IEC TS 60695-1-14

Edition 1.0 2017-12

TECHNICAL SPECIFICATION

Fire hazard testing –
Part 1-14: Guidance on the different levels of power and energy related to the probability of ignition and fire in low voltage electrotechnical products

colour inside

IEC TS 60695-1-14:2017-12(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 13.220.40, 29.020 ISBN 978-2-8322-4921-5

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIRE HAZARD TESTING –

Part 1-14: Guidance on the different levels of power and energy related to the probability of ignition and fire in low voltage electrotechnical products

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 60695-1-14, which is a technical specification, has been prepared by IEC technical committee 89: Fire hazard testing.

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

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
89/1334/DTS	89/1363/RVDTS

Full information on the voting for the approval of this technical specification 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.

This publication is to be used in conjunction with IEC 60695-1-10 and IEC 60695-1-11.

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 engineering

Part 1-14: Guidance on the different levels of power and energy related to the probability of ignition and fire in low voltage electrotechnical products (this document)

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

In this standard, the following print types or formats are used:

– requirements proper and normative annexes: in roman type;
– compliance statements and test specifications: *italic type;*
– notes/explanatory matter: in smaller roman type;
– normative conditions within tables: in smaller roman type;
– terms defined in Clause 3: **bold type**.

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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 the risk of fire to a tolerable level even in the event of reasonably foreseeable (mis)use, malfunction or failure.

IEC 60695-1-10, IEC 60695-1-11 and IEC 60695-1-12 provide guidance on how this is to be accomplished.

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

The aim of the IEC 60695 series of standards is to save lives and property by reducing the number of fires or reducing the consequences of the fire. This can be accomplished by trying 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;
– minimise flame spread beyond the product's enclosure and to minimise the harmful effects of fire effluents including heat, smoke, and toxic or corrosive combustion products.

This technical specification provides guidance to Product Committees on the power levels and amounts of energy that are likely to cause **ignition** and fire. It also provides guidance to Product Committees on the **fire hazard safeguards** that might be necessary to protect against the probability of **ignition**.

The probability of fire is highly dependent on the specific fire scenario within the electrotechnical product itself. Therefore, product committees are ultimately responsible for deciding what **fire hazard safeguards** are appropriate for their products.

This document was created due to a need (IEC technical committee 66) for guidance on electrical energy levels in relation to **ignition** and fire. The preparation of this TS is based on based on electrical energy 141 levels developed by TC 108, responsible for safety of audio, video and ICT equipment.

FIRE HAZARD TESTING –

Part 1-14: Guidance on the different levels of power and energy related to the probability of ignition and fire in low voltage electrotechnical products

1 Scope

This part of IEC 60695, which is a technical specification, provides guidance about the levels of power and energy that could cause **ignition** and fire in a low voltage electrotechnical product. It can be used by Product Committees to determine what **fire hazard safeguards** might be used, based on the electrical energy that could be dissipated as heat.

This document deals with products used in normal atmospheres commonly available in the home and does not deal with special locations such as those in explosive atmospheres. It is intended as guidance to IEC committees, and is intended be used with respect to their individual applications.

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.

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 are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60695-1-11, *Fire hazard testing - Part 1-11: Guidance for assessing the fire hazard of electrotechnical products - Fire hazard assessment*

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

IEC 62368-1:2014, *Audio/video, information and communication technology equipment - Part 1: Safety requirements*

IEC GUIDE 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

ISO 13943:2008, *Fire safety – Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60695-4:2012 and ISO 13943:2008 (some of which are reproduced below) and the following apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
fire hazard
physical object or condition with a potential for an undesirable consequence from fire

[SOURCE: ISO 13943:2008, 4.112]

3.2
fire hazard safeguard
part or system or instruction specifically provided to reduce the likelihood of **ignition** or spread of fire

Note 1 to entry: A **fire hazard safeguard** is often also called a protection method.

Note 2 to entry: Examples include current limiters, distances to or from **ignition** sources, materials with flame retardant properties.

