4.2.4.2 A systematic approach to the identification of hazardous situations (hazards, causes and effects) should yield the complete list necessary for risk analysis, assessment, and identification of risk reduction measures.

In order to assist in this process, a form for tabulating the results is contained in annex A, and a generic list of "thought-provoking key words" for potentially hazardous conditions is provided in annex B.

4.2.4.3 The general technique for identifying hazardous situations (hazards, causes and effects), intended for use by a risk analysis team, is described hereafter.

a) Peruse the list of "thought-provoking key words" (annex B) to allow the identification of every type of hazard that may arise or be present throughout the life cycle of a product, system or process.

b) Adjust the list to correspond to the specific scope of the risk analysis.

c) Enter the information on the identified hazardous situations (hazards, causes, and the associated effects of hazardous events) in the appropriate column of the "Document specimen" form (annex A).

4.2.4.4 The identification process should include the following hazards.

a) Hazards inherent to the system/process (see B.1): these are hazards that are inherent characteristics of the system or process being analysed, and include those hazards associated with use of the system/process, the power and propulsion means, the materials used, etc.

b) Hazards resulting from system or equipment malfunctions (see B.2): these are hazards that result from the failure or malfunction of safety-related systems, subsystems, components and processes. Additionally, if needed, these hazards can be checked through the use of failure modes and effects analysis, failure modes and effect criticality analysis, fault tree analysis, event tree analysis, etc.

c) Hazards resulting from outside influences (see B.3): these are hazards that typically result from the operating environment. They include the safety-related effects of temperature, fire, climatic conditions, lightning, rain, wind, snow, earthquakes, electromagnetic compatibility (EMC), conditions of the building and its use, etc.

d) Hazards resulting from operating procedures and use (see B.4): these are hazards associated with the use and misuse of the system or process. They include the safety-related aspects of the man/machine interfaces, the ergonomics and the potential for misuse.

e) Hazards resulting from the life cycle of the equipment (see B.5): these are hazards associated with the time element. They include the safety-related aspects of changes in system operation due to equipment/component ageing, component "wear", obsolescence of replacement parts, etc.

4.2.5 Step 5: Risk estimation

4.2.5.1 Assess the cause and effect of each hazard in terms of probability of occurrence of the hazard and the severity of its effect(s). The combination of severity and frequency quantifies the risk associated with the hazard. Figure 2 is a schematic representation of risk assessment.

4.2.5.2 Annex C sets out a risk assessment scale that defines the categories of hazard severity and their level of frequency.

4.2.5.3 Where a risk assessment team cannot reach consensus on the severity and frequency (probability) levels, the hazard, cause and effect should be re-examined (per step 4) for clarity and, if necessary, re-defined.

