

INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC SAFETY PUBLICATION

PUBLICATION FONDAMENTALE DE SÉCURITÉ

Fire hazard testing –

**Part 1-11: Guidance for assessing the fire hazard of electrotechnical products –
Fire hazard assessment**

Essais relatifs aux risques du feu –

**Partie 1-11: Lignes directrices pour l'évaluation du danger du feu des produits
électrotechniques – Evaluation du danger du feu**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIRE HAZARD TESTING –

**Part 1-11: Guidance for assessing the fire
hazard of electrotechnical products –
Fire hazard assessment**

FOREWORD

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International Standard IEC 60695-1-11 has been prepared by IEC technical committee 89: Fire hazard testing.

This second edition cancels and replaces the first edition of IEC 60695-1-11 published in 2010, and constitutes a technical revision.

The main changes with respect to the previous edition are:

- a) Updated references;
- b) Updated terms and definitions; and
- c) Added Figure 5 – Description of range of products and circumstances of use; and
- d) Updated Bibliography.

The text of this standard is based on the following documents:

FDIS	Report on voting
89/1220/FDIS	89/1239/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

It has the status of a basic safety publication in accordance with IEC Guide 104 and ISO/IEC Guide 51 [10] ¹.

This standard is to be used in conjunction with IEC 60695-1-10.

A list of all the parts in the IEC 60695 series, under the general title *Fire hazard testing*, can be found on the IEC website.

Part 1 consists of the following parts:

- Part 1-10: Guidance for assessing the fire hazard of electrotechnical products – General guidelines
- Part 1-11: Guidance for assessing the fire hazard of electrotechnical products – Fire hazard assessment
- Part 1-12: Guidance for assessing the fire hazard of electrotechnical products – Fire safety engineering²
- Part 1-20: Guidance for assessing the fire hazard of electrotechnical products – Ignitability – General Guidance
- Part 1-21: Guidance for assessing the fire hazard of electrotechnical products – Ignitability – Summary and relevance of test methods
- Part 1-30: Guidance for assessing the fire hazard of electrotechnical products – Preselection testing process – General guidelines
- Part 1-40: Guidance for assessing the fire hazard of electrotechnical products – Insulating liquids

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

¹ Figures in square brackets refer to the Bibliography.

² To be published.

INTRODUCTION

In the design of any electrotechnical product the risk of fire and the potential hazards associated with fire need to be considered. In this respect the objective of component, circuit and equipment design as well as the choice of materials is to reduce to acceptable levels the potential risks of fire even in the event of foreseeable abnormal use, malfunction or failure. This standard, together with its companion, IEC 60695-1-10, provides guidance on how this is to be accomplished.

The primary aims are to prevent ignition caused by an electrically energised component part and, in the event of ignition, to confine any resulting fire within the bounds of the enclosure of the electrotechnical product.

Secondary aims include the minimisation of any flame spread beyond the product's enclosure and the minimisation of harmful effects of fire effluents including heat, smoke, and toxic or corrosive combustion products.

Fires involving electrotechnical products can also be initiated from external non-electrical sources. Considerations of this nature are dealt with in the overall fire hazard assessment.

Fire hazard assessment is used to identify the kinds of fire events (fire scenarios) which will be associated with the product, to establish how the measurable fire properties of the product are related to the outcome of those events, and to establish test methods and performance requirements for those properties which will either result in a tolerable fire outcome or eliminate the event altogether.

Annex A demonstrates a relatively simple fire hazard assessment process as applied to the toxic hazard from a burning material.

Annex B demonstrates a more complex fire hazard assessment process as applied to an electrotechnical product, rigid plastic conduit.

Attention is drawn to the principles in IEC Guide 104, and to the role of committees with horizontal safety functions and group safety functions.

FIRE HAZARD TESTING –

Part 1-11: Guidance for assessing the fire hazard of electrotechnical products – Fire hazard assessment

1 Scope

This part of IEC 60695 provides guidance for assessing the fire hazard of electrotechnical products and for the resulting development of fire hazard testing as related directly to harm to people, animals or property.

It outlines a hazard-based process to identify appropriate fire test methods and performance criteria for products. The principles of the methodology are to identify fire events (fire scenarios) which will be associated with the product, to establish how the measurable fire properties of the product are related to the possible occurrence and outcome of those events, and to establish test methods and performance requirements for those properties which will either result in a tolerable fire outcome or eliminate the event altogether.

It is intended as guidance to IEC committees, to be used with respect to their individual applications. The actual implementation of this document remains the responsibility of each product committee, according to the minimum acceptable fire safety in its application field and taking into account the feedback from experience.

This basic safety publication is intended for use by technical committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51 [10].

One of the responsibilities of a technical committee is, wherever applicable, to make use of basic safety publications in the preparation of its publications. The requirements, test methods or test conditions of this basic safety publication will not apply unless specifically referred to or included in the relevant publications.

2 Normative references

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

IEC 60695-1-10:2009, *Fire hazard testing – Part 1-10: Guidance for assessing the fire hazard of electrotechnical products – General guidelines*

IEC 60695-1-12, *Fire hazard testing – Part 1-12 Guidance for assessing the fire hazard of electrotechnical products – Fire safety engineering*³

IEC 60695-4:2012, *Fire hazard testing – Part 4: Terminology concerning fire tests for electrotechnical products*

³ To be published.

IEC Guide 104:2010, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO 13943:2008, *Fire safety – Vocabulary*

3 Terms and definitions

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

3.1

asphyxiant

toxicant that causes hypoxia, which can result in central nervous system depression or cardiovascular effects

Note 1 to entry: Loss of consciousness and ultimately death may occur.

[SOURCE: ISO 13943:2008, definition 4.17]

3.2

available safe escape time

ASET

time available for escape for an individual occupant, the calculated time interval between the time of ignition and the time at which conditions become such that the occupant is estimated to be incapacitated, i.e. unable to take effective action to escape to a safe refuge or place of safety

Note 1 to entry: The time of ignition can be known, e.g. in the case of a fire model or a fire test, or it may be assumed, e.g. it may be based upon an estimate working back from the time of detection. The basis on which the time of ignition is determined is always stated.

Note 2 to entry: This definition equates incapacitation with failure to escape. Other criteria for ASET are possible. If an alternate criterion is selected, it is necessary that it be stated.

Note 3 to entry: Each occupant can have a different value of ASET, depending on that occupant's personal characteristics.

[SOURCE: ISO 13943:2008, definition 4.20]

3.3

built environment

building or other structure

EXAMPLES off-shore platforms, civil engineering works, such as tunnels, bridges and mines; and means of transportation such as motor vehicles and marine vessels.

Note 1 to entry: ISO 6707-1 [11] contains a number of terms and definitions for concepts related to the built environment.

[SOURCE: ISO 13943:2008, definition 4.26]

3.4

combustion

exothermic reaction of a substance with an oxidizing agent

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

[SOURCE: ISO 13943:2008, definition 4.46]

3.5**combustion product**
product of combustion

solid, liquid and gaseous material resulting from combustion

Note 1 to entry: Combustion products can include fire effluent, ash, char, clinker and/or soot.