3.3
ignition
DEPRECATED: sustained ignition
⟨general⟩ initiation of combustion

[SOURCE: ISO 13943:2008, 4.187]

3.4
low voltage equipment
set of electrical devices or electrical equipment necessary to perform a specific task such as generation, transmission, distribution, utilisation of electric energy and with a supply or output voltage not exceeding 1 000 V for alternating current and 1 500 V for direct current

Note 1 to entry: Examples of low voltage equipment are electric power generator, electrical switchgear and controlgear assemblies, electrical wiring systems, air conditioning units.

[SOURCE: IEC Guide 116:2010, 3.1]

3.5
permanently connected equipment
equipment that can only be electrically connected to or disconnected from the mains by the use of a tool

[SOURCE: IEC 62368-1:2014, 3.3.3.4]

3.6
pluggable equipment type A
equipment that is intended for connection to the mains via a non-industrial plug and socket-outlet or via a non-industrial appliance coupler, or both

Note 1 to entry: Examples are plugs and socket-outlets covered by standards such as IEC TR 60083 and IEC 60320-1.

[SOURCE: IEC 62368-1:2014, 3.3.3.5]

3.7
pluggable equipment type B
equipment that is intended for connection to the mains via an industrial plug and socket-outlet or via an industrial appliance coupler, or both

Note 1 to entry: Examples are plugs and socket-outlets covered by standards such as IEC 60309-1.

[SOURCE: IEC 62368-1:2014, 3.3.3.6]

3.8
potential ignition source
location where electrical energy can cause **ignition**

[SOURCE: IEC 62368-1:2014, 3.3.9.1]

4 Electrical energy as a cause of ignition

If a fault occurs, the energy used in a low voltage electrotechnical product may be converted to heat. This could be due to arcing or due to resistive heating.

An arc is a high-temperature luminous electric discharge across a gap. Temperatures within an arc can be in the range of several thousand degrees depending on circumstances including current, voltage drop, and the materials involved. In spite of the very high temperatures in an arc path, arcs may not be effective **ignition** sources for many fuel materials. In most cases, the arcing is so brief and localized that solid fuels cannot be ignited or can be difficult to ignite. However, fuels with a high surface-area-to-mass ratio, may be ignited when in contact with the arc.

In the case of resistive heating, the thermal energy, E, produced by in a direct current circuit is given by:

$$E = P \times t = I \times V \times \mathrm{t} \qquad (1)$$

where

P is the power (energy per unit time)

t is the time

I is the current passing through the resistance

V is the voltage drop across the resistance

For example if V = 12 volts and I = 2 amp, and the current flows for 5 seconds, then P = 24 watts and E = 120 joules.

In an alternating current circuit:

$$E = P_{\mathrm{avg}} \times t = I_{\mathrm{rms}} \times V_{\mathrm{rms}} \times cos\theta \times t \qquad (2)$$

where

P_{avg} is the average power over one complete a.c. cycle

I_{rms} is the root mean square current passing through the resistance

V_{rms} is the root mean square voltage drop across the resistance

θ is the phase difference between current and voltage

The thermal energy produced will cause a temperature rise in the resistive material and in its surroundings. The magnitude of the temperature rise will depend on many variables. The most important being:

– the mass of the affected material,
– the specific heat capacity of the affected material,
– the magnitude of any heat losses, and
– the geometry of the affected material.

Some of the variables will be temperature dependent and therefore the calculation of the temperature rise for a given energy input will be complex and requires the use of finite element analysis.

The temperature rise may be sufficient to cause decomposition of the affected material, but the extent of decomposition will depend on the chemical nature of the affected material. If the affected material is not exposed to air, the initial decomposition will be anaerobic pyrolysis which will probably generate gases such that internal pressure will cause mechanical rupture which, in turn, will probably expose the material to air. If the temperature is high enough, oxidative decomposition will be sufficiently rapid to cause **ignition**.

NOTE General guidance on ignitability is given in IEC 60695-1-20.

The complexities involved in the prediction of the temperature rise and the subsequent decomposition process are such that empirical values of the electrical power and energy have been adopted by various product committees for the definition of different levels of safety.

5 Empirical safety values of electrical power and energy

5.1 Different levels of power and electrical energy sources

The risk of an electrotechnical circuit to cause **ignition** is depending on the power consumption and duration.

A fire will only start if a certain amount of electrical energy is available so as to raise the temperature to such a level that it can cause **ignition**. The purpose of this document is to give guidance on how product committees may classify electrical energy sources in relation to power levels and durations.