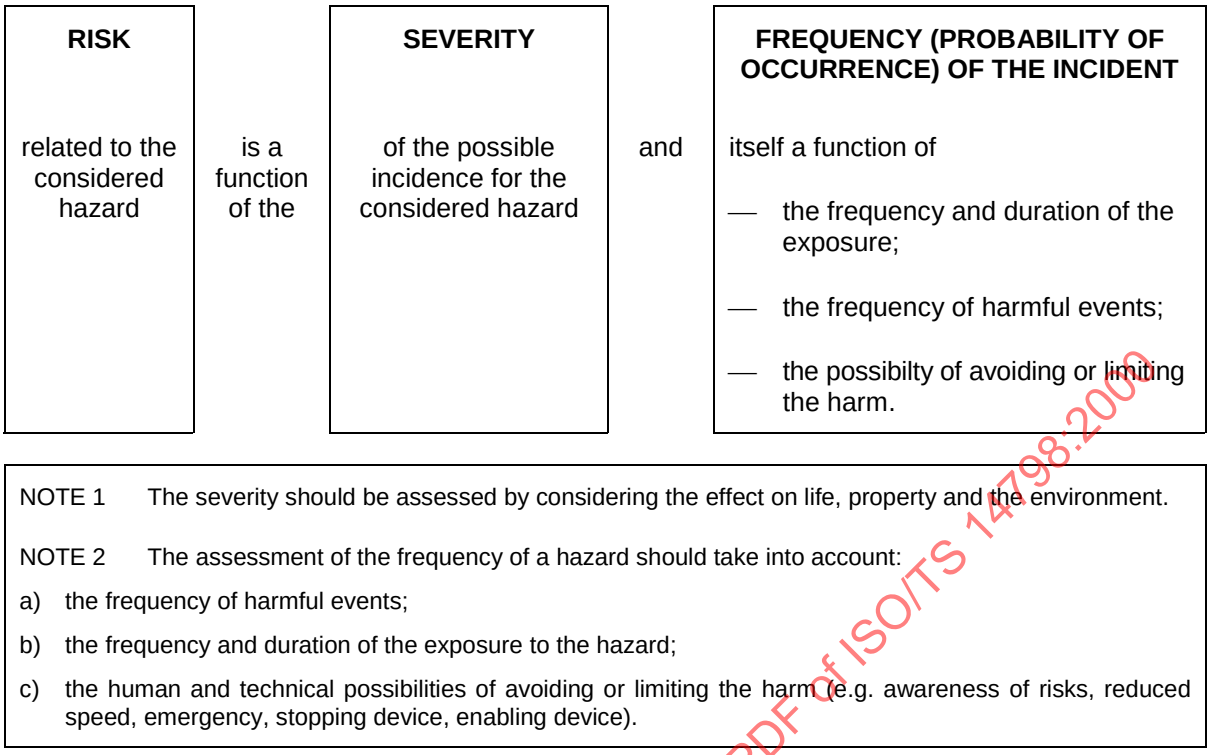


Figure 2 — Schematic representation of risk assessment

4.2.6 Step 6: Risk evaluation

Evaluate the risk assessment results in terms of residual risk and tolerable risk. Table D.1 and Figures D.1 and D.2 in annex D should be used to make this determination. If the risk is not tolerable, further risk reduction measures are required. The following procedure should be used.

a) Eliminate the hazard, if possible (by design or by substitution).

b) If the identified hazard cannot be eliminated, take the necessary measures to reduce the risk so that it becomes tolerable. These measures include redesigning equipment, altering procedures, adding protective devices guarding the equipment, etc.

c) Inform the users of the system/process of the residual risks. These measures include information, training, adding warning signs personal protection equipment, etc.

Annex E gives an example of risk analysis.

4.2.7 Step 7: Tentative assessment

If the risk evaluation still indicates that the remaining risk is not tolerable, repeat the process starting with step 4.

4.2.8 Step 8: Documentation and evaluation

Document the result of the risk analysis process (see form in annex A). The documentation package should contain, as a minimum:

a) a definition of the system/process that was analysed;

b) the hazardous situations (hazards, causes and effects), risk assessment and risk evaluation;

c) the reference data used and the sources of the data, e.g. codes and standards, historical information, drawings, design calculations, manufacturers, etc.;

d) the proposed risk reduction measures and the residual risks;

e) the risk profiles indicating the risks (see Figures D.1 and D.2)

   1) actual: assessment not considering the protective measures,

   2) tentative: assessment assuming protective measures are taken.

Annex A
(normative)

Documentation specimen

Risk analysis subject: **Moderator:** **Date:**

Case No.	Hazard (hazardous situation)	Harmful event (cause)	Incident (effect)	Assessment actual		Corrective action (risk reduction measure)	Assessment tentative		Residual risk
				S	F		S	F	

S is the severity; hazard effect category:

I: catastrophic II: critical III: marginal IV: negligible

F is the frequency; hazard cause level (actual, tentative):

A: frequent B: probable C: occasional D: remote E: improbable F: impossible

Annex B
(normative)

Basic list of “thought-provoking key words”

B.1 Hazardous characteristics

These include the following:

a) kinetics;

b) mechanical;

c) electrical;

d) chemical;

e) explosive mixtures;

f) flammability;

g) toxicity;

h) radiation;

i) pressure;

j) temperature;

k) vibration and noise;

l) contamination.

B.2 Malfunctions

These include the following:

a) structural;

b) mechanical;

c) electrical source, system, equipment;

d) software;

e) chemical;

f) biological.

B.3 Environmental influences

These include the following:

a) temperature [see l)];

b) humidity [see n)];

c) wind, weather;

d) radiation;

e) contamination [see m)];

f) mechanical [see k)];

g) electrical;

h) reactive chemicals;

i) soil;

j) human;

k) earthquakes;

l) fire;

m) smoke;

n) water.

B.4 Use and operation

These include the following:

a) unsafe conditions;

b) untimely operation;

c) outside influences;

d) unclear, faulty or incomplete instructions;

e) foreseeable misuse;

f) lack or insufficient warning/cautioning;

g) vendor/buyer performance.

B.5 Life cycle

These include the following:

a) ageing;

b) organization;

c) design;

d) procurement;

e) manufacturing/erection/commissioning;

f) testing/maintenance/modernization;

g) marketing/servicing;

h) disposal.

Annex C
(normative)

Assessment scale

C.1 The categories of severity given in Table C.1 are defined to provide a quantitative measure of the worst possible incident resulting from the hazardous situation, e.g. personal error, environmental incidents, design inadequacies, procedural deficiencies, and system, subsystem, or component failure or malfunction.

Table C.1 — Category of severity

Category of severity	Definition
I Catastrophic	Death, system loss, or severe environmental damage
II Critical	Severe injury, severe occupational illness, major system or environmental damage
III Marginal	Minor injury, minor occupational illness, minor system or environmental damage
IV Negligible	Will not result in injury, occupational illness, system or environmental damage
NOTE The definition of categories of severity needs to reflect the generic task being analysed, for example: 1) use of fire-fighting elevators; 2) use of elevators by persons with physical disabilities.	

C.2 The levels of frequency given in Table C.2 are defined to provide a quantitative measure of the probability that this hazard will be triggered by the cause and that the incident with the particular effect will occur during the planned life cycle of the system.