[SOURCE: ISO 13943:2008, definition 4.48]

3.6**effective heat of combustion**

heat released from a burning test specimen in a given time interval divided by the mass lost from the test specimen in the same time period

Note 1 to entry: It is the same as the net heat of combustion if all the test specimen is converted to volatile combustion products and if all the combustion products are fully oxidized.

Note 2 to entry: The typical units are $\text{kJ}\cdot\text{g}^{-1}$.

[SOURCE: ISO 13943:2008, definition 4.74]

3.7**end product**

product that is ready for use without modification

Note 1 to entry: An end product can be a component of another end product.

[SOURCE: IEC 60695-4:2012, definition 3.2.7]

3.8**environment**

conditions and surroundings that can influence the behaviour of an item or persons when exposed to fire

[SOURCE: ISO 13943:2008, definition 4.80]

3.9**escape**

effective action taken to reach a safe refuge or place of safety

[SOURCE: ISO 13943:2008, definition 4.82]

3.10**exposure dose**

measure of the maximum amount of a toxic gas or fire effluent that is available for inhalation, calculated by integration of the area under a concentration-time curve

Note 1 to entry: For fire effluent, typical units are grams times minutes per cubic metre ($\text{g}\cdot\text{min}\cdot\text{m}^{-3}$).

Note 2 to entry: For a toxic gas, typical units are microlitres times minutes per litre ($\mu\text{L}\cdot\text{min}\cdot\text{L}^{-1}$) (at $T = 298\text{ K}$ and $P = 1\text{ atm}$).

[SOURCE: ISO 13943:2008, definition 4.89]

3.11**extinction area of smoke**

product of the volume occupied by smoke and the extinction coefficient of the smoke

Note 1 to entry: It is a measure of the amount of smoke, and the typical units are square metres (m^2).

[SOURCE: ISO 13943:2008, definition 4.92]

3.12

fire

<general> process of combustion characterized by the emission of heat and fire effluent and usually accompanied by smoke, flame or glowing or a combination thereof

Note 1 to entry: In the English language the term "fire" is used to designate three concepts, two of which, fire (3.13) and fire (3.14), relate to specific types of self-supporting combustion with different meanings and two of them are designated using two different terms in both French and German.

[SOURCE: ISO 13943:2008, definition 4.96]

3.13

fire

<controlled> self-supporting combustion that has been deliberately arranged to provide useful effects and is limited in its extent in time and space

[SOURCE: ISO 13943:2008, definition 4.97]

3.14

fire

<uncontrolled> self-supporting combustion that has not been deliberately arranged to provide useful effects and is not limited in its extent in time and space

[SOURCE: ISO 13943:2008, definition 4.98]

3.15

fire effluent

totality of gases and aerosols, including suspended particles, created by combustion or pyrolysis in a fire

[SOURCE: ISO 13943:2008, definition 4.105]

3.16

fire growth

stage of fire (3.12) development during which the heat release rate and the temperature of the fire are increasing

[SOURCE: ISO 13943:2008, definition 4.111]

3.17

fire hazard

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

[SOURCE: ISO 13943:2008, definition 4.112]

3.18

fire risk

probability of a fire (3.14) combined with a quantified measure of its consequence

Note 1 to entry: It is often calculated as the product of probability and consequence.

[SOURCE: ISO 13943:2008, definition 4.124]

3.19**fire safety engineering**

application of engineering methods based on scientific principles to the development or assessment of designs in the built environment through the analysis of specific fire scenarios or through the quantification of risk for a group of fire scenarios

[SOURCE: ISO 13943:2008, definition 4.126]

3.20**fire scenario**

qualitative description of the course of a fire (3.14) with respect to time, identifying key events that characterise the studied fire and differentiate it from other possible fires

Note 1 to entry: It typically defines the ignition and fire growth processes, the fully developed fire stage, the fire decay stage, and the environment and systems that will impact on the course of the fire.

[SOURCE: ISO 13943:2008, definition 4.129]

3.21**fire test**

test that measures behaviour of a fire (3.12) or exposes an item to the effects of a fire (3.13)

Note 1 to entry: The results of a fire test can be used to quantify fire severity or determine the fire resistance or reaction to fire of the test specimen.

[SOURCE: ISO 13943:2008, definition 4.132]

3.22**flame front**

boundary of flaming combustion at the surface of a material or propagating through a gaseous mixture

[SOURCE: ISO 13943:2008, definition 4.136]

3.23**flame spread**

propagation of a flame front

[SOURCE: ISO 13943:2008, definition 4.142]

3.24**flashover**

⟨stage of fire⟩ transition to a state of total surface involvement in a fire (3.14) of combustible materials within an enclosure

[SOURCE: ISO 13943:2008, definition 4.156]

3.25**fractional effective dose*****FED***

ratio of the exposure dose for an asphyxiant to that exposure dose of the asphyxiant expected to produce a specified effect on an exposed subject of average susceptibility

Note 1 to entry: As a concept, fractional effective dose may refer to any effect, including incapacitation, lethality or other endpoints.

Note 2 to entry: When not used with reference to a specific asphyxiant, the term *FED* represents the summation of *FED* values for all asphyxiants in a combustion atmosphere.

Note 3 to entry: The *FED* is dimensionless.

[SOURCE: ISO 13943:2008, definition 4.160]

3.26

heat release

thermal energy produced by combustion

Note 1 to entry: The typical units are joules (J).

[SOURCE: ISO 13943:2008, definition 4.176]

3.27

heat release rate

burning rate (deprecated)

rate of burning (deprecated)

rate of thermal energy production generated by combustion

Note 1 to entry: The typical units are watts (W).

[SOURCE: ISO 13943:2008, definition 4.177]

3.28

ignition

sustained ignition (deprecated)

<general> initiation of combustion

[SOURCE: ISO 13943:2008, definition 4.187]

3.29

ignition

sustained ignition (deprecated)

<flaming combustion> initiation of sustained flame

[SOURCE: ISO 13943:2008, definition 4.188]

3.30

incapacitation

state of physical inability to accomplish a specific task

Note 1 to entry: An example of a specific task is to accomplish escape from a fire.

[SOURCE: ISO 13943:2008, definition 4.194]

3.31

irritant, noun

<sensory/upper respiratory> gas or aerosol that stimulates nerve receptors in the eyes, nose, mouth, throat and respiratory tract, causing varying degrees of discomfort and pain with the initiation of numerous physiological defence responses

Note 1 to entry: Physiological defence responses include reflex eye closure, tear production, coughing, and bronchoconstriction.

[SOURCE: ISO 13943:2008, definition 4.203]

3.32

mass loss rate

test specimen mass loss per unit time under specified conditions

Note 1 to entry: The typical units are grams per second ($\text{g}\cdot\text{s}^{-1}$).

[SOURCE: ISO 13943:2008, definition 4.224]

3.33

obscuration by smoke

reduction in the intensity of light due to its passage through smoke

Note 1 to entry: In practice, obscuration by smoke is usually measured as the transmittance, which is normally expressed as a percentage.

Note 2 to entry: Obscuration by smoke causes a reduction in visibility.