The classification can be applied to any part, circuit or end product.

The values used in 5.2 to 5.5 are based on practical experiences based on power levels and durations as shown in Figure 1. An alternative method making use of energy levels can be found in Figure 2. The power measuring method is indicated in the relevant product safety standard.

5.2 Electrical power and energy source that is unlikely to cause ignition (Class 1)

A Class 1 electrical energy source is considered unlikely to have sufficient electrical energy to cause **ignition** in electrotechnical circuits and components under most circumstances. As a result, a Class 1 electrical energy source is considered to be a safe electrical energy level. In general, no **fire hazard safeguard** is needed.

NOTE 1 Although **ignition** is unlikely to occur, this power level will be safe if there is an appropriate level of thermal insulation.

The continuous available power (voltage multiplied by current) should be less than 15 W to achieve a very low possibility of **ignition**. The value of 15 W has been used as the power threshold for **ignition** in electronic components in many standards, including IEC 60065, IEC 60335-1 and IEC 60950-1. It has also routinely been demonstrated through limited power fault testing in electronic circuits.

In order to address the ease of measurement, some IEC technical committees decided to make the 15 W measurement 3 s after introduction of the simulated fault. Values as short as 100 ms and as high as 5 s were also considered. Quickly establishing a 15 W limit (less than 1 s) is not practical for test purposes and not considered important for typical fuel **ignition** in **low voltage equipment**. It is recognized that it usually takes several seconds for plastic materials to ignite when impinged directly by a small flame (IEC 60695 small scale material testing methods).

The question can be raised if an electrical energy can be classified as Class 1 with an unlimited amount of power during the first 3 s. It is unlikely in low voltage equipment that a circuit would be capable of delivering a huge amount of energy in the first 3 s, and be limited to a maximum of 15 W after 3 s. Therefore it was considered unnecessary to establish a limit for the first 3 s. As no duration is associated with this 15 W value, the energies involved are undefined. It must be assumed that the heat loss rate is equivalent to 15 W at a temperature below that which could cause **ignition**.

NOTE 2 Although **ignition** is considered unlikely to occur, these power levels could be unsafe if there is a high level of thermal insulation because if heat losses are low, the temperature could rise sufficiently to cause **ignition**.

NOTE 3 Further details of the rationale for the definition of Class 1 (PS1) are given in IEC TR 62368-2.

5.3 Electrical power and energy source that may cause ignition (Class 2)

A Class 2 electrical energy source is assumed to have a level of power and electrical energy that has the possibility of **ignition** under certain circumstances and subsequently a **fire hazard safeguard** should be employed. Propagation of the **ignition** beyond the initially ignited component is limited by the low electrical power or energy contribution to the fault and subsequently by the employed **fire hazard safeguard** to control the resistance to **ignition** of nearby combustible materials.

The primary requirement is to limit the amount of electrical energy that is available to these circuits to no more than 100 W of continuous power. This value includes both the power available for normal operation and the power available during any possible single fault condition.

This value has been used in IEC 60950-1 for a similar purpose, where **ignition** of internal components is possible but fire enclosures are not required.

The value of 100 W is also commonly used in some building or fire codes to identify where low power wiring can be used outside of a fire enclosure.

The value is also 2 times 50 W, which can be related to the amount of energy of a standard flaming **ignition** sources (for example the IEC 60695-11-10 test flame) on which small scale flammability classes are based. It is recognized that the conversion of electrical energy to thermal energy is far less than 100 %, so this value is compatible with the **fire hazard safeguards** prescribed for Class 2 electrical energy circuits, which are generally isolation and materials of an applicable V–flammability class.

The 5 s measurement for Class 2 electrical energy sources ensures the available electrical energy limits are both limited and practical for the purposes of measurement. The value is also used in the IEC 60950 series as referenced above.

As for Class 1 energy sources, the question can be raised if an electrical energy can be classified as Class 2 with an unlimited amount of power during the first seconds. It is unlikely in low voltage equipment that a circuit would be capable of delivering a huge amount of energy in the first 5 s, and be limited to a maximum of 100 W after 5 s. Therefore it was considered unnecessary to establish a limit for the first 5 seconds. As no duration is associated with this 100 W value, the energies involved are undefined. It must be assumed that the heat loss rate is equivalent to 100 W at a temperature below that which could cause **ignition**.

