PD IEC/TR 62222:2012

BSI Standards Publication

Fire performance of communication cables installed in buildings

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National foreword

This Published Document is the UK implementation of IEC/TR 62222:2012. It supersedes PD IEC/TR 62222:2005 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/46, Cables, wires and waveguides, radio frequency connectors and accessories for communication and signalling.

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RAPPORT TECHNIQUE

Fire performance of communication cables installed in buildings

Tenue au feu des câbles de communication installés dans les bâtiments

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIRE PERFORMANCE OF COMMUNICATION CABLES INSTALLED IN BUILDINGS

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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IEC/TR 62222, which is a technical report, has been prepared by subcommittee 46C: Wires and symmetric cables, of IEC technical committee 46: Cables, wires, waveguides, r.f. connectors, r.f. and microwave passive components and accessories.

This second edition cancels and replaces the first edition published in 2005. It constitutes a technical revision.

The 2005 technical report 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. This second edition attempts to align all the installation guides found and further improve safety with fire and its possible transmission. Projects that formed the overall direction of the 2005 edition have been taken into account, enabling an overall general improvement of the document..

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

Enquiry draft	Report on voting
46C/959/DTR	46C/962/RVC

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

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

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- withdrawn,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

FIRE PERFORMANCE OF COMMUNICATION CABLES INSTALLED IN BUILDINGS

1 Scope

This Technical Report provides recommendations for the requirements and test methods to be specified for the fire performance of communication cables when installed in buildings.

The recommendations relate to typical applications and installation practices for copper and optical cables in buildings. This Technical Report includes an assessment of the fire hazards presented by such installations, and describes fire scenarios that have been established and the appropriate cable fire performances to mitigate these hazards. ISO/IEC 14763-2 recommends installation methods which, together with this Technical Report, provide guidelines for improving safety during fire.

The recommendations also take into account legislation and regulation applicable to the fire performance of cables, an assessment of known test methods and their ability to measure the recommended fire performance.

Power cables are usually segregated from communication cables for electrical safety and installed differently so they have not been addressed in this Technical Report.

2 Normative references

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

IEC 60332-1 (all parts), *Tests on electric and optical cables under fire conditions – Part 1: Test for vertical flame propagation for a single insulated wire or cable*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60332-1-3, *Tests on electric and optical fibre cables under fire conditions – Part 1-3: Test for vertical flame propagation for a single insulated wire or cable – Procedure for determination of flaming droplets/particles*

IEC 60332-2 (all parts), *Tests on electric and optical cables under fire conditions – Part 2: Test for vertical flame propagation for a single small insulated wire or cable*

IEC 60332-2-2, *Tests on electric and optical fibre cables under fire conditions – Part 2-2: Test for vertical flame propagation for a single small insulated wire or cable – Procedure for diffusion flame*

IEC 60332-3 (all parts), *Tests on electric and optical cables under fire conditions – Part 3: Test for vertical flame spread of vertically-mounted bunched wires or cables*

IEC 60332-3-24, *Tests on electric and optical fibre cables under fire conditions – Part 3-24: Test for vertical flame spread of vertically-mounted bunched wires or cables – Category C*

IEC 60695 (all parts), *Fire hazard testing*

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

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

IEC 60695-5-1, *Fire hazard testing – Part 5-1: Corrosion damage effects of fire effluent – General guidance*

IEC/TS 60695-5-2, *Fire hazard testing – Part 5-2: Corrosion damage effects of fire effluent – Summary and relevance of test methods*

IEC 60695-6-1, *Fire hazard testing – Part 6-1: Smoke obscuration – General guidance*

IEC 60695-6-2, *Fire hazard testing – Part 6-2: Smoke obscuration – Summary and relevance of test methods*

IEC 60695-7-1, *Fire hazard testing – Part 7-1: Toxicity of fire effluent – General guidance*

IEC 60695-7-2, *Toxicity of fire effluent – Part 7-2: Summary and relevance of test methods*

IEC 60695-7-3, *Fire hazard testing – Part 7-3: Toxicity of fire effluent – Use and interpretation of test results*

IEC 60695-8-1, *Fire hazard testing – Part 8-1: Heat release – General guidance*

IEC/TR 60695-8-2, *Fire hazard testing – Part 8-2: Heat release – Summary and relevance of test methods*

IEC 60695-9-1, *Fire hazard testing – Part 9-1: Surface spread of flame – General guidance*

IEC/TS 60695-9-2, *Fire hazard testing – Part 9-2: Surface spread of flame – Summary and relevance of test methods*

IEC 60754 (all parts), *Test on gases evolved during combustion of materials from cables*

IEC 60754-1, *Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content*

IEC 60754-2, *Test on gases evolved during combustion of materials from cables – Part 2: Determination of acidity (by pH measurement) and conductivity*