[SOURCE: ISO 13943:2008, definition 4.242]

3.34

qualitative fire test

fire test which is either:

- a) a pass/fail test; or
- b) a test which categorizes the behaviour of the test specimen by determining its position in a rank order of performance

3.35

quantitative fire test

fire test which takes into account the circumstances of product use in which the test conditions are based on, or are relatable to, the circumstances of use of the test specimen, and which measures a parameter or parameters, expressed in well defined terms and using rational scientific units, which can be used in the quantitative assessment of fire risk

3.36

radiant heat flux

power per unit area emitted, transferred or received in the form of heat radiation

Note 1 to entry: The typical units are kilowatts per square metre ($\text{kW}\cdot\text{m}^{-2}$).

[SOURCE: ISO 13943:2008, definition 4.269]

3.37

reaction to fire

response of a test specimen when it is exposed to fire under specified conditions in a fire test

Note 1 to entry: Fire resistance is regarded as a special case and is not normally considered as a reaction to fire property.

[SOURCE: ISO 13943:2008, definition 4.272]

3.38

smoke

visible part of fire effluent

[SOURCE: ISO 13943:2008, definition 4.293]

3.39

specific extinction area of smoke

extinction area of smoke produced by a test specimen in a given time period divided by the mass lost from the test specimen in the same time period

Note 1 to entry: The typical units are square metres per gram ($\text{m}^2\cdot\text{g}^{-1}$).

[SOURCE: ISO 13943:2008, definition 4.301]

3.40
toxic
poisonous

Note 1 to entry: A poisonous substance produces adverse effects upon a living organism, e.g. irritation, narcosis or death.

[SOURCE: ISO 13943:2008, definition 4.335]

3.41
toxic potency
measure of the amount of toxicant (3.42) required to elicit a specific toxic (3.40) effect

Note 1 to entry: A small value of toxic potency corresponds to a high toxicity (3.42) and vice versa.

[SOURCE: ISO 13943:2008, definition 4.338]

3.42
toxicant
toxin
toxic (3.40) substance

[SOURCE: ISO 13943:2008, definition 4.340]

3.43
toxicity
toxic (3.40) quality

[SOURCE: ISO 13943:2008, definition 4.341]

4 Elements of fire hazard assessment

4.1 Ignition sources

Ignition occurs as a result of an increase in temperature (see IEC 60695-1-20). Common ignition phenomena encountered in electrotechnical products are described in detail in Table 1 in IEC 60695-1-10:2009.

Fires involving electrotechnical products can also be initiated from external non-electrical sources, and an overall fire hazard assessment should include this possibility.

4.2 Fire hazard

A fire hazard is a physical object or condition with a potential for an undesirable consequence from fire (see 3.17). Fire hazards therefore encompass potential fuels and ignition sources (see 4.1).

4.3 Fire risk

Fire risk is calculated from the probability of the fire and a quantified measure of its consequences. The consequences may refer to injury or loss of life from threats such as heat, smoke, oxygen depletion, or the concentration of incapacitating fire gases. The consequences may also refer to loss of property, such as the extent of fire damage and the cost of repair and replacement. A wide range of potential fire scenarios may be analysed quantitatively to establish measures of overall fire risk

4.4 Fire hazard assessment

Fire hazard assessment involves the assessment of the possible causes of fire, the possibility and nature of subsequent fire growth, and the possible consequences of fire.

The fire hazard posed by a product, i.e. the possibility of ignition, subsequent fire growth and the possible consequences of a fire involving that product, depend upon the product's characteristics, service conditions and the environment in which it is used. This environment includes consideration of the number and capabilities of people exposed to a fire involving that product, and/or the value and vulnerability of exposed property.

The threat to life and property damage associated with a product is usually the primary result of the heat and fire effluent produced by the fire to which the product gives rise. Accordingly, consideration is given to ignition and fire growth, followed by the heat release and the opacity, toxicity and corrosivity of the fire effluent from a burning product, or from any materials that owe their fire involvement to the product. The direct effects of these fire properties, as well as their effects on people, affecting their ability to continue to function during and after the fire, are considered. In some cases, additional factors must be evaluated as well, such as the effects of excessive heat leading to the collapse of the surrounding structure or accumulation of flammable gases, vapours and/or dusts leading to the possibility of explosion.

Certain products may cover considerable portions of exposed surfaces or may penetrate fire-rated walls. Examples include products requiring large enclosures, as well as insulated cables and conduits. Such products, when exposed to an external fire, should be evaluated from the standpoint of their contribution to the fire in comparison to the same building, materials or structure in which the products are not installed.

Following a detailed review of all the fire hazards related to a defined fire scenario, the final product standards, as drafted, should include a series of tests or a single test, as appropriate, to address the specific issues that have been identified.

The fire hazard assessment process is discussed in more detail in Clause 6.

5 Fire hazard tests

A fire hazard assessment shows how the different fire performance characteristics of the product can initiate or contribute to the development of a hazardous fire situation under the foreseeable conditions of use or misuse. These fire performance characteristics should be obtained from quantitative fire tests in which the results are expressed in fundamental physical units, such as energy, mass, dimension, concentration and time, because this enables the calculation of the effect or effects of fire under consideration.

Although the results of qualitative fire tests usually cannot be correlated with real-scale fire performance, as the test conditions often cannot be related to the fire scenario of concern, nevertheless, under certain circumstances, it is appropriate to maintain such tests or even to develop new ones.

NOTE The nature and applicability of qualitative and quantitative fire tests are discussed in detail in IEC 60695-1-10.

A fire hazard assessment should provide the rationale for why a given fire test is selected and what performance requirements should be measured.

6 The fire hazard assessment process

6.1 General

Fire hazard assessment is achieved by the use of fire test data in scientifically based models of fire behaviour. The fire hazard assessment can then be used to control the hazards to life, property and the environment to which the product may give rise in a fire. This may be done by modification of the design of the product or by changing the way the product is used or installed.

This international standard makes use of many of the elements of fire safety engineering discussed in ISO documents. These are:

ISO 23932 [21], ISO 16730 [14], ISO 16732-1 [15], ISO/TS 16733 [16], ISO 16734 [17], ISO 16735 [18], ISO 16736 [19], ISO 16737 [20] and ISO/TR 13387 (all parts) [12].

These ISO documents, which relate to fire safety engineering, were developed to evaluate the design of the built environment, with the expectation that the design can be changed if the outcome of the analysis is unsatisfactory. In the case of electrotechnical end products, however, this approach is only appropriate when the end product is intended to be used in the built environment *after* design and construction are complete, either as movable contents or as part of a system that is installed post-construction. Fire hazard assessment of these electrotechnical end products must take the building design parameters as fixed, rather than controllable, elements in the process.

With respect to electrotechnical products, the primary concern of fire hazard assessment is to characterize and then to control the impact of fires caused by electrically induced ignition. A secondary concern is the possible involvement of the product after ignition has occurred elsewhere.

NOTE In fire hazard assessment the likelihood that ignition will occur is assumed. A broader risk-based approach to fire safety, of which fire hazard assessment can be a part, might also address the probability of ignition.

Other standards for fire safety engineering, such as the establishment and selection of fire scenarios and design fires, evaluation of behaviour and movement of people, and general guidance of performance-based fire safety design and assessment, are being developed by ISO. All relevant ISO standards should be taken into account whenever appropriate.

