IEC TR 62222

Edition 3.0 2021-01

TECHNICAL REPORT

Fire performance of communication cables installed in buildings

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Fire performance of communication cables installed in buildings

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FIRE PERFORMANCE OF COMMUNICATION CABLES INSTALLED IN BUILDINGS

FOREWORD

IEC TR 62222 has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is a Technical Report.

This third edition cancels and replaces the second edition published in 2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) Scope rewritten to clarify and bring into line current understanding from other technical sources;

b) Normative References updated to be in line with the most recent technical definitions and new additions;

c) new additional terms and definitions added to Annex F since these are not used in the document;

d) new inclusions to the list of abbreviated terms, some corrections;

e) project reports are now in Annex E, for information only;

f) Subclause 4.2 Mitigation of fire hazards, about fire protection, updated with clearer information on standards plus updates where new standards have been published or amended;

g) test methods, test methods conclusions and fire performance updated.

The text of this Technical Report is based on the following documents:

DTR	Report on voting
46C/1151/DTR	46C/1156/RVDTR

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

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

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

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- withdrawn,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

INTRODUCTION

IEC TR 62222:2005 was the first attempt in understanding the potential fire hazards concerning new installations where large quantities of data cable are involved. Although it is important to remember that data cables will probably not spontaneously combust and offices are still filled with other highly flammable products, the increase of "flood wiring" should be a building design concern. IEC TR 62222:2012 attempted to align all the installation guides found and further improve safety with fire and its possible transmission.

FIRE PERFORMANCE OF COMMUNICATION CABLES INSTALLED IN BUILDINGS

1 Scope

This document describes the test methods for various parameters relating to the reaction to fire properties of metallic and optical fibre communications cables. The parameters have particular importance for cables intended to be installed within buildings and other structures.

This document also maps the test methods and associated limits applied to the fire hazards created by particular installation conditions and which can be referenced by other international, regional and national standards. For example, it is important that compliance with the requirements and recommendations for installation methods in ISO/IEC 14763-2 taking into consideration this document improve safety concerning fire.

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

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

3.1.1
asphyxiant
toxicant that causes hypoxia, which can result in central nervous system depression or cardiovascular effects

[SOURCE: ISO 13943:2017, 3.23, modified – The note to entry has been removed.]

3.1.2
cabling
system of telecommunication cables, cords and connecting hardware that supports the connection of information technology equipment

[SOURCE: ISO/IEC 11801-1:2017, 3.1.21]

3.1.3
chimney effect
upward movement of hot fire effluent caused by convection currents confined within an essentially vertical enclosure

[SOURCE: ISO 13943:2017, 3.50, modified – The note to entry has been removed.]

3.1.4
combustible
capable of being ignited and burned

[SOURCE: ISO 13943:2017, 3.52]

3.1.5
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 13943:2017, 3.55]

3.1.6
communication cable
assembly of suitably insulated coaxial conductors, twisted pairs of insulated conductors or optical fibres fabricated to meet transmission, mechanical and environmental requirements, and sufficient to allow conveyance of information between two points with the minimum of radiation

3.1.7
compartment
discrete fire zone designed to contain a fire within that zone

Note 1 to entry: Compartments are also known as "fire compartments".

3.1.8
compartmentation
division of premises into compartments in order to provide protection for the rest of the premises

3.1.9
convection
transfer of heat by movement of a fluid

[SOURCE: ISO 13943:2017, 3.66]

3.1.10
contribution to fire
energy released by a product influencing the fire growth

3.1.11
corrosion damage
physical and/or chemical damage or impaired function caused by chemical action

[SOURCE: ISO 13943:2017, 3.69]

3.1.12
damaged length
maximum extent in a specified direction of damaged area

3.1.13
enclosure
<built environment> volume defined by bounding surfaces, which may have one or more openings

[SOURCE: ISO 13943:2017, 3.92]

3.1.14
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 relate to specific types of self-supporting combustion with different meanings. Of these three, two of them are designated using two different terms in both French and German.

[SOURCE: ISO 13943:2017, 3.114]

3.1.15
fire attack
thermal attack by fire test burner

3.1.16
fire compartment
enclosed space, which may be subdivided, separated from adjoining spaces by fire barriers

[SOURCE: ISO 13943:2017, 3.120]

3.1.17
fire danger
concept including both fire hazard and fire risk

[SOURCE: ISO 13943:2017, 3.121, modified – The note to entry has been removed.]

3.1.18
fire effluent
totality of gases and aerosols, including suspended particles, created by combustion or pyrolysis in a fire

[SOURCE: ISO 13943:2017, 3.123, modified – The definition has been rephrased.]

3.1.19
fire growth
stage of fire development during which the heat release rate and the temperature of the fire are increasing

[SOURCE: ISO 13943:2017, 3.129]

3.1.20
fire growth rate index
FIGRA index
highest value of the quotient between heat release rate (HRR) and time

Note 1 to entry: In this report FIGRA is expressed in W/s.

3.1.21
fire hazard
potential for harm associated with fire

Note 1 to entry: Alternatively, fire hazard can be a physical object or condition with a potential for an undesirable consequence from fire.

[SOURCE: ISO 13943:2017, 3.131]

3.1.22
fire load
quantity of heat which could be released by the complete combustion of all the combustible materials in a volume, including the facings and bounding surfaces

Note 1 to entry: Fire load may be based on effective heat of combustion, gross heat of combustion, or net heat of combustion as required by the specifier.

[SOURCE: ISO 13943:2017, 3.134, modified – Note 2 to entry and Note 3 to entry have been removed.]

3.1.23
fire performance
response of a material, product or assembly in a fire

[SOURCE: ISO 13943:2017, 3.137, modified – The notes to entry have been removed.]

3.1.24
fire propagation
combination of flame spread and spread of fire effluent

[SOURCE: ISO 13943:2017, 3.140]

3.1.25
fire resistance
ability of a test specimen to withstand fire or give protection from it for a period of time

Note 1 to entry: Typical criteria used to asses fire resistance in a standard fire test are fire integrity, fire stability and thermal insulation.

[SOURCE: ISO 13943:2017, 3.141, modified – Note 2 to entry has been removed.]

3.1.26
fire risk
estimation of expected fire loss that combines the potential for harm in various fire scenarios that can occur with the probabilities of occurrence of those scenarios

Note 1 to entry: An alternate definition of fire risk is, "combination of the probability of a fire and a quantified measure of its consequence".

Note 2 to entry: Fire risk is often calculated as the product of probability and consequence.

[SOURCE: ISO 13943:2017, 3.145]

3.1.27
fire scenario
qualitative description of the course of a fire with respect to time, identifying key events that characterize the studied fire and differentiate it from other possible fires

[SOURCE: ISO 13943:2017, 3.152, modified – The note to entry has been removed.]

3.1.28
fire severity
capacity of a fire to cause damage

[SOURCE: ISO 13943:2017, 3.155, modified – The note to entry has been removed.]

3.1.29
fire test
test that measures fire behaviour or exposes an item to the effects of a fire or reaction to fire of the test specimen

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 13943:2017, 3.157, modified – The words "or reaction to the fire of the test specimen" have been added to the definition.]

3.1.30
fire stability
fire resistance ability of a building element to resist collapse for a stated period of time in a standard fire resistance test

Note 1 to entry: The building element may or may not be load-bearing.

3.1.31
fire safety objective
desired outcome with respect to the probability of an unwanted fire, relative to essential aspects of the built environment

Note 1 to entry: The essential aspects typically relate to the issues of life safety, conservation of property, continuity of operations, protection of the environment and preservation of heritage.

[SOURCE: ISO 13943:2017, 3.151]

3.1.32
flame, noun
rapid, self-sustaining, sub-sonic propagation of combustion in a gaseous medium, usually with the emission of light

[SOURCE: ISO 13943:2017, 3.159]

3.1.33
flame, verb
produce flame

[SOURCE: ISO 13943:2017, 3.160]

3.1.34
flame retarded
treated with a flame retardant

[SOURCE: ISO 13943:2017, 3.167, modified – The note to entry has been removed.]

3.1.35
flame application time
period of time for which a burner flame is applied to a test specimen

[SOURCE: ISO 13943:2017, 3.161]

3.1.36
flame retardant
substance which suppresses or delays the appearance of a flame and/or reduces the flame spread rate

3.1.37
flame retardance
property of a material whereby flaming combustion is slowed, terminated or prevented

Note 1 to entry: Flame retardance can be an inherent property of the basic material or it may be imparted by specific treatment.