IEC 60794 (all parts), *Optical fibre cables*

IEC 61034 (all parts), *Measurement of smoke density of cables burning under defined conditions*

IEC 61034-1:2005, *Measurement of smoke density of cables burning under defined conditions – Part 1: Test apparatus*

IEC 61034-2:2005, *Measurement of smoke density of cables burning under defined conditions – Part 2: Test procedure and requirements*

IEC 61156 (all parts), *Multicore and symmetrical pair/quad cables for digital communications*

IEC 62012-1, *Multicore and symmetrical pair/quad cables for digital communications to be used in harsh environments – Part 1: Generic specification*

ISO/IEC 11801, *Information technology – Generic cabling for customer premises*

ISO 13571, *Life-threatening components of fire – Guidelines for the estimation of time available for escape using fire data*

ISO/IEC 13943:2008, *Fire safety – Vocabulary*

ISO/IEC 14763-2, *Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation*

ISO 9705, *Fire tests – Full-scale room test for surface products*

ISO 19706:2011, *Guidelines for assessing the fire threat to people*

EN 13501-1, *Fire classification of construction products and building elements – Part 1: Classification using test data from reaction to fire tests*

EN 13823, *Reaction to fire tests for building products – Building products, excluding floorings, exposed to the thermal attack by a single burning item*

EN 50174-2, *Information technology – cabling installation – Part 2 Installation planning and practises inside buildings*

EN 50267-2-3, *Common test methods for cables under fire conditions – Tests on gases evolved during combustion of materials from cables – Part 2-3: Procedures – Determination of degree of acidity of gases for cables by determination of the weighted average of pH and conductivity*

EN 50289-4-11, *Communication cables – Specifications for test methods – Part 4-11: Environmental test methods – A horizontal integrated fire test method*

EN 50399, *Common test methods for cables under fire conditions – Heat release and smoke production measurement on cables during flame spread test – Test apparatus, procedures, results*

BS 7671, *Requirements for electrical installations*

CSA FT4, Canadian Standards Association, *CSA 22.2 No. 03-01, Vertical flame test – Cables in cable trays*

CSA FT6, Canadian Standards Association, *CSA 22.2 No. 03-01, Horizontal flame and smoke test*

NFPA 262, *Standard method of test for flame travel and smoke of wires and cables for use in air handling spaces (formerly UL 910)*

UL 1666, Underwriters Laboratories, Inc., *Test for flame propagation height of electrical and optical fibre cables installed vertically in shafts*

UL 1685, Underwriters Laboratories, Inc., *Standard for vertical tray fire propagation and smoke release test for electrical and optical fibre cables*

UL VW-1, Underwriters Laboratories, Inc., *VW-1 (vertical specimen) flame test – UL 1581, Reference standard for electrical wires, cables and flexible cords*

3 Terms, definitions and abbreviations

For the purposes of this document, the terms and definitions given in ISO/IEC 13943, some of which are reproduced below for the user's convenience, as well as the following apply, together with some which are based on EN 13501-1.

3.1 Defined terms

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

[SOURCE: ISO 13943:2008, 4.17]

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

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

[SOURCE: ISO 13943:2008, 4.41]

3.1.4
combustible
capable of being ignited and burned

[SOURCE: ISO 13943:2008, 4.43]

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 13943:2008, 4.46]

3.1.6
fire compartment
enclosed space, which may be subdivided, separated from adjoining spaces by fire barriers

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

[SOURCE: ISO 13943:2008, 4.102]

3.1.7
compartmentation
division of a premise into compartments in order to provide protection for the rest of the premises

3.1.8
convection
transfer of heat by movement of a fluid

[SOURCE: ISO 13943:2008, 4.54]

3.1.9
contribution to fire
energy released by a product influencing the fire growth

3.1.10
corrosion damage
physical and/or chemical damage or impaired function caused by chemical action

[SOURCE: ISO 13943:2008, 4.56]

3.1.11
damaged length
maximum extent in a specified direction of damaged area

3.1.12
draught-free environment
space in which the results of experiments are not significantly affected by the local air speed

Note 1 to entry: A qualitative example sample is a space in which a wax candle flame (3.1.36) remains essentially undisturbed. Quantitative example examples are small-scale fire tests in which a maximum air speed of 0,1m.s^{-1} or 0,2 m.s^{-1} is sometimes specified.

[SOURCE: ISO 13943:2008, 4.70]

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

[SOURCE: ISO 13943:2008, 4.77]

3.1.14
end use application
real application of a product in relation to all aspects that influence the behaviour of that product under different fire situations

3.1.15
fire
<general> process of combustion characterized by the emission of heat and fire effluent and usually accompanied by smoke, flame, glowing or a combination thereof

3.1.16
fire attack
thermal attack by fire test burner

3.1.17
fire behaviour
change in, or maintenance of, the physical and/or chemical properties of an item and/or structure exposed to fire

Note 1 to entry: This concept covers both reaction to fire and fire resistance.