IEC 60695-1-12 gives guidance on the applications of fire safety engineering to electrotechnical products.

The basic steps to follow in developing a fire hazard assessment are:

- a) the definition of the product range and circumstances of use, to which the assessment applies (see 6.2);
- b) the identification, definition and analysis of the fire scenario or scenarios of concern, leading to a list of key product fire performance characteristics and/or test methods (see 6.3);
- c) the selection of the criteria defining acceptable outcomes of fire (see 6.4);
- d) the establishment of product performance requirements (see 6.5); and
- e) the interpretation of test results (see 6.6).

The relationships between the steps of the fire hazard assessment and the resulting tests are shown schematically in Flowcharts 1, 1A, 1B and 1C (contained in Figures 1 to 4).

6.2 Definition of the product range and the circumstances of use

The first step involves the definition of the class or range of those products to which the fire hazard assessment is to apply. This is done by selecting a candidate product, determining its circumstances of use, and describing in preliminary form the most significant fire scenario in which it may become involved. The same fire scenario, or a closely related one, may be an important source of hazard for other products, or other circumstances of use as well, so the eventual scope of the analysis may only become apparent as the fire scenario is defined more completely.

NOTE If appropriate, refer to the applicable IEC product standard.

6.3 Identification and analysis of fire scenarios

6.3.1 General

A fire scenario is a detailed qualitative description of conditions of one or more stages in an actual fire (or a full-scale simulation) from before ignition to completion of combustion. There will often be more than one fire scenario in which the product can participate, and in principle, the product can be assumed to contribute differently to the consequences of fire associated with each fire scenario. Therefore, a separate fire hazard assessment is required for each important fire scenario identified.

Whether the focus of assessment is a product or a system, typically the most important fire scenario characteristics will be those that either define the fire conditions that cause the product to become involved in fire, or that indicate the time in the fire when its contribution will cause the most serious consequences.

Thus, to be useful, the qualitative fire scenario must be analysed so as to provide data which quantitatively relates the outcome of the incident to the behaviour of the product – as a source of ignition and/or in terms of its measurable fire properties as determined by available reaction-to-fire tests.

6.3.2 Qualitative description of the fire scenario

A qualitative description of each fire scenario of concern should be developed. For each fire scenario, the following questions should be considered:

- a) What is the source of ignition, i.e., is it the product itself or is the product the victim of a fire, which has originated elsewhere?
- b) If the product is not the ignition source, describe the ignition conditions.
- c) How is ignition detected?
- d) What is the size of the fire when the product ignites?
- e) What are the other fuels for the fire?
- f) What is the location of the product? Is it enclosed?
- g) What are the ventilation conditions?
- h) What is the location of the fire relative to the product?
- i) What are the components of the fire effluent ?
- j) Describe the arrangement of the compartments in which the fire effluent will accumulate.
- k) What consequence or consequences of the fire are perceived to be of concern, e.g. heat or the effects of fire effluent?
- l) What is the target, e.g. exposed people, property or specialized equipment?
- m) If the targets are people, what are their capabilities and options for escape? How many people are likely to be affected?
- n) Where is the location of the target?

- o) What building fire safety systems exist?
- p) Can circumstances be envisioned where one or more of these building systems will fail in connection with the same events which cause the product to be involved in the fire situation?
- q) What other conditions will influence the course of ignition and/or fire growth?

Data available for use in fire hazard assessment may be any of the following types:

- 1) test results;
- 2) measurements of, or statistics concerning, characteristics of historical fires; or
- 3) documented judgement by experts.

These data may be used directly as fire hazard assessment measures or they may be used as input data to a calculation procedure that produces the final fire hazard assessment.

NOTE Additional guidance on how to define and describe a fire scenario can be found in ISO/TR 13387-1:1999, 10.4 and 10.5, and ISO/TR 13387-2:1999, 5.1 through 5.2.6. In this fire hazard assessment, however, the important fire scenarios are evaluated one at a time, not all together as in the ISO approach. (Hence, the material in ISO/TR 13387-2:1999, 5.2.7 through 5.2.11, is not used directly).

The fire scenario's primary purpose is to identify the product's potential contribution to each undesirable effect of the developing fire and, thereby, those aspects of the product's fire performance that affect the outcome of the fire scenario. Once the key contributors are established, methods for their quantification or measurement must be identified as illustrated in Figure 1.

The first fire scenario evaluated using Figure 1 will yield a list of the product's fire attributes, which relate to its contributions to the undesirable consequences arising from that fire scenario. Analysis of subsequent fire scenarios will often identify similar undesirable consequences and, therefore, many of the same fire attributes will be important. Hence, the list of required measurements will grow more slowly, or perhaps not at all, as the analysis of the fire scenarios proceeds.

Following this, the fire scenarios are ranked in order of their importance. Ranking can be done either on the basis of frequency or severity, or a combination of both. Once a fire scenario ranking is established, it becomes apparent which aspects of product fire performance are most important.

In many cases, particularly for products that will be used in a wide variety of different circumstances, it will not be possible to answer all the questions listed in 6.3.2.

6.3.3 Quantitative analysis of the fire scenario

While the appropriate test methods that are required can usually be identified from a qualitative analysis of the fire scenarios, a quantitative analysis of the most important fire scenarios is needed. The analysis serves two functions:

- 1) It provides data concerning the thermal environment of the product, so that test conditions can be set at levels to simulate actual fire scenario conditions.
- 2) It provides calculated values of the various parameters associated with the undesirable consequences of the fire, from the scenarios that involve the product, if the product's performance in the fire tests is known.

It is possible to see the change in the consequences of fire resulting from the presence of the product. This is done as follows:

- a) Describe the fire growth curve, and the thermal environment it produces, with and without the product present. The difference in the thermal environment is caused by the presence of the product.

- b) If fire effluent is of concern, describe the mass-loss curve associated with the fire growth curve, with and without the product present.
- c) Describe how the increase in the undesirable consequences of the fire at the target site is related to the mass loss curve.
- d) Connect the two: describe the increase in the undesirable consequences of the fire at the target site in terms of the fire growth curve with and without the product present.

Quantitatively describing the undesirable consequences of the fire requires that the methods of fire safety engineering be employed. The reader is referred to ISO TR 13387, parts 2, 3, 4, 5, 7 and 8 which provide additional information on how these quantitative techniques are employed and what data they require.

Many test methods and/or calculations based on the methods of fire safety engineering will require a number of specification or input values. For example, a test for rate of heat release of a burning product will require that the size and duration of the ignition source is specified, as well as the radiant heat intensity (flux) to which the product should be exposed and the ventilation conditions under which it burns.

When the product is the first item ignited (an ignition may happen within the product), the possibility of the occurrence of an excessive heat source and the possibility of the subsequent ignition of surrounding part(s) should be examined.

When the product is not the first item ignited, nearby combustibles will be important in determining the thermal conditions to which the product is exposed. Similarly, the heat, as well as the quality and quantity of fire effluent, produced by other nearby burning objects must be estimated in order to determine the importance of the contribution of the product.

The procedure for incorporating the appropriate tests into the analysis and for specifying the test settings is outlined further in Flowcharts 1, 1A, 1B and 1C.