Note 2 to entry: The degree of the flame retardance exhibited by a material during testing can vary with the test conditions.

3.1.38
flame spread
propagation of a flame front

[SOURCE: ISO 13943:2017, 3.168]

3.1.39
flame spread rate
DEPRECATED: burning rate
DEPRECATED: rate of burning
distance travelled by a flame front during its propagation, divided by the time of travel, under specified conditions

[SOURCE: ISO 13943:2017, 3.169, modified – The note to entry has been removed.]

3.1.40
flaming
continuation of the presence of a flame after its first appearance

[SOURCE: ISO 13943:2017, 3.174]

3.1.41
flaming droplets
flaming molten or flaming liquefied drops which fall from the test specimen during the fire test and continue to burn on the floor

[SOURCE: ISO 13943:2017, 3.177]

3.1.42
flammability
ability of a material or product to burn with a flame under specified conditions

[SOURCE: ISO 13943:2017, 3.178]

3.1.43
flammable
capable of flaming combustion under specified conditions

[SOURCE: ISO 13943:2017, 3.180]

3.1.44
flashover
<stage of fire> transition state of total surface involvement in a fire of combustible materials within an enclosure

[SOURCE: ISO 13943:2017, 3.184]

3.1.45
fuel
substance which can react exothermically with an oxidizing agent

[SOURCE: ISO 13943:2017, 3.189]

3.1.46
gross heat of combustion
heat of combustion of a substance when the combustion is complete and any produced water is entirely condensed under specified conditions

[SOURCE: ISO 13943:2017, 3.198, modified – The notes to entry have been removed.]

3.1.47
halogen free
free from halogen according to IEC 60754-2

Note 1 to entry: When added to abbreviations, "halogen free, HF" can be added to mean that the material also should be low smoke and have some resistance to ignitability, e.g. HF = halogen free, LS=low smoke, HFFR = halogen free flame retardant, HFFR LS = halogen free, flame retardant and low smoke!

3.1.48
heat of combustion
DEPRECATED: calorific potential
DEPRECATED: calorific value
thermal energy produced by combustion of unit mass of a given substance

Note 1 to entry: The typical unit is kilojoule per gram ($kJ \cdot g^{-1}$).

[SOURCE: ISO 13943:2017, 3.203, modified – Note 1 to entry has been removed.]

3.1.49
heat release
thermal energy produced by combustion

[SOURCE: ISO 13943:2017, 3.205, modified – The note to entry has been removed.]

3.1.50
heat release rate
HRR
DEPRECATED: burning rate
DEPRECATED: rate of burning
rate of thermal energy production generated by combustion

[SOURCE: ISO 13943:2017, 3.206, modified – The abbreviated term "HRR" has been added, and the note to entry has been removed.]

3.1.51
ignitability
measure of the ease with which a test specimen can be ignited, under specified conditions

[SOURCE: ISO 13943:2017, 3.212, modified – The synonym "ease of ignition" and the notes to entry have been removed.]

3.1.52
ignitable
capable of being ignited

[SOURCE: ISO 13943:2017, 3.213]

3.1.53
ignited
caused to be in a state of undergoing combustion

[SOURCE: ISO 13943:2017, 3.216]

3.1.54
irritant
<pulmonary> gas or aerosol that stimulates nerve receptors in the lower respiratory tract, which may result in breathing discomfort

Note 1 to entry: Examples of breathing discomfort are dyspnoea and an increase in respiratory rate. In severe cases, pneumonitis or pulmonary oedema (which can be fatal) may occur some hours after exposure.

[SOURCE: ISO 13943:2017, 3.238]

3.1.55
opacity of smoke
ratio of incident light intensity to transmitted light intensity through smoke, under specified conditions

Note 1 to entry: The opacity of smoke is the reciprocal of transmittance.

Note 2 to entry: The opacity of smoke is dimensionless.

[SOURCE: ISO 13943:2017, 3.287, modified – Note 1 to entry has been removed.]

3.1.56
optical density of smoke
measure of the attenuation of a light beam passing through smoke expressed as the logarithm to the base 10 of the opacity of smoke

Note 1 to entry: The optical density of smoke is dimensionless.

[SOURCE: ISO 13943:2017, 3.288, modified – Note 1 to entry has been removed.]

3.1.57
oxidizing agent
substance capable of causing oxidation

[SOURCE: ISO 13943:2017, 3.290, modified – The note to entry has been deleted.]

3.1.58
reaction to fire
response of a product in contributing by its own decomposition to a fire to which it is exposed, under specified conditions

3.1.59
reference fire scenario
fire scenario used as the basis of a fire test which is intended to reproduce specific aspects of a fire in the built environment

[SOURCE: ISO 13943:2017, 3.327]

3.1.60
small fire attack
thermal attack produced by a small flame such as a match or lighter

3.1.61
smoke hazard
potential for injury and/or damage from smoke

3.1.62
smoke
visible part of fire effluent

[SOURCE: ISO 13943:2017, 3.347]

3.1.63
smoke production
amount of smoke which is produced in a fire or fire test

Note 1 to entry: Compare with the term "extinction area of smoke".

Note 2 to entry: The typical unit is m^2.

[SOURCE: ISO 13943:2017, 3.350]

3.1.64
smoke production rate
amount of smoke produced per unit time in a fire or fire test

Note 1 to entry: It is calculated as the product of the volumetric flow rate of smoke and the extinction coefficient of the smoke at the point of measurement.

Note 2 to entry: The typical unit is square metres per second (m^2s^{-1}).

[SOURCE: ISO 13943:2017, 3.351, modified – The notes to entry have been reformulated.]

3.1.65
toxic
poisonous

3.1.66
toxicant
toxin
toxic substance

[SOURCE: ISO 13943:2017, 3.404]

3.2 Abbreviated terms

CENELEC	European Committee for Electrotechnical Standardization
CPR	Construction Products Regulation
CSA	Canadian Standards Association
EN	European norm (coming from CENELEC)
FEP	fluorinated ethylene propylene
FIPEC	fire performance of electric cables [4][1]
HR	heat release
HRR	heat release rate
ISO	International Organization for Standardization
NFPA	National Fire Protection Association
OD	optical density
PE	polyethylene
PP	polypropylene
PTFE	polytetrafluoroethylene
PVC	polyvinyl chloride
PVDF	polyvinylidene fluoride
SP	smoke production
SPR	smoke production rate
THR	total heat release
TSP	total smoke production
UL	Underwriters Laboratories Inc.

4 Communications cabling in buildings

4.1 Installations and associated fire danger

Large buildings are being designed and constructed using similar architectural techniques resulting in the distribution of utilities using risers between floors, raised floors and suspended ceilings – all of which act as building voids through which fire and smoke can spread.

These building voids accommodate cables to serve a variety of purposes. In new offices, it is common for more than 80 % of cables (by length) to be communication cables which increase the fuel load (flammability) of the building in the event of a fire – an aspect addressed by local regulations and standards such as ISO/IEC 14763-2 (and EN 50174-2 in Europe).

As transmission rates have increased from kilobits/s to many Gigabits/s, system upgrades to higher performance cables and components have been necessary leading to the multiple phases of installation of communications cables, mainly in hidden voids.

The majority of the communications cables support the structured cabling systems specified by ISO/IEC 11801 (all parts), EN 50173 (all parts) and ANSI/TIA-568 (all parts), termed generic information technology cabling systems, which serve data centres (computer rooms) and information technology service distribution throughout office, industrial and residential premises.

[1] Numbers in square brackets refer to the Bibliography.

More recently, standards for remote powering over generic information technology cabling have resulted in a further increase in installations to support distributed building services in all types of premises.

Whilst cables may be installed in conformance with a required transmission performance, they are unlikely to perform in the same manner under fire conditions. The reaction to fire tests do not normally assess transmission performance. The pass/fail criteria for resistance to fire tests are typically a simple degradation in cable transmission performance, which might not ensure that the system itself continues to perform at the required level.

The generic structured cabling system is a hierarchical star network linking distributors to other distributors and to outlets distributed throughout the premises. Cables are routed in risers between floors and in ceiling and underfloor voids. Even in a small office, this leads to a large number of cables being run in building voids.