In IEC 62368-1, it is assumed that with a Class 2 power source (PS2), **ignition** can occur under some conditions, but there will be limited growth and spread of fire. Class 2 (PS2) is defined as a power source that exceeds Class 1 (PS1) limits, but does not exceed 100 W after 5 s. It is assumed to have the possibility of **ignition** under certain circumstances and therefore a **fire hazard safeguard** should be employed.

Propagation of the **ignition** beyond the initially ignited component is assumed to be limited by the relatively low power consumption and by the use of **fire hazard safeguards**.

The **fire hazard safeguards** prescribed for Class 2 circuits are generally isolation and/or the use of insulation materials that are resistant to **ignition**.

NOTE Further details of the rationale for the definition of Class 2 (PS2) are given in IEC TR 62368-2.

5.4 Electrical power and energy source that is likely to cause ignition (Class 3)

A Class 3 electrical energy source is a circuit with an available power higher than 100 W and that last for longer than 5 s. The amount of electrical energy available makes it likely that **ignition** will occur in case a fault, such as a bad contact, occurs.

For most **low voltage equipment**, the available power is limited by the building overcurrent protective system to a maximum of about 4 kW. This power level was chosen to cover equipment that is connected to a low power mains (less than 240 V x 16 A), common in the office or home environment. Power consumption in a fault condition is likely to be considerably in excess of the 100 W level discussed in 5.3. Such power consumption is considered to be a probable cause of **ignition** and, as a possible consequence of it, a fire.

Some standards distinguish between two different Class 3 electrical energy levels. For most products used in the home or the office place, the available power is limited by the building overcurrent protective system to a maximum of about 4 000 W.

The power level of 4 000 W was chosen to provide a reasonable and practical separation of product types to separate products that are connected to a low power mains (less than 240 V x 16 A), common in the office place or the home. It is recognized that this is not representative for typical fault currents, but is a convenient and representative separation based on equipment connected to normal office and home mains circuits where experience with **fire hazard safeguards** against potential **ignition** sources is more common.

The 4 000 W value can be calculated for individual circuits as the product of the mains nominal voltage and mains overcurrent device rating. This is not a normal engineering convention but rather the product of two numbers that should not exceed 4 000. All **pluggable equipment type A** is considered to be below this steady state value. **Pluggable equipment type B** and **permanently connected equipment** are considered to be below this steady state value if the product of nominal mains voltage and the current rating of the installation overcurrent protective device is less than 4 000.

As Class 3 electrical energy sources are likely to cause **ignition** and fire in case a fault occurs, there should be a second **fire hazard safeguard** in place to prevent spread of fire. This can be done by different **fire hazard safeguard** methods, such as providing a fire enclosure or keeping a separation distance from the **potential ignition source** to other nearby combustible materials.

In IEC 62368-1, it is assumed that with a Class 3 power source (PS3), **ignition** may occur and fire will spread where combustible materials are available. A PS3 circuit has an available power higher than 100 W that lasts for longer than 5 s. The amount of energy available will be

500 J or more and this is assumed to make it likely that, in case a fault occurs – such as a bad contact – **ignition** will occur.

As these energy sources are likely to cause **ignition** and fire if a fault occurs, there should be a **fire hazard safeguard** in place in addition to the use of insulation materials that are resistant to **ignition**. This can be done in different ways, such as providing a fire enclosure or keeping a separation distance between the **potential ignition source** and other nearby combustible materials.

NOTE Further details of the rationale for the definition of Class 3 (PS3) are given in IEC TR 62368-2.

5.5 Graphical overview of the classification

The values given can be represented diagrammatically in a power/time graph, see Figure 1.

As discussed above, the amounts of energy that these power and time values represent are either unlimited or are not single-valued. A better system would be based on defined amounts of energy. An example is shown in Figure 2 where the chosen energy values are 45 J and 500 J to be in accordance with the 15 W / 3 s limit and the 100 W / 5 s limit.