6.3.4 Simple hypothetical fire scenarios

To carry out a full fire hazard assessment is both complex and potentially expensive. Also, as discussed above, information about the product environment may not be available or may be within a broad range. It is therefore often useful to assume a relatively simple hypothetical fire scenario based on historical data, and then to use this scenario to examine how a product would affect the consequences of the fire.

As a minimum, the following basic information will be needed to define the fire scenario:

- a) the nature of the fire growth curve – how much fuel is burning, at what rate, and how does the burning rate change as a function of time;
- b) the nature of the fuel, its heat of combustion, smoke yield and toxic gas yields;
- c) the stage or stages of fire; e.g. well ventilated or vitiated, low or high temperature; and
- d) the volume into which the fire effluent is being dispersed.

With this information it is relatively simple to calculate various parameters (heat, oxygen depletion, smoke, toxic gas emission) as a function of time. It is then possible to calculate what reaction-to-fire properties the product would need to have in order for the consequences of the assumed fire to be acceptable.

It should be noted that this approach is not rigorous and involves many assumptions, but it is better than not using quantified data at all, which historically has often been the case.

If this approach is used to specify or regulate the reaction-to-fire properties of products, it is essential that the hypothetical fire scenario is explicitly defined, and that the assumptions made are justified.

An example of the use of a simple hypothetical fire scenario is given in Annex A.

6.4 Selection of criteria for acceptable fire scenario outcomes

The intent of this step is to select fire hazard assessment measures that will provide valid technical information sufficient to estimate and to make decisions concerning the product's contribution to the potential consequences of fire. The measures used fall into the following categories:

a) Direct life and property loss

If the contribution of the product to the potential consequences can be expressed in these terms, it is desirable to do so. It is rare, however, that this can be accomplished, since the capabilities of the occupants, or the equipment and property are seldom known with sufficient certainty that the outcome to the fire scenario can be forecast quantitatively.

b) Indirect method of characterizing the consequences of fire

It is often possible to relate a measured or calculated product property to an increase in one or more of the undesirable effects of the fire. For example, the heat release rate of the product may govern the temperature of the compartment and hence affect equipment operation and/or continued human occupation. The rate of release of smoke from a product may influence the available safe escape time. In this approach, the quantitative relationship between the undesirable effect of the fire and the properties of the product is identified, so that changes in the level of the undesirable effect can be traced to changes in properties.

c) Comparative methods

Even when it is not possible to express these relationships quantitatively it may be possible to relate the performance of a tested product to a reference level. For example, cables with a known heat release may be considered as providing an acceptably slow increase in temperature, even though the precise relationship is unknown. Then one measure of the relative hazard is the comparison of the heat release rate of the product with the reference level.

6.5 Performance requirements

The quantitative analysis should make explicit how the fire performance of the product, as measured by the test methods identified as appropriate, affects the outcome of the fire scenario. The assessment should specify all the steps required to set meaningful safety thresholds, or pass/fail criteria can be set by those responsible. For illustrations of how this can be done, see Annex A and Annex B.

6.6 Interpretation of test results

At this point, the consequences of a fire assessment procedure will have identified which parameters are to be used and how they are to be calculated, but the interpretation of the results may still pose additional technical questions.

- a) In a fire hazard assessment, one should specify the procedure to be used in calculating an overall comparison between products, or when compared to a baseline. This procedure might be a formula for calculating one overall measure from several, in which case, a scientific rationale will be presented for the formula. The procedure could be a set of decision rules, such as a rule that one product is better than another only if it is better in all measures.
- b) If more than one fire scenario has been used, it is necessary to specify the procedure to be used in making an overall fire hazard assessment. This procedure could be a formula or a set of rules, for example if the fire scenario can be assigned relative probabilities of occurrence, as in a fire risk assessment, this would be a basis for making the overall fire hazard assessment based on several fire scenarios.
- c) If the fire hazard assessment is not expressed directly in terms of death, injuries or monetary loss, guidance on the other quantitative units and measurements should be provided (e.g. available safe escape time, extent of flame spread, or the size of the fire).

6.7 Consequential testing

When considering the fire hazard of a part in an electrotechnical product, the results of a fire test may indicate that fire could spread to a neighbouring part or parts. Further tests may therefore be required on the neighbouring part or parts. This is known as consequential testing.

Such consequential testing may be avoided by:

- a) re-design of the product to separate the parts, or
- b) local enclosure of the tested part, or
- c) re-design of the tested part to increase its fire performance

7 Extent and limitations of the fire hazard assessment

In the course of the fire hazard assessment many shortcomings in existing data and knowledge will be encountered which force the user either to reduce the scope of the analysis or to proceed using estimated data and/or unverifiable assumptions. Since these considerations affect how future users apply any product standards resulting from the analysis, it is necessary that these considerations are documented with considerable care, especially when setting forth the nature of the products and the context of uses to which the products are put. The exact limits of the assessment are seldom apparent before the assessment is complete and so the originally defined products and context of use should be reviewed.

- a) Has the formulation of the fire scenario identified any products in the original scope, which do not fit the final analytical scheme?
- b) If so, can the fire scenario be modified to accommodate them, or must the product scope be adjusted to exclude them?

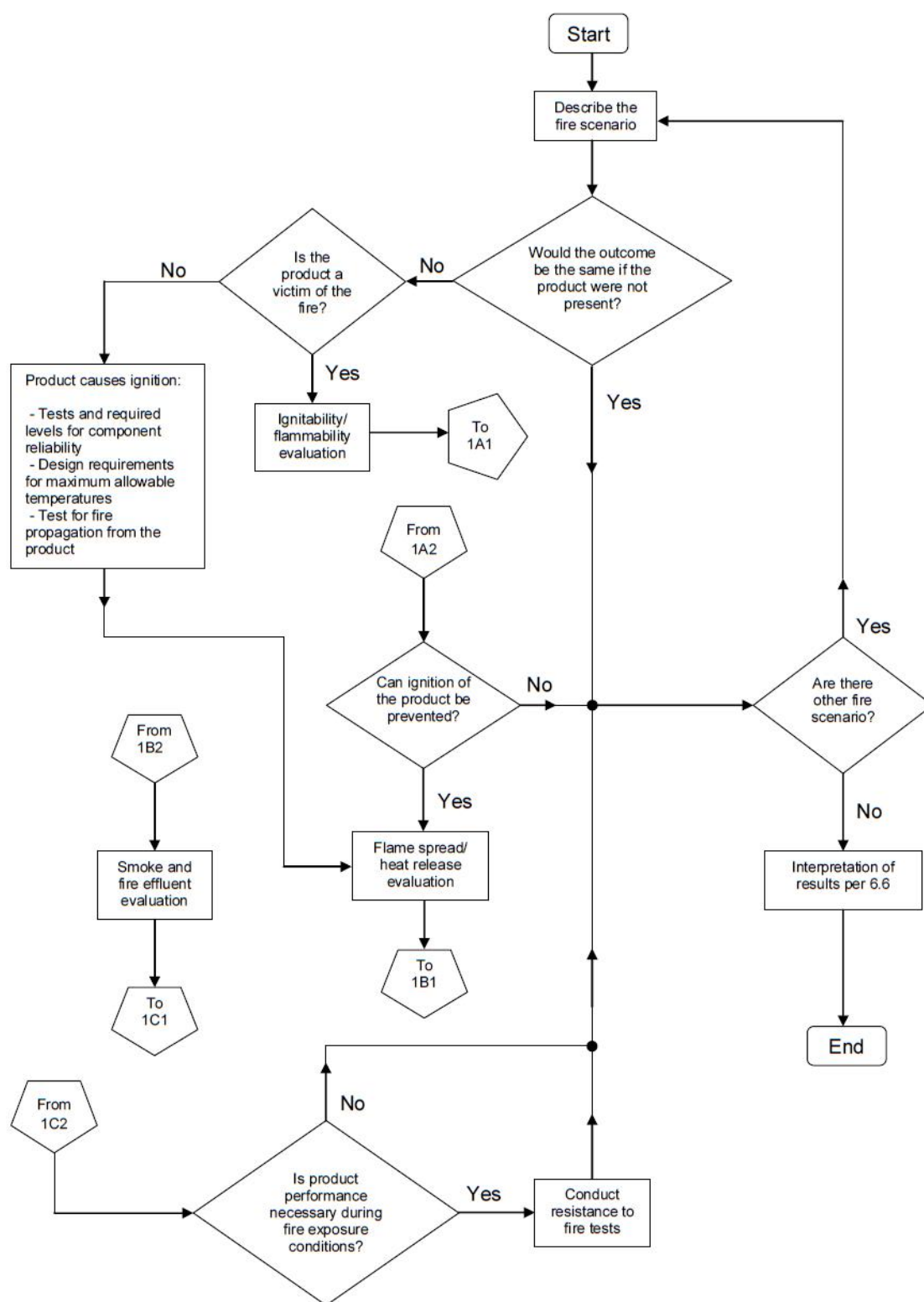
The trial description can be tested against a list of products that are potential candidates for inclusion in the fire hazard assessment by making use of the procedure outlined in Figure 5.

8 Fire test requirements and specifications

When preparing requirements and test specifications concerning fire hazard testing of products, it is suggested that the technical committees follow the procedures shown below.

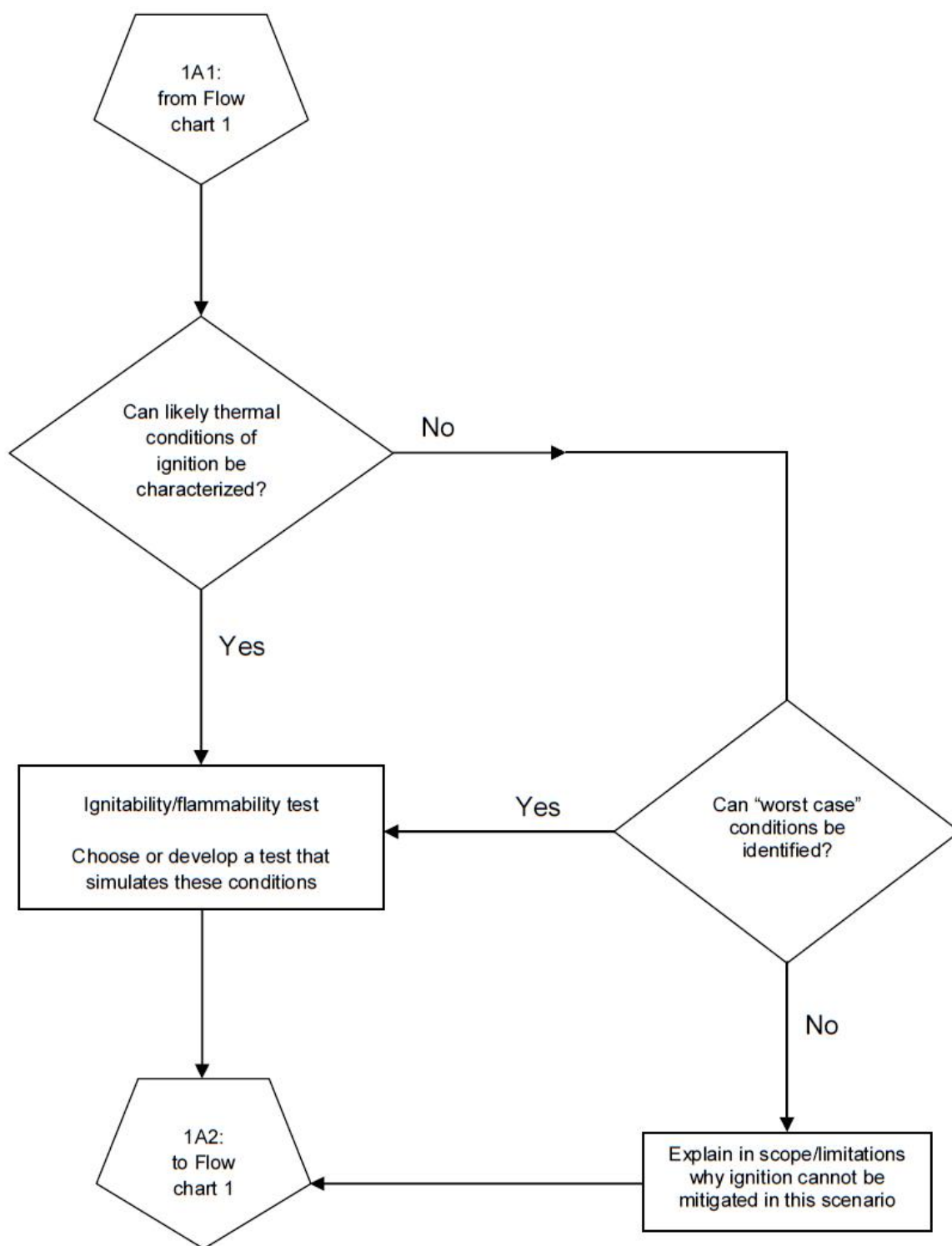
- a) Read and follow the guidance contained in this document.
- b) Examine appropriate test procedures developed for the parameter(s) of concern and consider their possible applicability and limitations. Reference to the following IEC publications will be helpful. They provide a summary and relevance of commonly used fire tests:
 - IEC 60695-1-21 (Ignitability) [1]
 - IEC/TS 60695-5-2 (Corrosion damage effects of fire effluent) [2]
 - IEC 60695-6-2 (Smoke obscuration) [3]
 - IEC 60695-7-2 (Toxicity of fire effluent) [5]
 - IEC 60695-8-2 (Heat release) [7]
 - IEC 60695-9-2 (Surface spread of flame) [8]
- c) Compare the relevant fire performance characteristics identified in the scenario analysis to the relevant scope and significance of the existing test procedures.
- d) If an existing test procedure appears suitable, check that:
 - 1) the test conditions finally adopted bear as close a relationship as possible to the environment which is being modelled or simulated,

- 2) the validity of the test data is related to the manner of use and installation of the product and its association with other products,
 - 3) the test procedure is acceptable as regards sensitivity, reproducibility and repeatability, and
 - 4) the test results are given in easily understood terms, parameters and units, giving a fully objective description. All indefinite, subjective and speculative phraseology should be avoided.
- e) If a new test procedure is to be developed, quantify the essential features as listed above. Further important features are the purpose of the test, the limitations of the test, the use of the information it provides and the ease of operation. In cases where fire tests are not yet specified and need to be developed or altered for the special purpose of an IEC technical committee, this should be done in close liaison with TC 89 as described in Clause 7 of IEC Guide 104:2010. Then prepare the standard for the test method, including the relevant information on its field of application, its limitations and reservations, and on the use of the test results obtained. Make reference in the standard to recommended test procedures wherever possible.



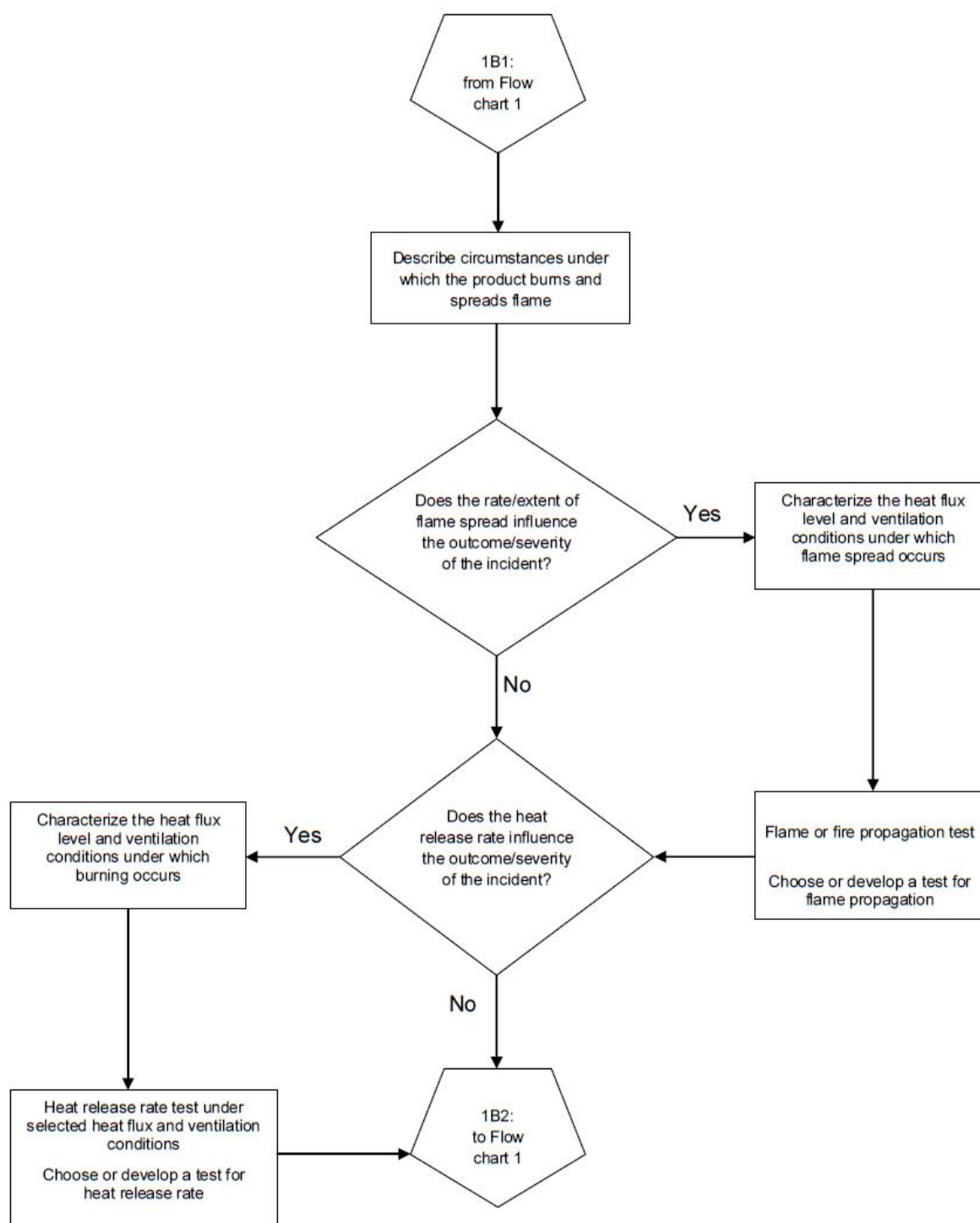
IEC

Figure 1 – Flowchart 1 for description of the fire scenario



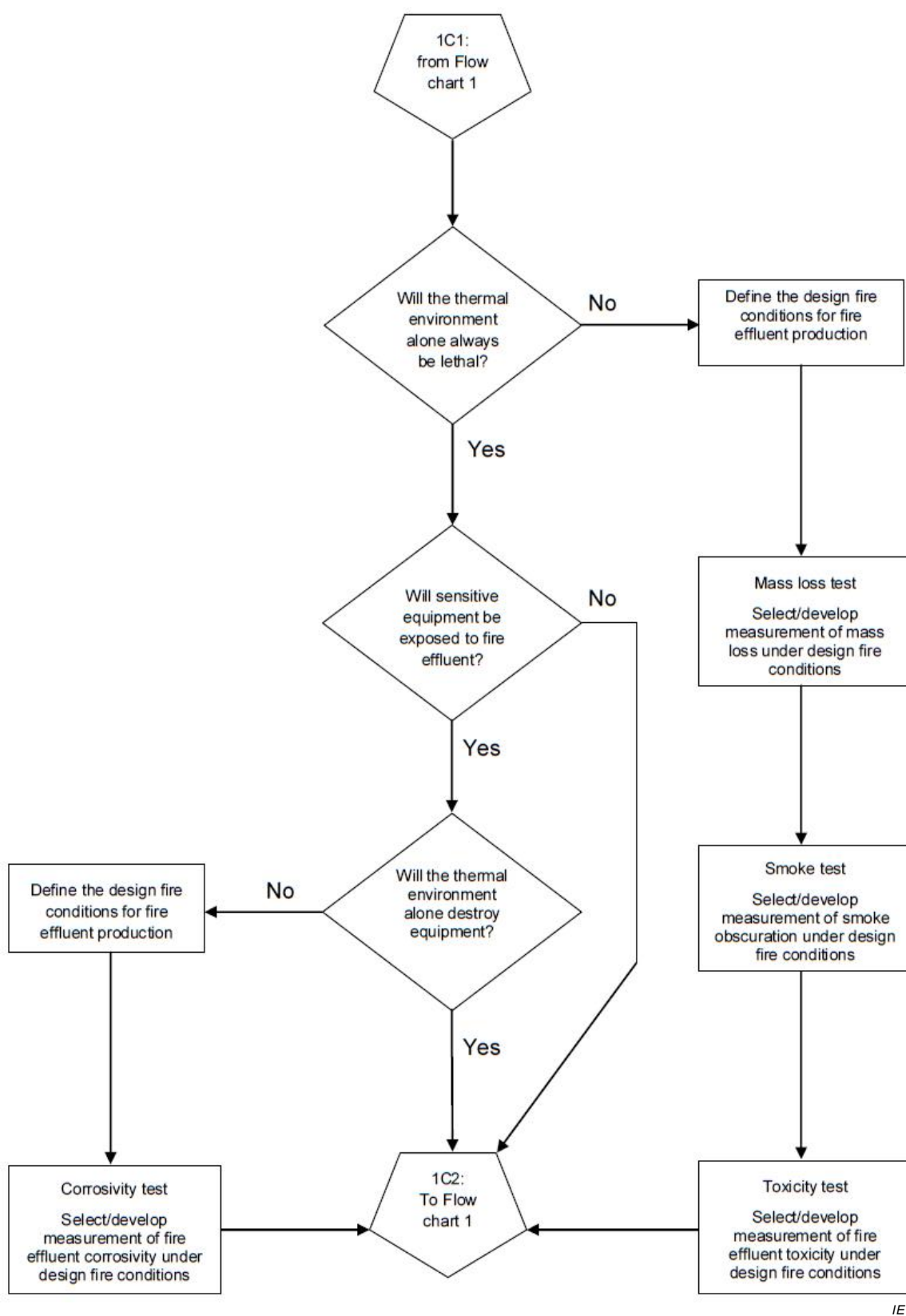
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Figure 2 – Flowchart 1A for evaluation of ignitability/flammability



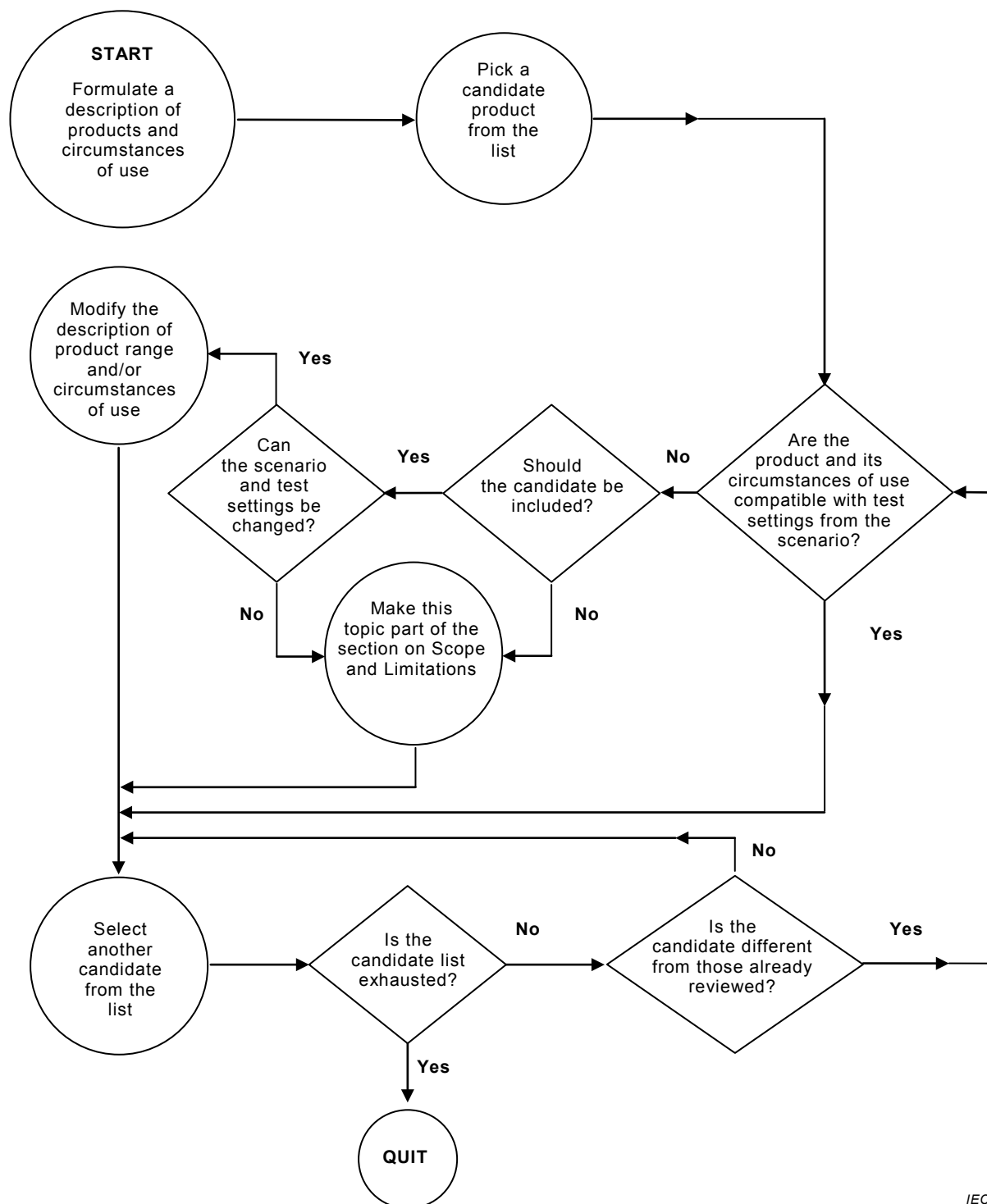
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Figure 3 – Flowchart 1B for evaluation of flame propagation and heat release



IEC

Figure 4 – Flowchart 1C for evaluation of fire effluent



IEC

Figure 5 – Flowchart for description of the range of products and circumstances of use

Annex A (informative)

Calculation of acceptable toxic yield values for an electrical insulation material, based on a simple hypothetical fire scenario

NOTE In this fire hazard assessment, a model that predicts the incapacitating effect of toxic effluent is used. This model is described in IEC 60695-7-1 [4]. This differs from the mass loss model, based on lethality that is used in Annex B.

A.1 Definition of the fire scenario

At the least, six questions have to be answered in order to define the fire scenario. These are:

- a) What is burning?
- b) How much of it is burning?
- c) Into what volume is the fire effluent being dispersed?
- d) What is the nature of the fire growth curve?
- e) What escape time is available?
- f) What is the fire model – a high or low temperature, well ventilated or oxygen starved?

To see how this could work in practice, consider the following example:

Suppose the fuel is 0,5 kg of an electrical insulation material burning into a volume of 100 m³. The escape time is 15 min and the fire growth curve is assumed to be parabolic, i.e. it grows as a function of time squared. The fire model is high temperature and well ventilated.

A.2 Irritant fire effluent

A.2.1 *F* values

With irritant gases it has been found that incapacitation depends on the volume fraction of the gas, but not on the time of exposure.

F values are the volume fractions that will incapacitate. At lower values an exposed person may well be in some discomfort but should be able to act rationally in order to attempt to escape from a fire.

F values for the seven common fire gas irritants are given in Table A.1.

A.2.2 Equation for irritants

For the assumed fire scenario, in order for no one to be incapacitated, the following equation applies:

$$\sum \frac{y_i}{X_i} < 1 \quad (\text{A.1})$$

where

y_i is the toxic yield of irritant i from the electrical insulation material, measured in a toxicity test at high temperature and high ventilation, and

the X_i values are calculated from the irritant F values and the parameters of the defined fire scenario. They are given in Column 3 of Table A.1.