Table C.2 — Levels of frequency

Level of frequency	Definition
A Frequent	Likely to occur often
B Probable	Will occur several times in the life cycle of the system
C Occasional	Will occur at least once in the life cycle of the system
D Remote	Unlikely, but may possibly occur in the life cycle of the system
E Improbable	So unlikely that it can be assumed occurrence will not be experienced
F Impossible	The hazard incident cannot occur unless caused by a deliberate act

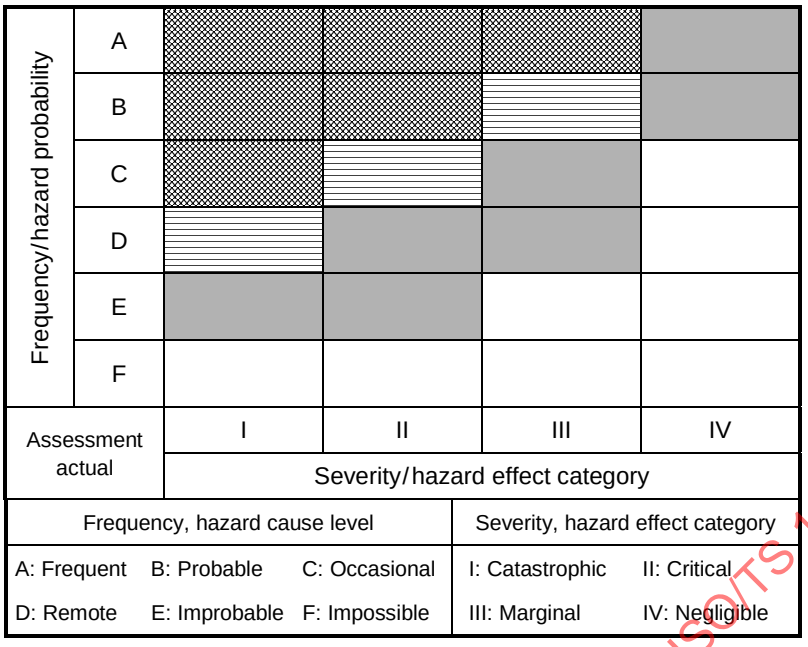
Annex D
(normative)

Risk profile

Table D.1 — Risk assessment

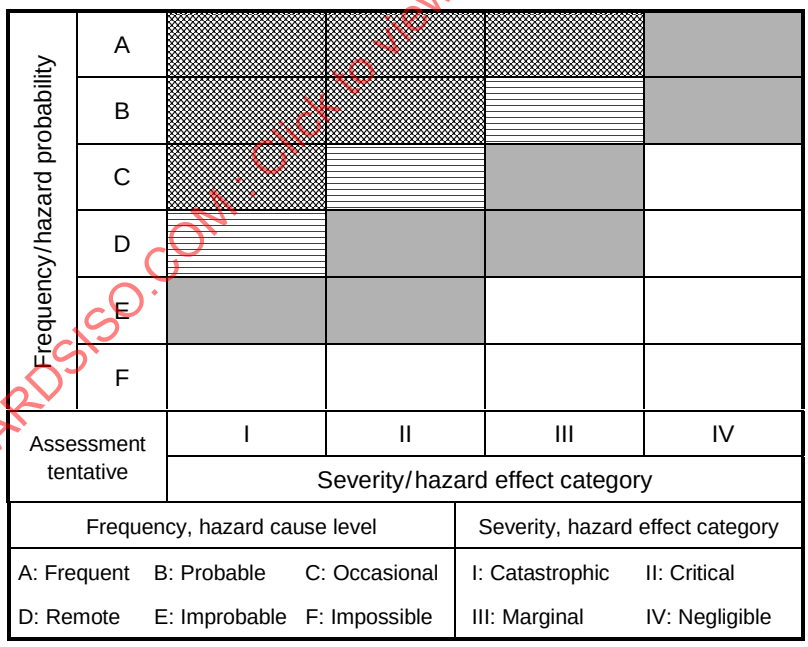
Frequency		Severity			
		I — Catastrophic	II — Critical	III — Marginal	IV — Negligible
A	Frequent	IA	IIA	IIIA	IVA
B	Probable	IB	IIB	IIIB	IVB
C	Occasional	IC	IIC	IIIC	IVC
D	Remote	ID	IID	IIID	IVD
E	Improbable	IE	IIE	IIIE	IVE
F	Impossible	IF	IIF	IIIF	IVF

	Unacceptable — IA, IB, IC, IIA, IIB, IIIA	Corrective action required to eliminate the risks
	Undesirable — ID, IIC, IIIB	Corrective action required to mitigate the risks
	Acceptable with review — IE, IID, IIE, IIIC, IIID, IVA, IVB	Review required to determine whether any action is necessary
	Acceptable without review — IF, IIF, IIIE, IIIF, IVC, IVD, IVE, IVF	No action required



NOTE This template is to be used in conjunction with risk evaluation by entering the case number into the relevant field to visualize the original level of safety (without considering corrective action). See 4.2.6 (Step 6).

Figure D.1 — Template of original risk profile



NOTE This template is to be used in conjunction with risk evaluation by entering the risk number into the relevant field to visualize the tentative level of safety (considering corrective action). See 4.2.6 (Step 6).

Figure D.2 — Template of tentative risk profile