Generic cabling systems use copper conductor cables manufactured to IEC 61156 (all parts) (EN 50288 series in Europe) and optical cables manufactured to IEC 60794-2 (all parts). These standards detail electrical and optical transmission requirements, mechanical performance and environmental characteristics. Communication cables operating at low voltages and currents are not a primary cause of fires, but their widespread use means that they may be involved in outbreaks of fire from an external source.

In order to define the appropriate fire test methods and performance requirements, it is necessary to consider the fire hazards presented by typical cable installations.

IEC 60695-1-10 gives general guidance on the fire hazards of electrotechnical products.

A review of typical installations of communication cables in buildings, summarised in Annex A, suggests the following general trends.

a) In public buildings such as airports, shops and older commercial offices with solid floors, cables are generally installed in ceiling voids with some local cabling in wall ducts. Standards specify segregation of communication and power cables in relation to electromagnetic interference and local regulations generally require segregation for electrical safety.
b) Generally, in offices and newer commercial offices, cables are installed in ceiling/underfloor voids and wall ducts. Lighting power cables and some communication cables are run in ceiling voids, whilst computer and telephone cables and their associated low voltage power cables are often run in underfloor voids. Again, standards specify segregation of communication and power cables in relation to electromagnetic interference and local regulations generally require segregation for electrical safety. In such installations, relatively shallow raised flooring provides the underfloor voids.
c) In newer large commercial offices with extensive computer facilities, the raised flooring is deep (1,0 m to 1,5 m is not uncommon) and can both accommodate cables and provide environmental air to information technology and other equipment.
d) Underfloor and ceiling voids can have particular airflow dynamics, especially where proper compartmentation was not considered, which could be reflected in the test method. In general, as airflow rate increases or another sufficient fire source energy in any given apparatus raises, the risk of fire propagation increases.
e) A considerable quantity of cables can be installed in vertical riser shafts where a chimney effect could result in the event of a fire. For convenience, these may be the same cables as are used for horizontal runs.
f) Patch cords and work area cables, whilst not permanently installed in buildings, often accumulate in large numbers and have been included in the scope of this document.
g) In many installations, cables can run behind and within walls.

4.2 Mitigation of fire hazards

4.2.1 Balanced approach

A balanced approach to fire mitigation should be used wherever possible. Assessing in isolation, i.e. using room by room designs, using test methods or fire hazards or mitigation shall be avoided.

4.2.2 Fire hazard management

Before considering the fire hazard and the fire safety objective, compartmentation should already have been considered. In cases where the location and contents of specific compartments remove the need to consider fire hazards as described in Table 1, the maintenance of the boundaries of those compartments is critical to the fire performance on the premises as a whole.

Table 1 – Traditional ranking of fire hazards

Ranking	Installations where evacuation of personnel is critical	General installations	Installations where protection of equipment is critical
0 (most important)	Ignitability	Ignitability	Ignitability
1	Smoke	heat release/flame spread	Corrosive fire effluent
2	Heat release/flame spread	Smoke	Heat release/flame spread
3	Toxic fire effluent	Corrosive fire effluent	Smoke
4 (least important)	Corrosive fire effluent	Toxic fire effluent	Toxic fire effluent

The fire hazard of each compartment should be assessed in accordance with Table 1, which gives an indication of the degree of mitigation that is necessary in a variety of installations. Other factors should be considered as part of the risk assessment and business continuity analysis. The assessment should consider:

a) architectural considerations;
b) the fabric and contents of the compartment building;
c) the requirements of the owners, landlords, tenants and insurers, including for example
   1) protection of the building and its personnel;
   2) business continuity;
   3) aesthetics and finish;
   4) electrical and optical performance of the cabling system;
d) the nature of the fire hazard;
e) the extent of the fire load within the local area where the cable is being installed including, for example:
   1) debris fire (small fire attack) waste paper/plastics collection areas, bins or boxes;
   2) furniture, density of the office, open plan;
   3) arson, ground floor, access or side streets;
f) chimney effects;
g) forced air environments.

In such cases, the use of cables with enhanced fire performance should be considered.

4.2.3 Compartmentation

When economies of scale, speed of installation and overall practicality have to be considered, a most economical solution could be chosen using a cable of lower fire performance consistent with the need to evacuate personnel (see Table 1), in which case it is necessary to:

a) apply increased levels of fire protection in certain compartments served by that cable, such as the use of water sprinklers or the use of non-combustible conduit; or
b) create additional sub-compartments in order to increase the level of fire protection; and/or
c) raise the level of fire performance of the cables.

5 Fire hazard

5.1 Fire hazard considerations

The traditional approach to the fire performance of cables was based on the hazards presented by the cable designs, cable-making materials and installations applicable at that time. Since then, new cable designs, materials and installation practices have been deployed, particularly for communication and computer cables.

Ease of ignition cannot be ignored but, with all fires, a material that is easiest to ignite (ignitable) will always be the first to develop flames; from this point on, fire engineering takes over.

Developments have taken place with regard to cable design, materials and installation practices, particularly associated with communications cabling. Recent and current research has introduced considerations of fire science and fire engineering, and discussions with fire professionals have shown their major concerns to be flame spread, heat (linked to flashover and structural collapse), smoke and toxic effluent (affecting building evacuation and fire-fighter safety).

The following guidance is now available:

- ISO 13571: Life-threatening components of fire; guidelines for the estimation of time to compromised tenability in fires;
- IEC 60695-1-10: Guidance for assessing the fire hazard of electrotechnical products; general requirements;
- IEC 60695-1-11: Guidance for assessing the fire hazard of electrotechnical products; fire hazard assessment.

Investigations of fires have shown that communication cables are not a primary source of fire. However, communication cables may be involved in, and contribute to the spread of, fires from other sources. Such sources include faults in power equipment, lighting equipment and more general fires caused by combustible waste.

NOTE Examples of fire spread routes are identified by ISO TC 92. Fire spread within roofs, above ceilings, below floors and through horizontal and vertical building voids are considered relevant to communication cables in buildings. For example, ISO 19706 discusses generation and nature of effluent.

Many more fires have occurred which have shown that communication cables are still not a primary source of fire, but they may be involved in fires caused, for example, by

- electrical faults in power equipment leading to riser cable fires;
- lighting fittings faults causing fires in concealed ceiling voids;
- rubbish fires and faults in cabinet fans resulting in computer room cabling fires.

The results of research indicate that, when considering suitable test methods to assess cable reaction to fire characteristics, the following should be taken into account.

a) Flame spread

Some test methods measure flame spread rate during the test, and others measure char length (damaged length) after the test. Some sheathing materials are designed to char in order to restrict flame propagation (flame retardance), in which case the char length after the test can be greater than the flame spread during the test. It is now recognised that the measurement of char at the completion of the test is not a measure of flame spread, and research such as the FIPEC project (see Annex E) suggests that heat release rate is a better measure of fire growth.

Attention is drawn to the guidance on surface spread of flame given in IEC 60695-9-1 and to the summary and relevance of test methods given in IEC 60695-9-2.

b) Heat

Heat is a fire hazard not currently addressed by IEC cable standards, but is addressed by EN 50399 (see 5.2). Generally, cables would be involved in a developing fire (contribution to fire), but with the advent of the IT office and workstations, a new fire hazard has been identified. This hazard starts with a fire in a waste paper basket under a workstation (common problem with cigarettes) which tests have shown can result in a 1 MW to 5 MW fire. Modern cable installation practices, particularly with structured wiring systems, have resulted in building voids becoming densely packed with communication cables, thereby increasing the fuel load. If redundant cables are not removed, many generations of cables may be present with different (and sometimes less safe) fire performances and different fuel loads. It is recommended therefore that cable fire performance requirements should include heat release as a major parameter. As a matter of good practice, cable installers should remove redundant cables before installing new ones. Attention is drawn to the guidance on heat release given in IEC 60695-8-1 and to the summary and relevance of test methods given in IEC 60695-8-2.

c) Smoke

When considering the evacuation of a building in an evolving fire scenario, smoke evolution and smoke density are critical hazards. Whilst smoke can be evaluated from many perspectives and has many components, the primary smoke hazard assessment parameter is the measurement of smoke obscuration or the visible part of the fire effluent. Several test methods exist for the separate measurement of total smoke production, smoke production rate or light transmittance (optical density of smoke).

Measurement of parameters such as rate of smoke production, peak smoke production rate, and total smoke production can enable the establishment of criteria to classify product performance. With measurements of light transmittance through the fire effluent and descriptions of peak and average optical density (in test methods EN 50399, NFPA 262 and EN 50289-4-11), peak smoke production rate and total smoke production at a given time, data can be generated to establish appropriate criteria for product performance and selection.

The traditional IEC 61034 series test is carried out on relatively short lengths of cable exposed to an alcohol fire source in a 27 m^3 by volume (cube) enclosure. Intended to represent a rubbish fire in an underground railway tunnel, it has no real scale scenario and it is not representative of communication cable installations in buildings.

Attention is drawn to the guidance on smoke opacity given in IEC 60695-6-1, and to IEC 60695-6-2 which gives a summary of smoke test methods, including comments on their relevance.

d) Effluent, toxic fire effluent

Fire effluent consists of a complex mixture of solid particulates, liquid aerosols, and gases. Although fires may generate effluent of widely differing compositions, toxicity tests have shown that gases are a major factor in the causes of acute toxicity. The predominant acute toxic effects may be separated into two classes:

- asphyxiant effects;
- sensory and/or upper respiratory irritation.

Both asphyxiants and irritants can incapacitate persons attempting to escape from a fire, and they can, ultimately, be lethal.

There is no real scale scenario or test method for the evaluation of the toxic hazard from burning cables. However, there are test methods to determine the toxic potency of fire effluent produced from the combustion of materials. Such toxic potency data can then be used as part of a hazard analysis.

Guidance on the toxicity of fire effluent is given in IEC 60695-7-1, and IEC 60695-7-2 gives a summary of toxicity test methods, including comments on their relevance. IEC 60695-7-3 describes the use and interpretation of toxicity test results.

e) Effluent, corrosion damage

Terms such as acid gas, acidity and conductivity defined by indirect measurements of halogen content and pH are not well understood in relation to fire hazards. In the first edition of IEC 60754 (from which the new edition of IEC 60754-1, IEC 60754-2 and IEC 60754-3 were derived), the hazard is described as the concern expressed by cable users over the amount of acid gas evolved when cable insulating, sheathing and other materials are burned, since this acid can cause extensive damage to electrical and electronic equipment not involved in the fire itself. It is also stated, although there is not a direct quantitative correlation between pH and corrosivity, the determination of pH and conductivity of evolved gases usually gives a qualitative indication of the possible corrosivity of the gases evolved during a fire. There is no real scale scenario for the hazard of acid gas, and the technical justification for the requirements in the IEC 60754-1, IEC 60754-2, and IEC 60754-3 series are not clear.

IEC 60695-5-1 gives general guidance on the corrosion damage effects of fire effluent, and points out that indirect tests which measure pH, conductivity and concentration of acids have the advantage of being relatively simple, but has the disadvantage that it does not measure corrosion damage. However, such damage can be assessed in terms of the damage to metal test specimens, or to the rate of functional impairment of test circuits. Such direct methods should be considered as more appropriate tests than those of IEC 60754 (all parts). IEC TS 60695-5-2 gives a summary of corrosivity test methods, including comments on their relevance.

f) Fire spread routes

Note should be made of the examples of fire spread routes as identified by ISO TC 92. Fire spread within roofs, above ceilings, below floors and through horizontal and vertical building voids are considered relevant to communication cables in buildings. For example, ISO 19706 discusses generation and nature of effluent.

5.2 Performance assessment

For over 30 years, the traditional approach to the fire performance of cables has been based on test methods and requirements developed in response to particular major fires such as power cable fires in vertical shafts in power stations, fires in underground railway tunnels and fires in telephone exchanges.

The main hazards from the involvement of cables in fires were seen as flame spread, heat release, smoke, acid gas and toxicity, but their importance was ranked differently depending on the type of installation, as shown in Table 1. For example:

- in general installations, flame spread was seen as the most important consideration;
- where evacuation of people was vital, smoke was ranked higher than flame spread;
- in installations where there were no or few people but expensive equipment critical to the business was present, the evolution of acid gas was seen as the greatest risk.

To evaluate cable fire performance in relation to the hazards in Table 1, several separate test methods were developed, though not all methods contained a requirement for cable performance when subject to the test.

- IEC 60332-1-2 is used to assess the vertical flame spread of single cables by measuring the length of char damage after completion of the test. The test uses a 1 kW burner and features minimum recommended requirements for the length of char to be less than 0,540 m. Table C.1 gives the applicable test methods and specifications as regards ignitability.

- Where risk of fire propagation is higher and for long runs with bunches of cable, IEC 60332-3 (all parts) specify test methods for vertical flame spread on bunched cables using a 20 kW burner. These documents contain minimum recommended requirements for the length of char to be less than 2,5 m. The series includes four categories A, B, C and D (IEC 60332-3-22, IEC 60332-3-23, IEC 60332-3-24 and IEC 60332-3-25, respectively) for different volumes of non-metallic material within the test sample. Category C (IEC 60332-3-24) has in the past been generally used for cables used within the generic cabling of ISO/IEC 11801 (all parts), EN 50173 and ANSI/TIA-568. Table C.2 gives the applicable test methods and specifications as regards vertical tests.

NOTE 1 The other categories are A (IEC 60332-3-22) and B (IEC60332-3-23), which are generally for large PVC cables, and D (IEC 60332-3-25, developed for cables of cross sectional area less than 35 mm^2). Large quantities of cable mounted on a cable does not necessarily define levels of severity as cable mounting has greater influence.

- Overall cable dimensions from a product to be tested guide the laboratory to which part of the IEC 60332-3 series is best suited for an indicative report. It is important that cables, especially data cables below 10 mm, are tested according to IEC 60332-3-24 or IEC 60332-3-25.
- Misuse of the individual parts can happen accidently through inexperience, for example claiming IEC 60332-3 approval should be avoided as it should always be justified with the correct section, for example IEC 60332-3-24. In the case of IEC 60332-3-22 with non-PVC small data cables, when the installation does not compact in large numbers in the same way, the result for the flame test is misguided. See FIPEC Final Report [4], discussed in Annex E, where similar issues conceal the true severity. When testing PVC cables, the reverse reaction can be found, making consideration for the IEC 60332-3-22 test more important.
- Heat release is addressed in EN 50399 testing capability and in 5.1 a) and 5.1 b).
- IEC 61034 (all parts) assesses smoke generated by samples of cables exposed to an alcohol fire source in a 27 m^3 by volume (cube) enclosure, where a minimum light transmittance of 60 % is required. Table C.4 gives the applicable test methods and specifications as regards indirect measurements of smoke.
- IEC 60754-1 is described as a test on gases evolved during combustion of materials from cables: determination of the halogen acid gas content from burning small samples of materials (approximately 1 g).
- IEC 60754-2 determines the acidity (PH measurement) and the conductivity of gases evolved during combustion of materials from cables.
- Thus, a cable fire performance meeting the minimum recommended requirements of a given part of the IEC 60332-3 series (generally IEC 60332-3-24), IEC 61034 series, IEC 60754-1 and IEC 60754-2 as shown in Table 2 has, in the past, been deemed to be satisfactory.

Within the European arena, EN 50399 has been developed to provide a test method for flame spread which also supports measurement of heat release (total and rate) and smoke (total and rate) and includes software to produce reporting as to the time to the first peak of both heat and smoke. An improved air inlet and method to mount cables has improved repeatability. The test includes a set up with a more severe test, where increased flame (30 kW) and a backboard mounted on the ladder are included for differentiation between the very high performance cables. Table B.1 shows the fire hazards, installations, applications and test methods for communication cables used in buildings.

NOTE 2 An important difference between the test method of IEC 60332-3 (all parts) and EN 50399 is the mounting of the cable sample on the ladder. For IEC 60332-3 (all parts), the cable samples having conductors of 35 mm^2 and below and optical cables are mounted in touching formation, whereas for EN 50399 the samples are arranged with a space.

Table 2 – Cable fire performance test methods

Parameter	Test method	Requirement
Flame spread – single cable	IEC 60332-1-2	Char less than 0,54 m at completions of test (minimum recommended requirement)
Flame spread – bunched cables	IEC 60332-3-24, Category C	Char less than 2,5 m at completion of the test (minimum recommended requirement)
Smoke	IEC 61034 (all parts)	Minimum light transmittance 60 %
Acid gas	IEC 60754-2	pH not less than 4,3 Conductivity not more than 10 µS/mm
Integrated test	EN 50399 (no IEC document yet)	Char, heat, rate of heat, smoke, FIGRA

6 Test methods

6.1 Review

Test methods are subject to continuing amendment and additions. The most up to date review of cable fire test methods is contained within the IEC TC 89 series of standards which give a summary and relevance of test methods for electrotechnical products. The methods addressed include flame spread, heat release, smoke, toxicity and corrosivity in addition to ignitability. A summary is given in Annex A of IEC 60695-1-10:2016. Cable test methods can be grouped and ranked in terms of severity as shown in Table 3 and a further review of the current status of these various test methods is shown in Annex C. Additional comments are given in 6.2 to 6.8.

Table 3 – Severity

Severity	Test method
Highest	NFPA 262; EN 50399 (30 kW); CSA FT6
⇧	UL 1666; EN 50399 (20 kW)
	IEC 60332-3 (all parts)
	UL 1685 (method 1)
Lowest	IEC 60332-1 (all parts); UL VW 1

6.2 NFPA 262

The NFPA 262 (formerly UL 910) real scale scenario is a horizontal ventilation shaft containing cables with a wood crib fire that produces 88 kW. The test was developed for building products and initially, the main interest was flame spread and smoke.

There are four types of apparatus worldwide (3 in the USA and 1 in Japan) that have undergone an extensive harmonisation. Table C.3 gives the applicable test methods and specifications as regards horizontal tests for forced air systems.

NFPA 262 is specified for cables for harsh environments in IEC 62012-1.

The recommended use for this test is in defining the fire performance of cables in the following:

- horizontal high-density telecommunication installations with forced air and low level detection and suppression systems;
- high-risk/high-hazard installations, for example aerospace, nautical, oil apparatuses, tunnels, etc.

Advantages:

- the test is capable of discriminating between the performances of different highly flame retarded cables;
- the test corresponds to a real scale fire scenario.

Disadvantages:

- there is only limited apparatus availability;
- the test is not suitable for cables that are not highly flame retarded.

6.3 EN 50399

Integrated fire test apparatus: this is based upon the IEC 60332-3 test apparatus but with advanced calibration, air flow and conditioning applied.

There are two scenarios where two fire attacks are available. One uses a 20 kW ignition source, and the other uses a 30 kW ignition source together with a backboard.

NOTE The 30 kW EN 50399 and NFPA 262 (UL 910) vertical tests are of a similar severity.

The main advantages compared to the IEC 60332-3 apparatus are as follows:

- an improved ventilation system as the air inlet and air flow are now specified;
- the sample selection is now not a consideration, the old method using litres of combustible material as the ladder is loaded by a single layer spaced only by the cable outside diameter;
- any apparatus to apparatus variation is reduced as a start-up calibration method removes discrepancies (pre-mix burner easy to calibrate) before a test can begin;
- an improved heat source for product differentiation using 2 methods;
- sample mounting improved; new mounting method has increased differentiation between relevant fire retardancy levels;
- a FIPEC reference fire scenario available to reference all tests;
- comprehensive test results generating "reaction to fire" data available after every test;
- an installation type bundle method of loading the ladder would disguise performance ensuring that the present single cable spaced version is worst case.

Disadvantages:

- an unrealistic premix burner compared to a real fire scenario;
- inconsistent results for cables under 5,0 mm due to bundling where interpretation of the bundle method and lay can change results;
- cable mounting does not represent installation practice as all communication installations rarely leave spaces;
- cable test method to differentiate clearly between cable families, not an installation test method indicating performance of bundled cables laid horizontally.

6.4 IEC 60332-3 (all parts)

This test was developed to simulate a fire in a vertical shaft in a power station with large electrical cables mounted on vertical ladders. There is no known reference scenario.

- IEC 60332-3-10: Apparatus
- IEC 60332-3-21: Category A F/R
- IEC 60332-3-22: Category A
- IEC 60332-3-23: Category B

- IEC 60332-3-24: Category C
- IEC 60332-3-25: Category D

Sample selection is based on non-metallic volume, category A requiring 7 l/m, category B requiring 3,5 l/m, category C requiring 1,5 l/m and category D requiring 0,5 l/m.

If this test is used for small communication cables, very large numbers of cables can be involved and the test becomes a material test that is not representative of typical horizontal installations of communication cables.

Initially, the only criterion of performance was a char length less than 2,5 m after completion of the test.

Advantages:

- the test apparatus equipment is widely available;
- guidance for large installations if required.

Disadvantages:

- un-calibrated air flow causing insufficient ventilation and air inlets placed anywhere on the floor of the apparatus;
- loading and sample selection is by volume of non-combustible material, which can cause interpretation by the operator loading cable (tight or loose layers?) causing variations to results even on the same cable types;
- some apparatus to apparatus variation by design and interpretation of layout;
- some limited harmonisation, usually between companies;
- some insufficient heat source for product differentiation, especially for higher flame resistance products;
- test has not shown to be relevant to communication cable installations (no real scale scenario);
- testing on completion does not generate "reaction to fire" data for fire engineering only a char length;
- uncontrolled apparatus environment due to little calibration especially from apparatus to apparatus;
- unrealistic pre-mix burner when compared to a real fire scenario situation;
- mounting method can hide weak cable performance.

6.5 UL 1666

This test method represents real installations of communication cables in a vertical riser shaft that breaches floors in a building. Samples are mounted in one layer touching, over a width of 300 mm.

The advantages include conditioned samples and simplicity of test.

Amongst the disadvantages are that smoke is not measured, and availability of the apparatus is limited.

6.6 UL 1685 and CSA FT4

UL 1685 represents vertical tray installations in a nuclear power station. It is a general purpose test for building wires, data and power cables and other relatively low fire performance cables. It has adequate airflow but is not environmentally controlled.

The samples are mounted in one layer, spaced over a width of 150 mm. The criteria of performance are char and smoke production with heat release as an option.

CSA FT4 is a Canadian test using the same method but with an angled burner and bundled cables resulting in a more stringent requirement. See Annex D.

6.7 Other considerations

6.7.1 Sample selection

Sample selection by volume of combustible material is not suitable for discriminating the fire performance of communication cables where the ratio of combustible to non-combustible materials is high. At 1,5 l/m, the test is a materials test, discriminating against the more sophisticated materials, for example cables using thinner thickness of higher performance materials would need a larger number of cables to keep the combustible content constant. The more cable lengths can actually disguise the result and indicate a performance that is better than expected. The ratio of metal to combustible material per cable can also enhance performance.

6.7.2 Cable mounting

Several test methods use cables mounted in bundles, either twisted or parallel with bundles generally spaced. IEC 60332-3-24, category C, uses cables touching in multiple layers whilst others use one layer of touching cables. Experience with testing cables in bundles has shown practical problems with achieving a consistent repeatable test configuration, for example single cable spacing as in EN 50399. For example, tightness of bundling can give either a chimney effect if slack, or protection to the centre cables if tight and the bundle configuration can be more or less severe depending on cable designs and materials. The problem is more pronounced if, as in the FIPEC test methods, the bundles are not twisted.

6.7.3 Conditioned environment

Only one test method calls for the test apparatus to be installed in a conditioned environment, and the harmonisation programme for NFPA 262 showed it to be important. Other tests such as IEC 60332-3-24, category C, and EN 13823 do not require such controls and more consideration needs to be given to which tests a conditioned environment is necessary and for which tests it is not important. For good practice, a conditioned environment is recommended. EN 50399 in comparison uses specialised calibration procedures before starting the testing that can only be achieved by a stable environment.

6.7.4 Reference scenario

It is essential that all test methods have a good correlation to a real scale scenario, an example of which is ISO 9705 (all parts).

As many as possible of the fire performance parameters for fire hazard assessment should be measured in the same integrated test method.

NOTE As an example, FIGRA is basically a parameter that measures the rate at which a construction product will contribute heat to a fire. See EN 13823 SBI test specimen. See ISO 11925-2 regarding small flame test. The room corner test (ISO 9705) was the "reference scenario" used in the development of the European classification system.

6.8 Test method conclusions

The main cable test methods could be the following four test methods.

a) A severe horizontal test such as EN 50289-4-11. This method can be used to define the enhanced fire performance required for high density and hazardous installations with forced air. A test duration (flame application time) of 20 min is recommended.

b) The tests of EN 50399, IEC 60332-1 (all parts), IEC 61034-2 and IEC 60754-2 are now the harmonised (legal European documents for a regulation) test methods for "CPR" [5] CE marked cables in Europe. After extensive trials and round robins, the overall result is one that shows good repeatability and reproducibility; something that the European legislation demands before allowing the regulation to become a legal harmonised document. This is an integrated test method using advanced measuring devices to collate a whole range of results that are used in fire safety engineering. Smoke density measurements are now collated using the EN 50399 tests, where there is a strong correlation between the amount of burn and the amount of smoke. Results formed from these tests, for the particular Euro Classes, give clearer perceptions to the smoke generated in a real fire situation. This new indicative source of smoke measurement increases the awareness of probable conditions relating to the real fire situation.

c) For ignitability, IEC 60332-1 (all parts) is an appropriate test for communication cables.

NOTE In some cases, the above ignitability test is not valid; in these cases, the less onerous tests of IEC 60332-2-2 can be used.

d) For installations with equipment critical to business continuity, a suitable corrosivity test is one that directly measures functional impairment.

7 Fire performance

7.1 Parameters

The traditional fire performance requirements specified in cable standards are no longer appropriate for modern installations of communication cables in buildings. In particular, an enhanced fire performance is necessary, when all advice for compartmentation and fire detection/suppression has been ignored, to mitigate the hazard presented by heavy concentrations of data cables in horizontal concealed spaces.

Research has shown that the hazards to be addressed in cable standards should now be heat, smoke, propagation, ignitability and effluents. The test parameters specified should relate to the end-use application and typical installation practices, and the test methods should have a good correlation to a real scale scenario.

Attention is drawn to the work of IEC TC 89 related to fire hazard testing, and the parameters addressed in IEC 60695 (all parts). These include the following, all of which are relevant to the burning behaviour of cables:

- peak heat release rate;
- total heat release;
- peak smoke production rate;
- total smoke production;
- peak optical density
- average optical density;
- flame spread;
- ignitability;
- flaming droplets;
- corrosion;
- toxicity.

7.2 Heat

The importance of heat release as a fire performance parameter is recognized by EN 13501-6 which specifies total heat release and FIGRA index measured in the EN 13823 test. The FIGRA index is a fire growth rate index derived from the peak heat release and the time at which the peak occurs.

For modern communication cables, the demanding electrical transmission requirements at high frequencies restrict the choice of insulating materials to a few electrically pure materials with low permittivity and dielectric losses. A wider choice of materials is available for sheathing, but when fire performance is important, consideration should be given to properties such as gross heat of combustion as shown in Table 4.

With these materials, two burning behaviours can be experienced with communication cables, those for which any burning occurs early, and those for which by the nature of their construction or sheathing materials, burning occurs at a later stage in a fire. For these parameters, the measure of fire performance is to address both peak heat release and total heat release, the latter being defined with values specified at various stages of the test. EN 50399 is a 20 min test and by measuring heat release throughout the test, and total heat release at 10 min and 20 min, fire growth can be specified.

The specified requirements (according to EN 13501-6) and test methods for heat are shown in Table 5.

Table 4 – Examples of materials for communication cables

Application	Material	Heat of combustion kJ/g
Insulation	PP (flammable)	46,5
Insulation	PE (flammable)	46,3
Sheath	Halogen free (flame retardant)	15 to 25
Sheath	uPVC	17,5
Sheath	PVDF	14,9
Sheath	PVC (low smoke)	4 to 15
Sheath/tubes	PBT	26,2
Insulation	FEP, PTFE, PTFE-Hexafluoropropylene (HFP)	5,1

Table 5 – Heat requirements of EN 13501-6

Test method			Geometry within an installation affecting safety[b]	Peak[a] HRR	Total HR[a]
Reference	Heat source kW	Airflow		kW	1 200 s MJ
EN 50399	30	8 m^3/min ± 0,4 m^3/min	Vertical/Horizontal	20	10
EN 50399	20	8 m^3/min ± 0,4 m^3/min	Vertical/Horizontal	30	15
EN 50399	20	8 m^3/min ± 0,4 m^3/min	Vertical/Horizontal	60	30
EN 50399	20	8 m^3/min ± 0,4 m^3/min	General	400	70

[a] Specified values according to EN 13501-6.

[b] Experience concludes that the testing geometry makes little difference to the result of an actual installation.

7.3 Effluent smoke

Smoke emission during a fire is an important element of fire safety, and performance should be specified for horizontal, vertical riser and general installations. A requirement for a real scale reference scenario applies to smoke as well as other reaction to fire parameters, and it is therefore appropriate to integrate smoke measurements into the fire performance test methods. EN 13501-6 defines smoke in terms of total smoke production and peak. This approach is preferred.

The recommended requirements and test methods for smoke are shown in Table 6.

Table 6 – Smoke requirements comparisons

Test method				Geometry of actual test	Peak SPR[a]	Total SP[a]	
Reference	Flame type	Heat source	Airflow			600 s	1200 s
					m^2/s	m^2	m^2
EN 50289-4-11	Diffusion	88 kW	7 m^3/min	Horizontal	0,35	75	80
EN 50399	Pre-mix	30 kW	8 m^3/min ± 0,4 m^3/min	Vertical	0,25		50
EN 50399	Pre-mix	20 kW	8 m^3/min ± 0,4 m^3/min	Vertical	0,25		50
EN 61034	Diffusion	1 l alcohol	Natural	Horizontal	Light transmittance > 60 %		

[a] Recommended values.

7.4 Propagation

Propagation is defined by flame spread. Regulation requiring the measurement of flame spread applies only to enhanced fire performance cables tested to NFPA 262, EN 50399, IEC 60332-1-2 and IEC 60332-3 (all parts).

7.5 Ignitability

The existing requirements of IEC 60332-1 (all parts) are deemed satisfactory for end-use applications such as exposed work area cables or patch cords.

7.6 Damaging effects of fire effluents

Taking into account the guidance given in IEC 60695-5-1 on corrosion, it is recommended that the damaging effects of fire effluents be assessed by a corrosivity test that directly measures functional impairment. For guidance on test methods, see IEC 60695-5-2.

7.7 Flaming droplets

EN 13501-6 requires the observation of any material separating from the samples during the EN 50399 test, and a measurement of the duration of any flaming. Flaming droplets can be a source of fire spread, and it is recommended that in tests to EN 50289-4-11 and EN 50399, the maximum duration of any such secondary flaming be specified as 10 s.

7.8 Toxicity

IEC 60695-7-1 gives general guidance on the toxicity of fire effluents. However, current knowledge of the specific hazards presented by cables is such that for the moment it is considered that any requirements for toxicity are beyond the expectations of cable specifications. IEC TC89 recognizes that the effective mitigation of toxic hazard from electrotechnical products is best accomplished by tests and regulations leading to improved resistance to ignition and to reduced rates of fire growth, thus limiting the level of exposure to fire effluent.

8 Legislation and regulation examples

There are many different regional and local regulations, codes and standards which become de-facto Codes of Practice (CoP), for example the following.

a) An EU (EU European Union part of EEA European Economic Area) overview of radical changes – the Construction Products Regulation (CPR) – has a significant impact on the fire performance requirements for cables.

The Construction Products Regulation was published by the European Commission in 1989, and has six essential requirements for building products, namely mechanical stability, safety in case of fire, health and environment, safety in use, protection against noise and energy economy. For safety in case of fire, a harmonised European system for the classification of the fire performance of building products and the corresponding test methods has been developed. The EN 50399 test proposed for fire classification (reaction to fire) of cables under the CPR was developed in part with the research by the FIPEC project, in which it was validated against real reference scenarios specific for cables. All "installed" products shall be tested for reaction to fire giving a complete insight to engineers/designers.

It should be noted that the CPR is not intended to harmonise regulation, or to impose regulation where none exists, but it is intended to harmonise the classification of the reaction to fire of products, and the test methods used. Countries now legislating to the new Construction Products Regulation have improved cable flame resistance, making these areas safer. When using the CPR classifications, found in EN 13501-6, decisions and choice are improved by the variety.

Self-certification of cable fire performance still exists generally, but the trend is for third party certification. Third party certification is practised in North America, and by the insurance industry, and required in Europe because of the CPR. The CPR system 1+ has also introduced a 3 year check of all products ensuring variance in materials/manufacturing process/test reliability is balanced and repeatable. Any manufacturing plant taking on the system 1+ has an audit twice a year of all materials and manufacturing process. The class structure is shown in Table 7.

Table 7 – Class structure of EN 13501-6

<table>
<tr><th>Euroclass (ca)</th><th>Classification criteria</th><th>Additional criteria</th><th>Attestation of conformity system</th></tr>
<tr><td>A</td><td>Gross heat of combustion
ISO 1716</td><td>NA</td><td rowspan="4">**1+**
Initial type-testing and continuous surveillance with audit testing of samples by 3rd party certification body
Factory production control (FPC) by manufacturer</td></tr>
<tr><td>B1</td><td rowspan="5">Heat release
Flame spread
EN 50399
Flame propagation
IEC 60332-1-2</td><td rowspan="5">Smoke production
(s1a, s1b, s1, s2, s3)
EN 50399 / IEC 61034-2
Acidity
(a1, a2, a3)
IEC 60754-2
Flaming droplets
(d0, d1, d2)
EN 50399</td></tr>
<tr><td>B2</td></tr>
<tr><td>C</td></tr>
<tr><td>D</td><td rowspan="2">**3**
Initial type-testing by 3rd party laboratory
FPC by manufacturer</td></tr>
<tr><td>E</td><td>Flame propagation
IEC 60332-1-2</td><td>NA</td></tr>
<tr><td>F</td><td>Requires a test to fail</td><td>NA</td><td>**4**
Initial type-testing and FPC by manufacturer</td></tr>
</table>

b) In Germany, guidance is related to numbers of people, escape routes and security conscious buildings using the CPR class B2ca as the minimum, otherwise Eca is generally used; these are advised through CoPs, for example EN 50174-2.

c) In the USA, building codes have stringent performance requirements. Cables installed in buildings are regulated by the National Electrical Code [6]. The fire performance requirements are specified either in code regulations (e.g. NFPA) or in specific product standards. Flame propagation and smoke are the main criteria for cables in building voids with forced air movement. This is achieved by either the use of highly flame retardant materials or installation of lower performing flame retardant cables into non-combustible conduit. Building codes are not mandatory; other codes that have different requirements can be used.

d) In the UK, there is very little or no regulation for the fire performance of cables using building regulations that implement severe restrictions on air flow and other contributing factors. There are de facto local regulations (local government, chief engineers) that mostly advise low smoke halogen free materials for large communal area such as airports, railway stations and hospitals. In the building regulations, the main concerns regarding fire safety are: preventing any movement of air from one compartment to another, means of escape, fire spread and access facilities for the fire service. Using the CoP (Constancy of Performance) ethos, British standards referenced within contracts can become legally binding. In addition, and in specific cases, certain standards are considered "instruments of regulation" where there is a serious accident or fatality. BS 7671, the UK standard for low voltage cabling installations is an example of such a standard. BS 7671 states that cables installed inside buildings should as a minimum meet IEC 60332-1-2 and, in specific areas of risk, consideration should be given to cables that pass IEC 60332-3-XX 1055 (XX being dependent on the type of cable matched to the relevant number in the series) with the production of smoke ensured by compliance with IEC 61034-1. Supplementary, and also separately, addressing telecommunications cables, BS 6701 adds to the basic requirement of the BS EN 50174 series (CPR classification Eca) by requiring cables in specified circumstances to meet CPR classification Cca-s1b, d2, a2.

e) In South Africa, there is little or no regulation for the fire performance of cables in dwellings and high-rise buildings. The wiring code provides for the segregation of power and communication cables as well as the certification of installations by means of physical examination and electrical testing, by accredited persons. In the building regulations, the main concerns regarding fire safety are means of escape, the prevention of fire spread by the use of firewalls, fire-fighting equipment and the accessibility of the premises for external fire-fighting. In the mining industry, although not regulated, underground power and communication cables generally have a superior fire performance.

f) France, Spain, Holland, Italy and others have legislation for public buildings, offices and other at risk or security conscious buildings, using the CPR classes. In most cases, these are now Cca requirements.

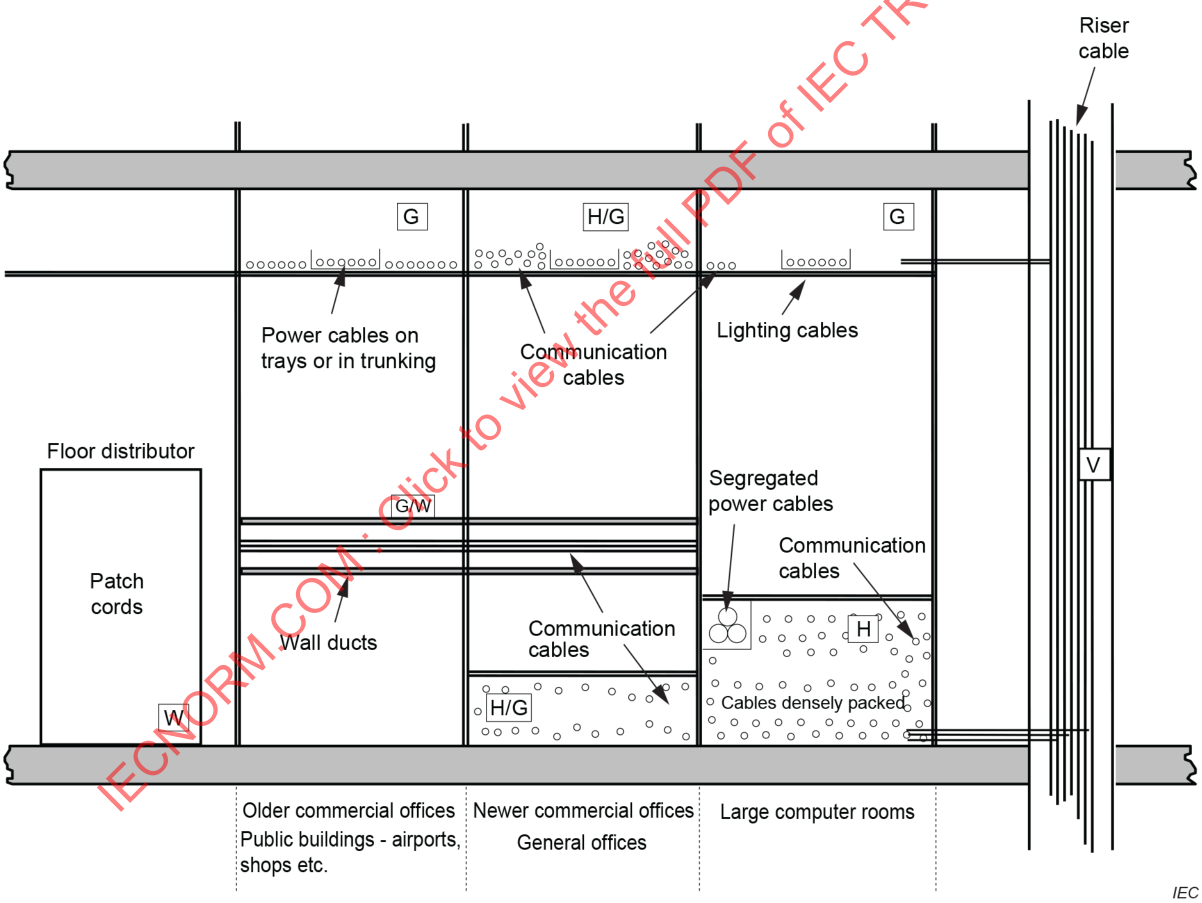
Annex A
(informative)

Typical communication cable installations

Figure A.1 indicates the locations of typical communication cabling installation (see Clause 8 for further information).

For the purposes of defining the fire hazards and the fire performance to be specified, the typical installations as described above and shown in Figure A.1 can be categorised as:

1) horizontal installations in building voids (designated H in Figure A.1);
2) vertical installations in riser shafts (designated V in Figure A.1);
3) general installations (designated G in Figure A.1);
4) exposed work areas (designated W in Figure A.1);
5) installations where protection of equipment is critical.



Installation categories: H = horizontal, G = general, V = vertical riser, W = work area

Figure A.1 – Typical installation locations

Annex B
(informative)

Fire hazards/installations/applications/test methods for communication cables in buildings

Table B.1 – Fire hazards/installations/applications/test methods for communication cables in buildings

Installation	Fire hazard parameter		Test methods
Installations where evacuation of personnel is critical	Heat flame spread Smoke	EN 50289-4-11 EN 50399 (30 kW)	EN 50399 (20 kW)
	Toxicity		Under consideration (IEC TC 89 and ISO TC 92)
Installations where protection of equipment is critical	Heat flame spread	EN 50289-4-11 EN 50399 (30 kW)	EN 50399 (20 kW)
	Corrosivity		A corrosivity test that directly measures functional impairment (see IEC 60695-5-2)
All other installations	Ignitability		IEC 60332-1 (all parts)

Annex C
(informative)

Review of test methods

Table C.1 – Ignitability

Test method	UL VW-1	IEC 60332-1 (all parts) and for thin cables IEC 60332-2-2
Cable orientation/ mounting	Vertical single wire or cable	Vertical single wire or cable
Test duration	Variable, 1,5 mm to 6 min	−1 variable, 60 s to 480 s: for -2-2 20 s
Heat source	500 W Tirrill burner mounted 20° to vertical, flame applied 5 times at 15 s (or more) intervals	1 kW Bunsen burner mounted 45° to vertical for IEC 60332-1; burner with diffusion flame mounted 45° to vertical for IEC 60332-2-2.
Airflow	Convection	Convection
Test specimen conditioning	Open laboratory but should be in a closed draught free chamber. Cables conditioned 48 h 50 % RH 23 °C	Open laboratory, but should be draught free. Cables conditioned 16 h 50 % RH 23 °C
Test runs	Varies	1 or 3 depending on results
Requirements if not specified in the cable specification	Max. burn distance 25,4 mm Max time after flame removal 60 s No flaming drips or sparks	Distance between top support and char less than 50 mm. If downward burning occurs, distance between it and top support should be less than 540 mm.
Real scale reference scenario	None	None
Major attribute	None	None
Test used for	Residential installations for low performance cables, appliance wire and building wire Small scale test for ignitability	Small scale test for ignitability
Advantages	Simple test for small wires and cables Available worldwide	Simple test for small wires and cables Available worldwide
Disadvantages	Not suitable for large cables Not generally used for communication cables	Does not test for flaming droplets (under consideration) IEC 60332-1 (all parts) not suitable for very thin copper and optical cables

Table C.2 – Vertical tests

Test method	UL 1685/CSA FT4	IEC 60332-3 (all parts)
Cable orientation and mounting	Vertical tray, 2,5 m long 300 mm wide 1 layer 152 mm wide cables spaced 0,5 x overall diameter For CSA FT4, cables are bundled Cable samples are mounted with a space to each other on the ladder. Cables with a diameter equal or smaller than 5 mm are bundled.	Vertical ladder, 2,5 m long, 500 mm wide. Multiple layers non-metallic 1,5 l/m for Cat C, 0,5 l/m for Cat D Layer width 300 mm The cable samples are mounted in two possible ways depending on the size: in touching formation or with a space.
Test duration	20 min	20 min
Heat source	20,6 kW burner, horizontal for UL 1685, angled 20 °C to horizontal for CSA FT4	20,6 kW burner
Airflow	Convection	5 000 l/min
Test specimen conditioning	Chamber in open laboratory, chamber should be dry Cables conditioned 3 h (minimum) at 23 °C	Chamber in open laboratory Cables conditioned 16 h at 20 °C
Test runs	2 in a row to pass	1 to pass
Requirements if not specified in the cable specification	Char 2,4 m for UL 1685, peak SPR 0,25 m^2/s TSP 95 m^2 over 20 min	Char 2,5 m
Real scale reference scenario	None	Unknown
Major attributes	None	None
Test used for	General purpose installations for data, power and low performance cables.	All cables
Advantages	HR and SP are easy to incorporate. Adequate airflow	Available worldwide HR and SP are easy to incorporate
Disadvantages	Only available in North America No HR or SP in CSA FT4 Not environmentally controlled	Insufficient ventilation. Mass volume loading (layers of cables) makes it a material test rather than a cable test. Variability of test apparatus, no round robin data. Heat flux too low for differentiation. Questionable relevance to communication cables. Not environmentally controlled. Does not generate data suitable for fire safety engineering purposes. The cable samples are mounted in two possible ways depending on the size: in touching formation or with a space.
Notes	Similar to IEC 60332-3 (all parts) except for airflow. CSA FT4 is more severe because of angled burner, bundled cables and char limit	Technical Report until recent conversion to a Standard. Originally developed for power cables on ladders in vertical shafts in power stations

Test method	UL 1666	EN 50399
Cable orientation and mounting	Vertical Single layer, cables touching, 300 mm wide Cables clamped at both ends – no tray or ladder	500 mm wide single layer single cable spacing Cable samples are mounted with a space to each other on the ladder. Cables with a diameter equal or smaller than 5 mm are bundled.
Test duration	30 min	20 min
Heat source	154 kW burner	20 kW or 30 kW
Airflow	Non-restricted convection – fan to impinge flame on cable	(8 000 ± 400) l/min
Test specimen conditioning	Chamber in open laboratory (controlled environment being introduced) Cable conditioned 24 h, 50 % RH, 23 °C	16 h at a temperature of (20 ± 10) °C.
Test runs	2 in a row to pass	1 to pass
Requirements if not specified in the cable specification	Flame height 3,6 m, temperature rise 472 °C	Depending on area of installation from data provided, e.g. FS HRR SPR etc.
Real scale reference scenario	None	Real scale test methods (vertical and horizontal) developed in the FIPEC project (see Annex E) and presented in the FIPEC Final Report [4]
Major attributes	Measures flame spread and temperature rise based on typical real installation	Integrated fire test taking detailed data throughout test after complete calibration
Test used for	Vertical installations in risers and shafts that breach floors	All installations
Advantages	Conditioned cables for test consistency Established test for communication cables HR and SP are easy to incorporate Environmental control being introduced	Repeatable. Calibrated. Good fire data for detailed engineering and fire safety
Disadvantages	No apparatus in Europe Does not measure smoke	Apparatus available. Extensive apparatus and calibration effort.
Notes		

Test	EN 50399 (30 kW)
Cable orientation and mounting	Vertical 500 mm wide single layer single cable spacing Cable samples are mounted with a space to each other on the ladder. Cables with a diameter equal or smaller than 5 mm are bundled.
Test duration	20 min
Heat source	30 kW burner
Airflow	(8 000 ± 400) l/min
Test specimen conditioning	16 h at a temperature of (20 ± 10) °C.
Test runs	1 to pass
Requirements if not specified in the cable specification	For NFPA 262, flame spread 1,75 m THR 10 Mj, HRR 20 kW
Real scale reference scenario	Based on real scale test methods (vertical and horizontal) developed in the FIPEC project (see Annex E) and presented in the FIPEC Final Report [4]
Major attributes	Measures reaction to fire for cables
Test used for	Horizontal high density communication cable installations High-risk, high-hazard installations, e.g. aircraft, ships, oil apparatuses etc. Installations subject to regulation
Advantages	Recognised for EU for regulation Several harmonised facilities (Europe 5 apparatuses) Detailed test Exhaustive calibration techniques EN 50399 includes heat and flaming droplets Less labour intensive than IEC 60332-3-24, category C
Disadvantages	Extensive apparatus and calibration effort.

Table C.3 – Horizontal tests for forced air systems

Test	EN 50289-4-11/NFPA 262
Cable orientation and mounting	Horizontal Cables side by side in a single 300 mm layer on a 7,5 m ladder
Test duration	20 min
Heat source	88 kW burner
Airflow	(8 000 ± 800) l/min
Test specimen conditioning	Chamber in environmentally controlled laboratory, cables conditioned 24 h, 50 % RH, 23 °C
Test runs	2 in a row to pass
Requirements if not specified in the cable specification	For NFPA 262, flame spread 1,5 m, peak OD 0,5 and average OD 0,15. Requirements for EN 50289-4-11 are given in the cable specifications.
Real scale reference scenario	The "Cardington" test apparatus for EN 50289-4-11; 2 rooms with connecting corridor for NFPA 262
Major attributes	Measures reaction to fire for cables
Test used for	Horizontal high density communication cable installations High-risk, high-hazard installations, e.g. aircraft, ships, oil apparatuses, etc. Installations subject to regulation
Advantages	R5 harmonised facilities (3 in USA, 1 in Japan) Detailed testing Reference cable used for calibration Controlled environment for consistent results with preconditioned cables EN 50289-4-11 includes heat and flaming droplets Less labour intensive than IEC 60332-3-24, Category C
Disadvantages	Limited number of test facilities