In Figure 2, the area denoted as "$E \leq 45$ J" represents the energy regime where **ignition** is considered to be unlikely (Class 1). The area denoted as "45 J $< E \leq$ 500 J" represents the region where **ignition** might occur (Class 2), and the area denoted as "$E >$ 500 J" represents the region where **ignition** and subsequent fire is likely if a fault occurs (Class 3).

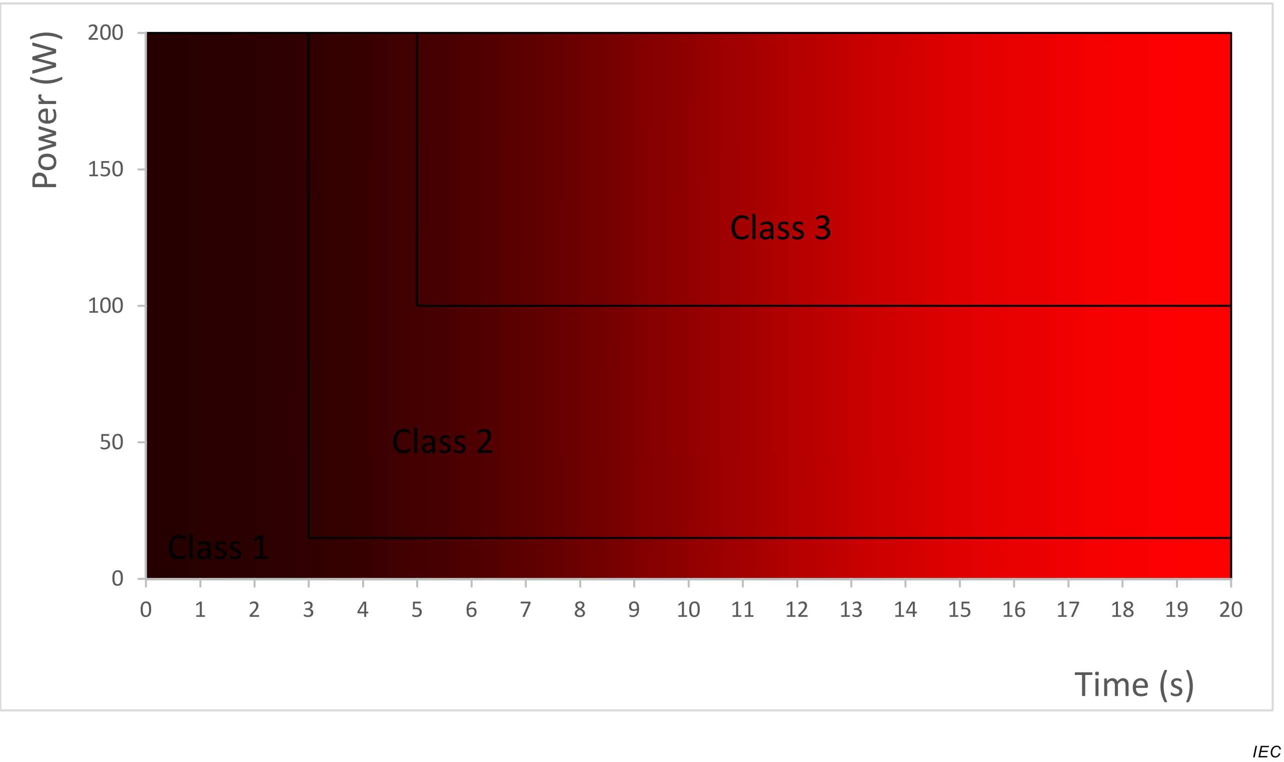

Figure 1 – Illustration of power/time limits related to fire and ignition

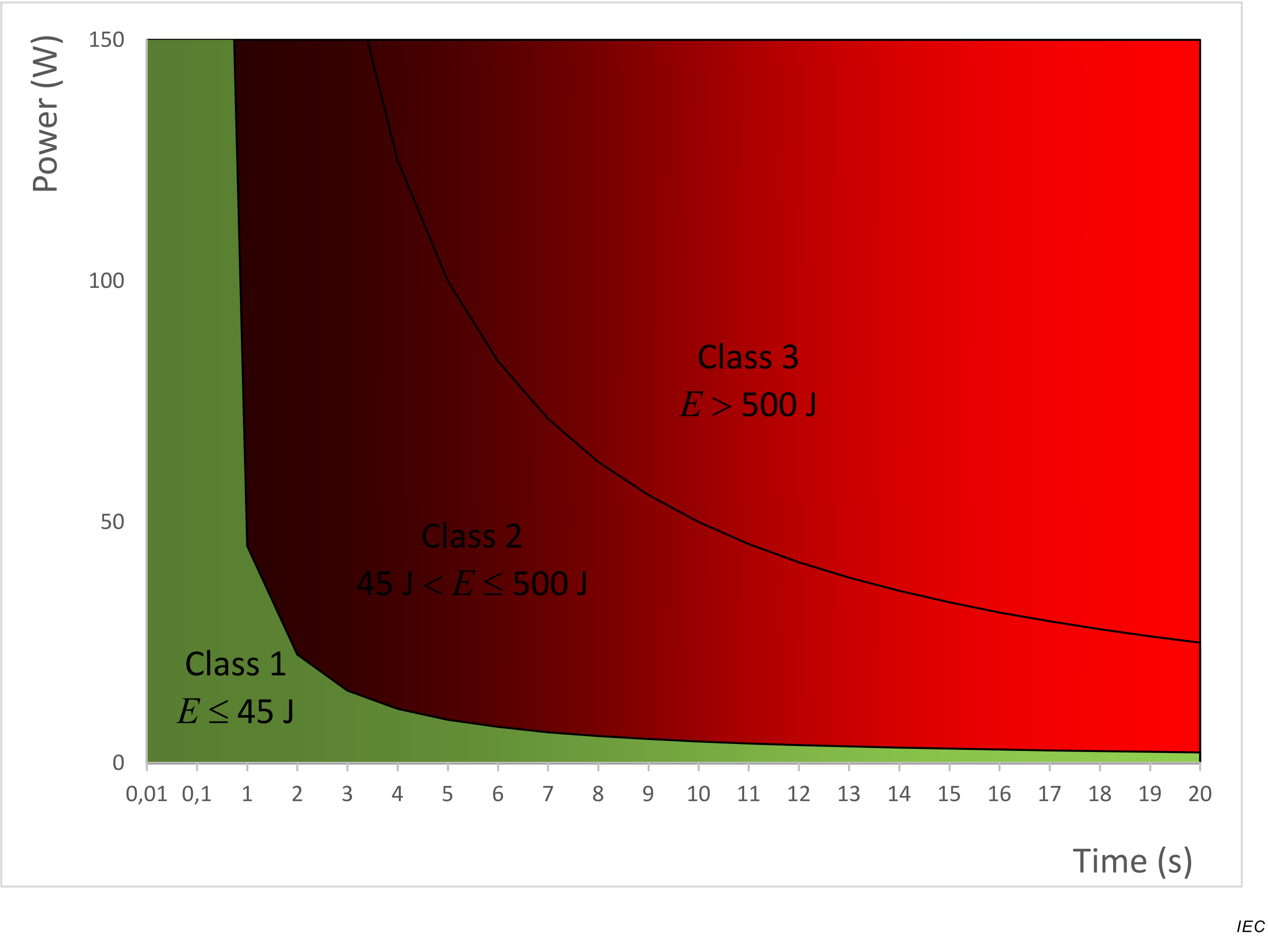

Figure 2 – Illustration of energy limits related to fire and ignition

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[4] IEC 60335-1, *Household and similar electrical appliances - Safety - Part 1: General requirements*

[5] IEC 60309-1, *Plugs, socket-outlets and couplers for industrial purposes - Part 1: General requirements*

[6] IEC 60695-1-12, *Fire hazard testing - Part 1-12: Guidance for assessing the fire hazard of electrotechnical products - Fire safety engineering*

[7] IEC 60695-1-20, *Fire hazard testing - Part 1-20: Guidance for assessing the fire hazard of electrotechnical products - Ignitability - General guidance*

[8] IEC 60950-1, *Information technology equipment - Safety - Part 1: General requirements*

[9] IEC TR 62368-2, *Audio/video, information and communication technology equipment - Part 2: Explanatory information related to IEC 62368-1*

[10] IEC GUIDE 116:2010, *Guidelines for safety related risk assessment and risk reduction for low voltage equipment*

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch