
Guide to the development and inclusion of aspects of safety in International Standards for medical devices

*Guide pour l'élaboration des aspects de sécurité et leur incorporation
dans des Normes internationales relatives aux dispositifs médicaux*

STANDARDSISO.COM : Click to view the full PDF of ISO/IEC Guide 63:2019



STANDARDSISO.COM : Click to view the full PDF of ISO/IEC Guide 63:2019



COPYRIGHT PROTECTED DOCUMENT

© ISO/IEC 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword	v
Introduction	vii
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Use of the terms “safety”, “safe”, “effective”, and “effectiveness”	4
4.1 Safety.....	4
4.2 Safe.....	5
4.3 Effective.....	5
4.4 Effectiveness.....	5
5 Principles for including aspects of safety in medical device standards	5
5.1 Scope of medical device standards that include aspects of safety.....	5
5.2 Objective of medical device standards that include aspects of safety.....	6
5.3 Types of standards.....	6
5.3.1 Product standards.....	6
5.3.2 Process standards.....	6
5.3.3 Installation and environmental standards.....	7
5.3.4 In-service standards.....	7
5.4 Taking a practical view of safety.....	7
5.5 Coordination of medical device standards.....	7
5.6 Implications of the regulatory or legal use of standards.....	8
6 The nature of risk	8
6.1 The elements of risk.....	8
6.2 Systematic or random nature of risks.....	9
6.2.1 Types of causes of risks.....	9
6.2.2 Risks arising from systematic causes.....	10
6.2.3 Risks arising from random causes.....	10
7 Risk-based process for developing a medical device standard that includes aspects of safety	10
7.1 General.....	10
7.2 Preparatory work.....	11
7.2.1 Identifying the need for a new or revised standard including aspects of safety... 11	11
7.2.2 Establishing the risk management framework under which the standard will be developed.....	11
7.2.3 Risk acceptability criteria.....	12
7.3 Drafting.....	14
7.3.1 General.....	14
7.3.2 Iterative process of managing risk.....	14
7.3.3 Intended use and characteristics that can influence safety.....	16
7.3.4 Identification of hazards and hazardous situations.....	17
7.3.5 Risk estimation.....	18
7.3.6 Risk evaluation.....	19
7.3.7 Identification of risk controls.....	19
7.3.8 Verification of effectiveness.....	22
7.3.9 Assessment of residual risks.....	22
7.3.10 Impact of introduced risk control measures.....	22
7.3.11 All identified hazards and hazardous situations considered.....	22
7.4 Validation of the standard.....	22
7.5 Conclusion.....	22
8 Overview of the application of medical device standards including aspects of safety in a risk management framework	22

Annex A (informative) Product and process safety standards	24
Annex B (informative) Risk information	25
Bibliography	26

STANDARDSISO.COM : Click to view the full PDF of ISO/IEC Guide 63:2019

Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work.

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 and IEC 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) or the IEC list of patent declarations received (see <http://patents.iec.ch>).

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.

ISO/IEC Guide 63 was prepared by a Joint Working Group of ISO/TC 210, *Quality management and corresponding general aspects for medical devices*, and IEC/SC 62A, *Common aspects of electrical equipment used in medical practice*.

This third edition cancels and replaces the second edition (ISO/IEC Guide 63:2012), which has been technically revised.

The main changes compared with the previous edition are as follows:

- restructuring of content to more closely follow the structure of ISO/IEC Guide 51:2014;
- revision of clause numbering, including the inclusion of [Clause 2](#) on normative references, in order to respect the fixed clause structure for the first three clauses specified in the ISO/IEC Directives, Part 2;
- updating of defined terms in [Clause 3](#), with many derived from ISO/IEC Guide 51:2014, and the definitions of “manufacturer” and “medical device” now based on the GHTF guidance documents GHTF/SG1/N055:2009 and GHTF/SG1/N071:2012;
- addition of new content in [Clause 4](#) to provide guidance on the use of the terms “safety”, “safe”, “effective” and “effectiveness”;
- reorganization of existing content into [Clause 5](#) discussing the principles, [Clause 6](#) discussing the nature of risk, [Clause 7](#) focusing on the process for developing standards that include aspects of safety, and [Clause 8](#) providing an overview of the application of medical device standards;
- revision of [Figure 1](#) to better illustrate how a sequence of events can transform a hazard into a hazardous situation that can lead to harm;
- addition of [Figure 2](#) to illustrate the iterative process of risk management.

ISO/IEC GUIDE 63:2019(E)

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.

STANDARDSISO.COM : Click to view the full PDF of ISO/IEC Guide 63:2019

Introduction

This document provides practical guidance to standards writers on how to include safety aspects in the development of medical device standards, including management system standards related to medical devices. This document is based on risk management principles and ISO/IEC Guide 51:2014 to address the needs of the medical device sector.

The concept of safety, as described in this document, is closely related to protecting patients who are the subjects of medical care, as well as those persons who provide the care and other potentially affected persons. Safety is also related to harm to property or the environment.

The approach described in this document aims to reduce the risk arising during the life cycle of a medical device, including design, production, distribution, installation, use, service, maintenance, and destruction or disposal. The complete life cycle of a medical device (including both the intended use and the reasonably foreseeable misuse) is considered. The goal is to achieve acceptable risk for people, property and the environment.

As different circumstances warrant different approaches to ensuring safety, it is impossible to provide precise requirements and recommendations that apply to every case. Examples of such differences are the development of standards for manufacturers of medical devices and standards for health care providers and institutions. However, this document, when followed on a judicious “use when applicable” basis, will help in developing standards that include aspects of safety which are consistent with the generally acknowledged state of the art.

NOTE The term “standard” used throughout this document includes International Standards, Technical Specifications, Publicly Available Specifications, Technical Reports and Guides developed by ISO or IEC.

STANDARDSISO.COM : Click to view the full PDF of ISO/IEC Guide 63:2019

Guide to the development and inclusion of aspects of safety in International Standards for medical devices

1 Scope

This document provides requirements and recommendations to writers of medical device standards on the inclusion of aspects related to safety in International Standards, based on well-established risk management concepts and methodology.

This document is applicable to any aspect related to the safety of people, property, the environment, or a combination of these.

In this document, the term “product” includes a medical device or a system consisting of one or more medical devices, possibly combined with non-medical devices.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

harm

injury or damage to the health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:2014, 3.1]

3.2

hazard

potential source of *harm* (3.1)

[SOURCE: ISO/IEC Guide 51:2014, 3.2]

3.3

hazardous situation

circumstance in which people, property or the environment is/are exposed to one or more *hazards* (3.2)

[SOURCE: ISO/IEC Guide 51:2014, 3.4]

3.4

intended use

use for which a product, process or service is intended according to the specifications, instructions and information provided by the *manufacturer* (3.6)

Note 1 to entry: The intended medical indication, patient population, part of the body or type of tissue interacted with, user profile, use environment, and operating principle are typical elements of the intended use.

3.5

life cycle

series of all phases in the life of a *medical device* (3.7), from the initial conception to final decommissioning and disposal

3.6

manufacturer

natural or legal person with responsibility for design and/or manufacture of a *medical device* (3.7) with the intention of making the medical device available for use, under his name; whether or not such a medical device is designed and/or manufactured by that person himself or on his behalf by another person(s)

Note 1 to entry: This "natural or legal person" has ultimate legal responsibility for ensuring compliance with all applicable regulatory requirements for the medical device in the countries or jurisdictions where it is intended to be made available or sold, unless this responsibility is specifically imposed on another person by the Regulatory Authority within that jurisdiction.

Note 2 to entry: The manufacturer's responsibilities are described in other GHTF guidance documents. These responsibilities include meeting both pre-market requirements and post-market requirements, such as adverse event reporting and notification of corrective actions.

Note 3 to entry: "Design and/or manufacture" can include specification development, production, fabrication, assembly, processing, packaging, repackaging, labelling, relabelling, sterilization, installation, or remanufacturing of a medical device; or putting a collection of devices, and possibly other products, together for a medical purpose.

Note 4 to entry: Any person who assembles or adapts a medical device that has already been supplied by another person for an individual patient, in accordance with the instructions for use, is not the manufacturer, provided the assembly or adaptation does not change the *intended use* (3.4) of the medical device.

Note 5 to entry: Any person who changes the intended use of, or modifies, a medical device without acting on behalf of the original manufacturer and who makes it available for use under his own name, should be considered the manufacturer of the modified medical device.

Note 6 to entry: An authorized representative, distributor or importer who only adds its own address and contact details to the medical device or the packaging, without covering or changing the existing labelling, is not considered a manufacturer.

Note 7 to entry: To the extent that an accessory is subject to the regulatory requirements of a medical device, the person responsible for the design and/or manufacture of that accessory is considered to be a manufacturer.

[SOURCE: GHTF/SG1/N055:2009, 5.1, modified - The words "may include" have been replaced with "can include" in Note 3 to entry.]

3.7

medical device

instrument, apparatus, implement, machine, appliance, implant, reagent for in vitro use, software, material or other similar or related article, intended by the *manufacturer* (3.6) to be used, alone or in combination, for human beings, for one or more of the specific medical purpose(s) of

- diagnosis, prevention, monitoring, treatment or alleviation of disease,
- diagnosis, monitoring, treatment, alleviation of or compensation for an injury,
- investigation, replacement, modification, or support of the anatomy or of a physiological process,
- supporting or sustaining life,
- control of conception,
- disinfection of medical devices,
- providing information by means of in vitro examination of specimens derived from the human body,

and which does not achieve its primary intended action by pharmacological, immunological or metabolic means, in or on the human body, but which can be assisted in its intended function by such means

Note 1 to entry: Products which can be considered to be medical devices in some jurisdictions but not in others include:

- disinfection substances,
- aids for persons with disabilities,
- devices incorporating animal and/or human tissues,
- devices for in-vitro fertilization or assisted reproductive technologies.

[SOURCE: GHTF/SG1/N071:2012, 5.1, modified — The words "may be assisted" have been replaced with "can be assisted" in the definition, and the words "may be considered" have been replaced with "can be considered" in Note 1 to entry.]

3.8

reasonably foreseeable misuse

use of a product or system in a way not intended by the *manufacturer* (3.6), but which can result from readily predictable human behaviour

Note 1 to entry: Readily predictable human behaviour includes the behaviour of all types of users, e.g. lay and professional users.

Note 2 to entry: Reasonably foreseeable misuse can be intentional or unintentional.

[SOURCE: ISO/IEC Guide 51:2014, 3.7, modified — The word "supplier" has been replaced with "manufacturer", the example in Note 1 to entry has been modified, and Note 2 to entry has been replaced with a new Note to entry.]

3.9

residual risk

risk (3.10) remaining after *risk control* (3.12) measures have been implemented

[SOURCE: ISO/IEC Guide 51:2014, 3.8, modified — The words "risk reduction measures" have been replaced with "risk control measures".]

3.10

risk

combination of the probability of occurrence of *harm* (3.1) and the *severity* (3.17) of that harm

Note 1 to entry: The probability of occurrence includes the exposure to a *hazardous situation* (3.3) and the possibility to avoid or limit the harm.

[SOURCE: ISO/IEC Guide 51:2014, 3.9, modified — The words "the occurrence of a hazardous event" have been removed from Note 1 to entry.]

3.11

risk analysis

systematic use of available information to identify *hazards* (3.2) and to estimate the *risk* (3.10)

[SOURCE: ISO/IEC Guide 51:2014, 3.10]

3.12

risk control

process in which decisions are made and measures implemented by which *risks* (3.10) are reduced to, or maintained within, specified levels

3.13

risk estimation

process used to assign values to the probability of occurrence of *harm* (3.1) and the *severity* (3.17) of that harm

3.14

risk evaluation

process of comparing the estimated *risk* (3.10) against given risk criteria to determine the acceptability of the risk

3.15

risk management

systematic application of management policies, procedures and practices to the tasks of analysing, evaluating, controlling and monitoring *risk* (3.10)

3.16

safety

freedom from unacceptable *risk* (3.10)

3.17

severity

measure of the possible consequences of a *hazard* (3.2)

3.18

state of the art

developed stage of technical capability at a given time as regards products, processes and services, based on the relevant consolidated findings of science, technology and experience

Note 1 to entry: The state of the art embodies what is currently and generally accepted as good practice in technology and medicine. The state of the art does not necessarily imply the most technologically advanced solution. The state of the art described here is sometimes referred to as the "generally acknowledged state of the art".

[SOURCE: ISO/IEC Guide 2:2004, 1.4, modified — Note 1 to entry has been added.]

3.19

verification

confirmation, through the provision of objective evidence, that specified requirements have been fulfilled

Note 1 to entry: The objective evidence needed for a verification can be the result of an inspection or of other forms of determination such as performing alternative calculations or reviewing documents.

Note 2 to entry: The activities carried out for verification are sometimes called a qualification process.

Note 3 to entry: The word "verified" is used to designate the corresponding status.

[SOURCE: ISO 9000:2015, 3.8.12]

4 Use of the terms "safety", "safe", "effective", and "effectiveness"

4.1 Safety

The use of the term "safety" in medical device standards should be as a noun rather than as a descriptive adjective. As an adjective, it is likely to be misinterpreted as an assurance of freedom from risk. The recommended approach is to replace, wherever possible, the terms "safety" with an indication of the objective.

EXAMPLE "Protective helmet" instead of "safety helmet"; "protective impedance device" instead of "safety impedance".

4.2 Safe

The term “safe” in medical device standards should be used to indicate the state where the risks from recognized hazardous situations have been reduced to an acceptable level.

The term “safe” should only be used with the term “effective” to describe the situation where a balance has been achieved between the state where the risks from recognized hazardous situations have been reduced to an acceptable level and the product is achieving the intended use. Other uses of safe should be replaced, whenever possible, with an indication of the objective.

EXAMPLE “Slip resistant floor-covering” instead of “safe floor-covering”.

4.3 Effective

The term “effective” in medical device standards should be used to characterize a medical device that fulfils its intended use.

4.4 Effectiveness

The term “effectiveness” can be used in medical device standards to express a variety of related concepts depending upon the context of where it is used. Standards writers need to carefully establish the meaning within the context of their standard, if it differs from the context established in this document, and then use it consistently. In this document, the term is used in the context of verification of risk control measures.

EXAMPLE In IEC 62366-1:2015, 3.4, “effectiveness” is defined as “accuracy and completeness with which users achieve specified goals”. In IEC 80001-1:2010, 2.6, “effectiveness” defined as “ability to produce the intended result for the patient and the responsible organization”.

5 Principles for including aspects of safety in medical device standards

5.1 Scope of medical device standards that include aspects of safety

The planning and development of medical device standards that include aspects of safety requires a global approach that includes manufacturers, users, regulatory authorities and other stakeholders. This document is intended to assist committees responsible for different medical device standards to create a coherent approach to the treatment of safety in the preparation of those standards. Defining the scope of these standards will ensure that each standard is restricted to specific aspects and that each standard makes reference to standards of wider application for all other relevant aspects. A useful hierarchy is built on:

- **basic standards**, including fundamental concepts, principles and requirements with regard to general aspects of safety applicable to all kinds or a wide range of products, processes and services (basic standards are sometimes referred to as horizontal standards);
- **group standards**, including aspects of safety applicable to several products, processes or services dealt with by two or more technical committees or subcommittees, making reference, as far as possible, to basic standards;
- **(a family of) specific product and/or process standards**, including all necessary aspects of safety applicable to a specific, or a family of, product(s), process(es), or service(s) within the scope of a single technical committee or subcommittee, making reference, as far as possible, to basic standards and group standards (family product and process standards are sometimes referred to as vertical standards);
- **other standards containing aspects of safety**, but which do not deal exclusively with aspects of safety, making reference as far as possible to basic standards, group standards, and family product and process standards.

This hierarchy is based on ISO/IEC Guide 51:2014, 7.1.

Requirements dealing with aspects of safety for medical devices can be incorporated in different types of standards (see [5.3](#)) that can be found at any appropriate level in the hierarchy described above.

5.2 Objective of medical device standards that include aspects of safety

The goal of medical device standards including aspects related to safety is to support the development and production of medical devices with a predictable, consistent level of safety.

To achieve this goal, these standards should:

- a) assist manufacturers in the design and production of safe and effective medical devices;
NOTE See [4.2](#) and [4.3](#) for guidance on the use of the terms "safe" and "effective".
- b) assist manufacturers, certification bodies, testing laboratories or test houses, and regulatory authorities in assessing compliance with legal and market requirements;
- c) assist health care providers and users in managing risks associated with the use of medical devices.

To produce medical device standards that include aspects of safety that are well suited to assisting the stakeholders listed above, standards writers should employ the risk-based framework in this document.

When writing medical device standards that include aspects of safety, standards writers should carefully adhere to the definitions in [Clause 3](#) in order to support this goal and to help ensure that the standards can be correctly applied.

5.3 Types of standards

5.3.1 Product standards

These can be:

- a) standards that state safety or performance parameters and include reference test methods that can be used to demonstrate conformance to those parameters; or
- b) standards that require provision of information for safety or test method standards where adherence to declared pass/fail criteria are necessary for safety and performance.

See [Clause A.1](#) for a discussion of how product standards can contribute to safe and effective medical devices.

5.3.2 Process standards

These can be:

- a) management system standards, such as those addressing quality or risk management, that establish a framework within which the manufacturer can design, develop and produce medical devices that consistently meet specifications; or
- b) process standards that establish a framework within which the manufacturer can design, develop and produce consistently safe and effective medical devices, (e.g. sterilization, biological evaluation, clinical investigation).

See [Clause A.2](#) for a discussion of how process standards can contribute to safe and effective medical devices.

Some types of standards cannot be easily allocated to one of these categories since they combine properties of product standards and process standards. Examples are described in [5.3.3](#) and [5.3.4](#).

5.3.3 Installation and environmental standards

These standards are generally appropriate for complex, integrated systems, active medical devices and medical devices operating in an information technology (IT) environment. These can be:

- a) construction and installation standards (e.g. X-ray shielding, electrical wiring);
- b) system standards that address the proper precautions and procedures for interconnection of multiple devices into a single system;
- c) commissioning standards that address the proper testing and inspection procedures to apply to permanently installed equipment and systems prior to initial use;
- d) environmental standards that address precautions and testing to ensure that a medical device does not negatively affect its environment and that the environment does not degrade or otherwise impair the performance of a medical device (e.g. electromagnetic compatibility standards); or
- e) IT security or cybersecurity standards.

5.3.4 In-service standards

These can be

- a) routine in-service testing standards to ensure that the safety and effectiveness of medical devices is maintained over the useful life of the equipment; or
- b) quality assurance and calibration standards to ensure the continued proper function and accuracy of medical devices where relevant to safety.

5.4 Taking a practical view of safety

Risk needs to be balanced against other demands on the product, process or service. These other demands include benefit, suitability and availability. Standards writers should remember that the level of required effort from the manufacturer (e.g. for required documentation or testing) should be scaled to the level of risk.

Because zero risk is unattainable, safety is defined as freedom from unacceptable risk. A practical approach is to establish a level of acceptable risk that takes into account available information, such as the generally acknowledged state of the art and known stakeholder concerns, and that results in a high level of safety and protection of health.

In assessing the safety of medical devices, it is also necessary to consider that certain medical devices, because of their means of operation, composition or the circumstances of their use, carry with them an inherent risk that cannot be eliminated without degrading their effectiveness (e.g. surgical lasers, electrosurgery, X-ray imaging and radiotherapy devices).

Differences exist in medical and health practices in different parts of the world including judgments about the safety of medical devices. Furthermore, what is considered safe evolves over time as technologies and social values change. These issues can often be addressed by identifying the specific conditions under which a technical requirement applies.

5.5 Coordination of medical device standards

The development of each new medical device standard needs to be viewed in the context of existing medical devices and standards, as well as national, regional and international laws. New standards should make use of the body of existing standards, whenever relevant, either by reference or by reproduction of text where this is justified by convenience or clarity.

5.6 Implications of the regulatory or legal use of standards

Standards writers should be aware of the possible legal and regulatory implications of the standard they develop.

Safe and effective medical devices, whose sale and use is regulated in many countries, are of particular concern to regulatory authorities in those countries. However, International Standards should not be written to address only a specific regulation.

Standards can be cited in regulations and legislation, in which case the standards themselves become legally binding. Alternatively, there are regulatory schemes where a medical device that complies with a specified standard is “deemed to comply” with the regulations.

Standards writers need to be aware that the application of standards can also be modified by regulatory authorities.

Standards can also be cited in litigation as what should reasonably be expected by society, and thus used to establish compliance with these expectations.

Experience shows that non-normative information, like an informative annex or notes with rationales and examples can be misinterpreted as normative. The inclusion of informative annexes other than explanatory rationales should be carefully considered and be worded accordingly.

6 The nature of risk

6.1 The elements of risk

The risk associated with a particular hazardous situation is a combination of the following elements (see [Figure 1](#)):

- a) the probability of occurrence of harm, which can be considered to be composed of:
 - the probability P_1 that a specific sequence or combination of events leads to the hazardous situation (i.e. exposure to the hazard);
 - the probability P_2 that the hazardous situation leads to a harm;
- b) the severity of harm that can result from the hazardous situation.

Depending on the complexity of the medical device, the intended use, or the frequency or duration of exposure, the probability of occurrence of harm can be expressed as a combination of separate probabilities (P_1 , P_2), or expressed as a single probability (P). [Figure 1](#) illustrates how these elements are related to each other. A decomposition into P_1 and P_2 is not mandatory.

The risk can then be assessed by combining the independent estimates of the severity and probability of occurrence of harm.

If the probability of occurrence of harm cannot be estimated, it is usually necessary to evaluate the risk on the basis of the severity of the harm alone. The greater the consequence and the less effective the risk control measures, the higher the required rigour of the relevant risk control.

In situations where either P_1 or P_2 can be estimated and the other probability cannot, a conservative approach can be followed by setting the unknown probability equal to 1. The risk can then be assessed based on the severity and the conservative estimate of the probability of occurrence of harm.

NOTE Annex B provides guidance on the use of sources and methods for obtaining risk information.

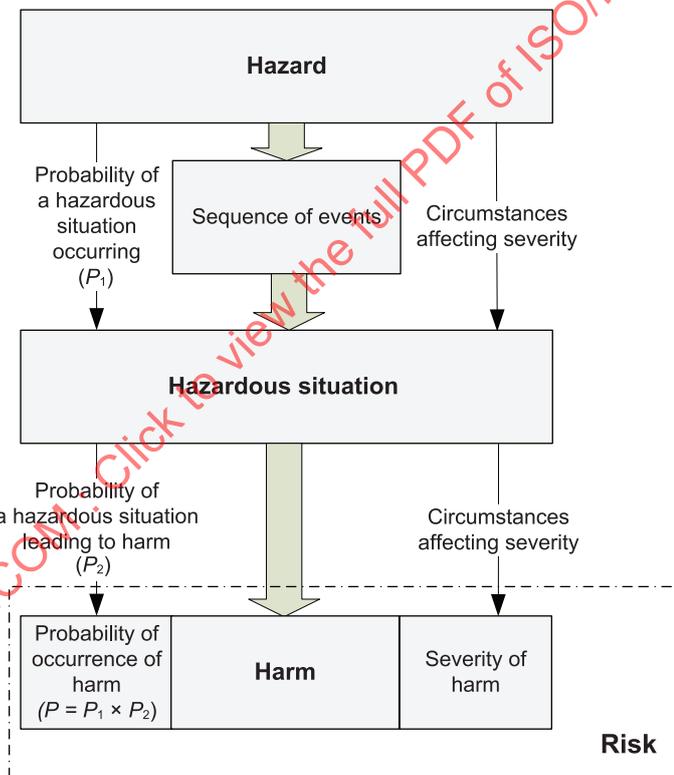
6.2 Systematic or random nature of risks

6.2.1 Types of causes of risks

Risk can arise from either systematic or random causes. Consequently, the probability of occurrence of harm can be related to either a systematic or a random cause.

For example, a toxic substance can be on a product resulting from a systematic flaw in the production process (e.g. insufficient washing steps, insufficient aeration after sterilization). On the other hand, random variations in a raw material or random processing variations can also lead to the presence of toxic substances. Confidence in risk estimates is enhanced when a quantitative estimate of the probability of occurrence of harm can be made on the basis of accurate and reliable data or when a reasonable qualitative estimate is possible. However, this is not always achievable. When the accuracy of the estimation of the probability of occurrence of harm is in doubt, it is often necessary to establish a broad range for the probability of occurrence of harm, or to determine that it is no worse than some particular value.

Standards writers need to consider the difference between systematic and random causes for the standard they are writing.



NOTE 1 Depending on the complexity of the medical device, a hazard can lead to multiple hazardous situations, and each hazardous situation can lead to multiple harms.

NOTE 2 The probability of occurrence of harm (P) can be composed of separate P_1 and P_2 values.

NOTE 3 The thin arrows represent elements of risk analysis and the thick arrows depict how a hazard can lead to harm.

Figure 1 — Illustration of the relationship between hazard, sequence of events, hazardous situation and harm

6.2.2 Risks arising from systematic causes

An error in any activity can lead to a systematic cause, which will give rise to a failure when a particular combination of inputs or conditions arises. These errors can occur any time during a product's life cycle. The probability that a systematic cause will occur can be difficult to estimate.

Examples include the following:

- a) software caused failures;
- b) inadequate design or flaws in the instructions for use;
- c) novel medical applications.

In cases where a hazardous situation occurs due to a systematic cause, the probability of a systematic cause occurring is not the same as the probability of the occurrence of harm. A cause does not always result in a hazardous situation, and a hazardous situation does not always result in harm.

Examples of risk control measures applicable for risks arising from systematic causes can include the following:

- rigour of applied processes in design, development and manufacturing: it is usually assumed that the more rigorous the processes used in the design and development or manufacturing, the lower the probability of systematic faults being introduced or remaining undetected;
- applying redundancy of risk control measures: more than one independent risk control measure usually increases confidence in the overall protection from a specific risk;
- reducing the time window within which two or more independent events contributing to a hazardous situation and subsequent harm need to happen: detailed actions can range from periodic self-checks to periodic maintenance;
- applying processes and mechanisms for the continuous monitoring of critical parameters, and subsequent evaluation and corrective action.

6.2.3 Risks arising from random causes

For many events, a numerical value can be given for the probability that the failure will occur. A quantitative estimate can only be applied if sufficient information is known about the hazard and the circumstances affecting the probability of a hazardous situation occurring (exposure to hazard) (P_1 in [Figure 1](#)) and the probability of a hazardous situation leading to harm (P_2 in [Figure 1](#)).

The following are some examples of random failures:

- power surge resulting in a failure of a part such as an integrated circuit in an electronic assembly;
- contamination of an IVD reagent resulting in its deterioration;
- presence of an infectious agent in or on a medical device leading to a biological reaction;
- presence of a toxic substance in or on a medical device leading to an allergic reaction.

7 Risk-based process for developing a medical device standard that includes aspects of safety

7.1 General

When writing medical device standards that include aspects of safety, standards writers should use a risk-based framework including risk management planning, which includes determination of risk acceptability criteria, risk analysis, a risk evaluation, risk control, and evaluation of overall residual risk acceptability. The information in this clause can be applied to both product and process standards.

The subclauses below outline the procedural steps to follow and describes a risk management framework to be used when developing the standard.

7.2 Preparatory work

7.2.1 Identifying the need for a new or revised standard including aspects of safety

Before beginning a project to prepare or revise a standard including aspects of safety, those proposing the project should identify what needs to be addressed in the standard and for whom it is intended. This is usually achieved by answering the following questions.

- a) To which medical device(s) or related medical device process will the standard apply?
- b) Are there already existing standards?
- c) Who is the target audience for the standard?
 - Who will apply the standard and how?
 - Who and/or what will be affected by the standard including a possible environmental impact?
 - What do those applying and/or affected by the standard require from it?
 - Which stakeholders need to be engaged during development of the standard?
- d) What type of standard is it to become:
 - a basic standard;
 - a group standard;
 - a specific product or process standard?
- e) What is the purpose of the standard?
 - Identify characteristics that can influence the safety that will be addressed?
 - Will the standard be used for testing?
 - Will the standard serve as a basis for conformity assessment?
 - Will the standard be used to assess the conformity of products commercialized prior to publication of the standard (i.e. legacy products)?

This information can be included in a New Work Item Proposal to the responsible Technical Committee.

7.2.2 Establishing the risk management framework under which the standard will be developed

The risk management work on a standard starts with the identification of the aspects of safety to be covered. At this stage, it is essential to gather all relevant information (e.g. accident data, research reports). A detailed outline should then be prepared which will serve as a basis for the standard. Expertise that reflects the knowledge required to develop the standard needs to be assembled within the committee. Such knowledge includes, for example, the following:

- detailed working knowledge of the product or process;
- requirements and guidelines from various origins, both general and specific to the standard to be developed;
- human behaviour studies and anthropometric data;
- injury/incident data of defects, and the recall history of the product;

- knowledge of the potential health and environmental effects of the product;
- feedback based on experience of end users of the product;
- knowledge of the potential risk control measures (protective measures);
- knowledge of the implications of possible future developments of the product;
- industry standards and guidelines;
- available expertise and scientific advice from relevant stakeholders;
- regulatory and legal requirements.

Once the principle content of the standard has been established, the following safety aspects should be considered (not all of these are necessarily relevant to a given standard):

- intended use and reasonably foreseeable misuse;
- ability of a product to perform under expected conditions of use;
- environmental compatibility (e.g. considering electromagnetic, mechanical and climatic phenomena);
- ergonomic and usability factors;
- existing relevant standards;
- availability and/or reliability of known risk control measures;
- serviceability (including “service maintenance”, such as ease of access to serviceable items and the method of refuelling/lubrication);
- maintenance and care;
- durability and dependability of known risk control measures;
- disposability (including any relevant instructions);
- special needs of end users of the product (e.g. obvious as opposed to unseen);
- failure characteristics;
- markings, information and labelling;
- assembly instructions;
- information for safety.

7.2.3 Risk acceptability criteria

7.2.3.1 Establishing risk criteria

It is important for standards writers to establish risk criteria suitable for use in evaluating the appropriateness of the requirements in the standard.

Standards writers should first define criteria to be used to evaluate the significance of risk. The criteria should reflect the technological capabilities and health care delivery values, objectives and resources. Some criteria can be imposed by, or derived from, legal and regulatory requirements and other requirements which apply to the technology under consideration. Different risk acceptability criteria can be defined for patients, care givers and other persons.

When establishing risk criteria, factors to be considered should include the following:

- the nature and types of causes and consequences that can occur with the technology and how they will be measured;
- how probabilities will be defined;
- the timeframe(s) of the probability and/or harm/consequence(s);
- how the level of risk is to be determined;
- how the views of stakeholders are to be determined.

7.2.3.2 Determining acceptable risk

Using the risk criteria, standards writers determine what level of risk can be considered acceptable. Methods of determining acceptable risk include, but are not limited to, the following:

- use of applicable basic and group standards representing the generally acknowledged state of the art, and including requirements for the demonstration of acceptable risk balanced towards clinical risk to benefit ratio;
- comparing levels of risk evident from medical devices already in use, being considered generally acknowledged state of the art;
- use of expert opinion;
- use of scientific research results, including clinical data;
- stakeholder concerns and societal expectations;
- applicable national or regional regulations.

7.2.3.3 State of the art

In establishing the risk criteria, standards writers should consider the generally acknowledged state of the art, which embodies what is currently and generally accepted as good practice in technology and medicine. The state of the art does not necessarily imply the most technologically advanced solution.

7.2.3.4 Stakeholder concerns

It is well established that the perception of risk often differs from empirically determined risk estimates. Thus, the perception of risk from a wide cross-section of stakeholders should be taken into account when deciding what risk is acceptable. To meet the expectations of public opinion, it can be necessary to give additional weight to some risks. In some cases, the only option can be to consider that identified stakeholder concerns reflect the values of society and that these concerns have been taken into account.

7.2.3.5 Societal expectations

The perception of risk can differ from society to society, and this should be taken into account. Nevertheless, it would be assumed for a medical device standard which incorporates aspects of safety, that differing societal expectations are included once the standard is accepted by the approval process.

7.2.3.6 Risk determination and acceptability when the probability cannot be estimated

For situations for which either the probability of a sequence of events leading to a hazardous situation (P_1) or the probability of a hazardous situation resulting in harm (P_2 as defined in 6.1) cannot be estimated, a conservative estimate of the probability of occurrence of harm can be made by setting the unknown probability equal to 1. When the probability of occurrence of harm cannot be estimated at all,

the possible consequences should be considered to determine the risk and to evaluate the acceptability of the risk.

7.3 Drafting

7.3.1 General

The rules and recommendations given below complement the ISO/IEC Directives, Part 2, and apply to the drafting of documents intended to become standards that include aspects related to safety.

Writers of medical device standards that include aspects related to safety should be familiar with hazards and hazardous situations associated with the product or process that is the subject of the standard. For a product standard, they should consider including a list of the known hazards and/or hazardous situations common for the particular medical device or system (e.g. in the form of an annex). For process standards, they should include a rationale explaining how the application of the standard will reduce risk.

The standard should contain, whenever possible, those requirements important in eliminating hazards or in otherwise reducing risks. These requirements should be expressed in terms of risk control measures (e.g. protective measures), which should be verifiable as specified in the standard.

Requirements for risk control measures should be:

- a) laid down in precise and clearly understandable language;
- b) technically correct;
- c) verifiable.

Standards should contain clear and complete statements specifying methods for verifying that the requirements have been met.

Where performance-based risk control measures are prescribed by the standard, the requirements should include:

- a list of the risks to be controlled;
- clear performance requirements for each risk control measure;
- detailed verification methods for determining compliance with the performance requirements.

NOTE 1 It is advisable to express risk control requirements in terms of verifiable performance with regard to safety, using performance characteristics (parameters) together with their values (e.g. a required stopping distance of x m for a mobile machine with a travelling speed of y km/h as characteristic for the required performance of the braking system), rather than merely design descriptive characteristics.

NOTE 2 It is advisable to minimize the use of subjective terms or words unless they are defined in the standard.

Standards writers should consider creating a brief history or rationale for decisions taken in the development of the standard.

7.3.2 Iterative process of managing risk

Development of the aspects of safety should be based on hazard identification. The goal of standards development is to produce standards that identify hazards and describe measures to control risks such that a level of acceptable risk is achieved.

The iterative process of risk analysis, a risk evaluation and risk control for hazardous situations is suitable in achieving acceptable risk. Standards writers need to remember that a medical device goes through the complete life cycle from development to disposal. The critical issue for the writers

of product standards or process standards is to determine whether the iterative process of risk management is assumed by:

- the standards drafting committee — to perform the risk analysis and a risk evaluation for specific and known hazards (e.g. a product-specific standard that is used to demonstrate regulatory compliance); or
- the standard readers/users (e.g. the manufacturer/supplier of the product) — to perform the risk analysis and a risk evaluation for hazards and hazardous situations that they identify.

These considerations should then be taken into account as standards writers determine the appropriate requirements to be included in the standard.

NOTE When the standard includes aspects of safety, it can only provide safety requirements for specific hazardous situations. This does not remove the obligation for the manufacturer to identify any additional hazardous situations and control the risks associated with the identified hazardous situations.

The following procedure should be followed to reduce risks to an acceptable level ([Figure 2](#)):

- a) identify the intended use and the reasonably foreseeable misuse of the product (see [7.3.3.1](#));
- b) identify the characteristics of the product or process that can influence safety (see [7.3.3.2](#));
- c) establish risk criteria and determine the level of acceptable risk (see [7.2.3](#));
- d) identify each hazard (including reasonably foreseeable hazardous situations) arising in the life cycle of the medical device, for example: conditions for the use of the product, installation, operation, maintenance, repair and destruction/disposal (see [7.3.4](#));
- e) estimate the risk to the affected user group arising from the hazard(s) and hazardous situation(s) identified using the risk criteria established in c) above (see [7.3.5](#));
- f) evaluate the risk against the level of acceptable risk established in c) above — evaluation can also be made by comparison with similar medical devices (see [7.3.6](#));
- g) if the risk is not acceptable, identify risk control measures to reduce each risk, as needed, to meet the risk acceptability criteria (see [7.3.7](#));
- h) verify the effectiveness of the selected risk control measures (see [7.3.8](#));
- i) estimate and evaluate the residual risk remaining after the risk control measure would be implemented (see [7.3.9](#));
- j) determine if new hazards or hazardous situations have been introduced or existing risks affected by the risk control measures (see [7.3.10](#));
- k) determine if all the identified hazards have been considered (see [7.3.11](#)).

[Clause 8](#) provides an overview of how medical device standards that include aspects of safety can facilitate the implementation of a risk management system that is compliant with the risk management framework.

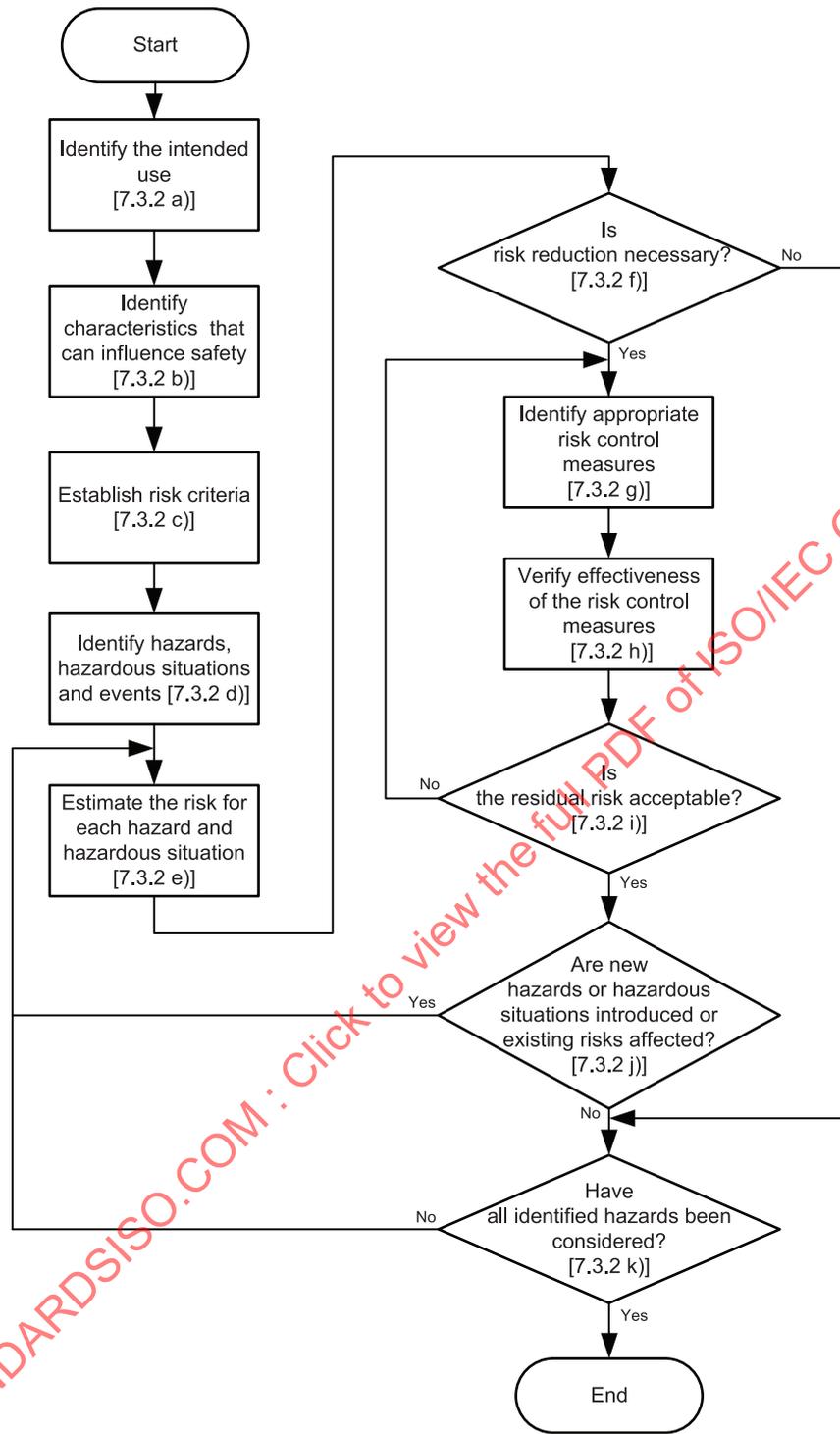


Figure 2 — Overview of the iterative process of risk management activities

7.3.3 Intended use and characteristics that can influence safety

7.3.3.1 Intended use

Determination of the application of the product or processes under consideration includes the following:

- a) intended medical indication (e.g. condition(s) or disease(s) to be screened, monitored, treated, diagnosed, or prevented);

- b) intended patient population (e.g. age, weight, health, condition);
- c) intended part of the body or type of tissue applied to or interacted with;
- d) intended user profile;
- e) intended environment conditions and methods of use.

7.3.3.2 Characteristics that can influence safety

Characteristics of the product or process can influence the safety of patients and users. These characteristics should be taken into account when considering the need for a standard. Typical characteristics include the following:

- production processes and service procedures (e.g. assembly, calibration);
- design process control (e.g. software development);
- sterility;
- biocompatibility;
- pyrogenicity;
- reliability;
- usability;
- functionality;
- sensitivity and specificity;
- environmental impacts;
- electrical safety;
- mechanical strength;
- radiation safety;
- stability;
- homogeneity;
- data integrity and security.

In order to systematically identify hazards and hazardous situations, it is important to define the product or process under consideration in sufficient detail to establish where safety issues can arise. However, standards writers should understand that they can only identify the hazards and hazardous situations in general, and they should not attempt to include every hazardous situation encountered by every manufacturer.

7.3.4 Identification of hazards and hazardous situations

7.3.4.1 Hazard identification

Hazard identification related to the intended use and reasonably foreseeable misuse usually includes the identification of known and foreseeable hazards associated with the product in both normal and fault conditions.

NOTE Events related to fault conditions can include medical device life cycle processes including, but not limited to, those related to the design, manufacturing, installation, servicing or decommissioning of a product.

7.3.4.2 Types of hazards and hazardous situations

Once the hazards have been identified, then the sequences or combinations of events that can result in hazardous situations that can lead to harm are to be considered. According to the definitions, a hazard cannot result in harm until such time as a sequence of events or other circumstances (including normal use) results in exposure to the hazards. i.e. leads to a hazardous situation (P_1 in [Figure 1](#)). Even the presence of a hazardous situation does not necessarily result in harm (P_2 in [Figure 1](#)).

7.3.4.3 Medical device-related hazards and hazardous situations

To a great extent, the possible medical device-related hazards depend on the nature of the product. Since it is not possible to ensure that a product will not fail, the standard should recognize the hazards of the medical devices as they pertain to the condition, health and the safety of the patient and the health and safety of the user and other persons. When identifying hazards and hazardous situations, standards writers should consider factors contributing to hazardous situations primarily related to:

- a) the design, construction or chemical stability of the medical device;
- b) the patient's condition and the patient environment;
- c) the application of the medical device by the user;
- d) the use, service or repair of the medical device where persons can be exposed to hazards such as infectious substances, hazardous chemicals or radiation.

[Table 1](#) illustrates the relationship between hazards, sequences of events, hazardous situations and harm for some simplified examples.

7.3.5 Risk estimation

For identified hazardous situation(s), the associated risk(s) need to be estimated using available information or data. In principle, there is no preference for quantitative versus qualitative estimation of the probability of occurrence of harm. Quantitative probability estimates of occurrence of harm can be limited to those factors which can be backed by valid statistical data. The probability of occurrence of harm related to systematic causes can be difficult to estimate (see [6.2.2](#)).

For hazardous situations for which the probability of the occurrence of harm cannot be estimated, the possible consequences should be considered.

This document does not suggest that standards writers use a particular tool or method for estimating risk related to a hazardous situation to be addressed by the standard.

Risk estimation performed by standards writers should consider available data representing the generally acknowledged state of the art to obtain a reliable set of requirements. Reference to the source and the rationale for using these data should be included in the standard.

Table 1 — Relationship between hazards, foreseeable sequences of events, hazardous situations and the harm that can occur

Hazard	Foreseeable sequence of events	Hazardous situation	Harm
Electromagnetic energy (high voltage)	(1) Electrode cable unintentionally plugged in power line receptacle	Line voltage appears on electrodes	Serious burns Heart fibrillation
Chemical (volatile solvent, embolus)	(1) Incomplete removal of volatile solvent used in manufacturing (2) Solvent residue converts to gas at body temperature	Development of gas embolism (bubbles in the blood stream) during dialysis	Infarct Brain damage

Table 1 (continued)

Hazard	Foreseeable sequence of events	Hazardous situation	Harm
Biological (microbial contamination)	(1) Inadequate instructions provided for decontaminating re-used anaesthesia tubing (2) Contaminated tubing used during anaesthesia	Bacteria released into airway of patient during anaesthesia	Bacterial infection
Functionality (no delivery)	(1) Electrostatically charged patient touches infusion pump (2) Electrostatic discharge (ESD) causes pump and pump alarms to fail	Failure to deliver insulin patient with elevated blood glucose level, no warning given	Minor organ damage Decreased consciousness
Functionality (no output)	(1) Implantable defibrillator battery reaches the end of its useful life (2) Inappropriately long interval between clinical follow-up visits	Defibrillator cannot deliver shock when an arrhythmia occurs	Death
Measurement (incorrect information)	(1) Measurement error (2) No detection by user	Incorrect information reported to clinician, leading to misdiagnosis and/or lack of proper therapy	Progression of disease Serious injury

7.3.6 Risk evaluation

Using the risk acceptability criteria established in 7.2.3, standards writers decide which of the risks under consideration are to be controlled through requirements in the standard.

7.3.7 Identification of risk controls

7.3.7.1 Selection of risk control measures

The risk control measures selected can include both product design features and process controls. The selection is dependent upon the product and/or process that is analysed, the resulting risks that are identified, and the effectiveness and feasibility of the available risk control measures. The scope of the standard should reflect this. The selected risk control measures need to be both appropriate and consistent with a practical view of safety (see 5.4).

7.3.7.2 Hierarchical approach to risk control

When deciding on the risk control measure(s) that are appropriate for reducing the risk(s) to an acceptable level, the following risk control options shall be applied in the priority order listed:

- a) inherent safety by design;
- b) protective measures including alarms in the medical device itself, or control of processes related to manufacturing or maintenance;
- c) information for safety.

Standards writers shall consider the practicable risk control options at each level in this hierarchy before moving to a lower level.

Inherent safety by design is the first and most important step in the risk control process. This is because design solutions inherent to the characteristics of the product are likely to remain effective, whereas experience has shown that even well-designed guards and protective measures can fail or be violated, and information for safety is not necessarily followed.

Whenever inherent safety by design measures do not reasonably make it possible either to remove hazards or to sufficiently control risks, guards and protective measures shall be considered. It can be necessary to implement complementary protective measures involving additional equipment (e.g. emergency stop equipment).

The end user has a role to play in risk control by complying with the information for safety or training provided by the manufacturer. However, information for safety or training shall not be a substitute for the correct application of inherent safety by design measures, guards or complementary protective measures.

7.3.7.3 Product or process standard requirement as an appropriate risk control

When a risk needs to be controlled, standards writers determine if a requirement(s) in a product or process standard is an appropriate risk control.

Product standards should contain, where possible, verifiable technical requirements and specifications that standards writers consider effective in reducing the risk to an acceptable level.

Risk control measures can reduce the severity of the harm or reduce the probability of occurrence of the harm, or both. When determining which control measures can be included in the standard to deal with the unacceptable risks identified in 7.3.6, the general approaches available for controlling risk should be considered first. See 7.3.7.2.

7.3.7.4 Labelling as a risk control measure within product or process standards

7.3.7.4.1 Type of information

The standard should specify all information necessary for the intended use to be provided to persons involved with the product (e.g. purchasers, installers, testing technicians, end users and service personnel).

The information in the labelling should be perceivable, understandable and support the correct use of the product in the intended use environment.

Standards writers should clearly identify whether the information presented in the labelling is information for safety or a disclosure of residual risk. Disclosure of residual risk is not considered a risk control measure.

In the case of process standards, these standards can require verification or validation activities for information for safety.

In the case of product standards, these standards should clearly indicate what safety-related information needs to be:

- displayed on the product itself and/or on its packaging;
- made clearly visible at the point of sale; or
- given in the instruction manual(s), e.g. for installation, use, maintenance and disposal: this should include information on the necessity of training or personal protective equipment.

Where working practices will significantly reduce the risks if followed by the persons involved, the information should describe appropriate working practices. Where product safety depends to a considerable degree upon appropriate working practices, and where these practices are not self-evident, a marking referring to the instruction manual(s) should be specified as a minimum.

Unnecessary information should be avoided, because it tends to decrease the value of the information for safety that is essential for the use of the product.