[SOURCE: ISO 13943:2008, 4.100]

3.1.18
fire compartment
enclosed space, which may be subdivided, separated from adjoining spaces by fire barriers

[SOURCE: ISO 13943:2008, 4.102]

3.1.19
fire danger
concept including both fire hazard and fire risk

[SOURCE: ISO 13943:2008, 4.103]

3.1.20
fire effluent
totality of gases and aerosols, including suspended particles, created by combustion or pyrolysis in a fire

[SOURCE: ISO 13943:2008, 4.105]

3.1.21
fire-effluent transport
movement of fire effluent from the location of the fire

[SOURCE: ISO 13943:2008, 4.107]

3.1.22
fire exposure
extent to which persons, animals or items are subjected to the conditions created by fire

[SOURCE: ISO 13943:2008, 4.108]

3.1.23
fire extinguishment
process that eliminates combustion

[SOURCE: ISO 13943:2008, 4.109]

3.1.24
fire growth
stage of fire development during which the heat release rate and the temperature of the fire are increasing

[SOURCE: ISO 13943:2008, 4.111]

3.1.25
fire growth rate index
FIGRA index
maximum quotient of heat release rate from a specimen and the time of its occurrence

3.1.26
fire hazard
physical object or condition with a potential for an undesirable consequence from fire

[SOURCE: ISO 13943:2008, 4.112]

3.1.27
fire load
quantity of heat which can 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: 4.114]

3.1.28
fire performance
response of a test specimen when exposed to a fire test

[SOURCE: ISO 13943:2008, 4.117]

3.1.29
fire propagation
combination of flame spread and spread of fire effluent

[SOURCE: ISO 13943:2008, 4.120]

3.1.30
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 assess fire resistance in a standard fire test are fire integrity, fire stability and thermal insulation material.

[SOURCE: ISO 13943:2008, 4.121]

3.1.31
fire retardance
flame retardance, fire retardant and flame retardant

[SOURCE: ISO 13943:2008, 4.122]

3.1.32
fire retardant, noun
substance added, or a treatment applied, to a material in order to delay ignition or to reduce the rate of combustion

[SOURCE: ISO 13943:2008, 4.123]

3.1.33
fire risk
probability of a fire combined with a quantified measure of its consequences

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

[SOURCE: ISO 13943:2008, 4.124]

3.1.34
fire safety management
application and service life maintenance of procedures to achieve fire-safety objectives

[SOURCE: ISO 13943:2008, 4.127]

3.1.35
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 13943:2008, 4.128]

3.1.36
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 13943:2008, 4.129]

3.1.37
fire severity
capacity of a fire to cause damage

[SOURCE: ISO 13943:2008, 4.130]

3.1.38
fire situation
stage in the development of a fire, characterized by the nature, severity and size of the thermal attack on the products involved

3.1.39
fire test
test that measures behaviour of a fire or exposes an item to the effects of a fire

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

[SOURCE: ISO 13943:2008, 4.132]

3.1.40
flame, noun
rapid, self-sustaining, sub-sonic propagation of combustion in a gaseous medium, usually with the emission of light

[SOURCE: ISO 13943:2008, 4.133]

3.1.41
flame, verb
produce flame

[SOURCE: ISO 13943:2008, 4.134]

3.1.42
flame application time
period of time for which a burner flame is applied to a test specimen

[SOURCE: ISO 13943:2008, 4.135]

3.1.43
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.

[SOURCE: ISO 13943:2008, 4.138]

3.1.44
flame retarded
treated with a flame retardant

[SOURCE: ISO 13943:2008, 4.141]

3.1.45
flame spread
propagation of a flame front

[SOURCE: ISO 13943:2008, 4.142]

3.1.46
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 13943:2008, 4.143]

3.1.47
flame-spread time
time taken by a flame front on a burning material to travel a specified distance on the surface, or to cover a specified surface area under specified conditions

[SOURCE: ISO 13943:2008, 4.144]

3.1.48
flaming, noun
continuation of the presence of a flame after its first appearance

[SOURCE: ISO 13943:2008, 4.147]

3.1.49
flaming combustion
combustion in the gaseous phase, usually with emission of light

[SOURCE: ISO 13943:2008, 4.148]

3.1.50
flaming debris
material separating from a burning item and continuing to flame during a fire or fire test

[SOURCE: ISO 13943:2008, 4.149]

3.1.51
flaming droplet
molten material separating from a burning item and continuing to flame during a fire or fire test method

[SOURCE: ISO 13943:2008, 4.150]

3.1.52
flammability
ability of a material or product to burn with a flame under specified conditions

[SOURCE: ISO 13943:2008, 4.151]

3.1.53
flammable
capable of flaming combustion under specified conditions

[SOURCE: ISO 13943:2008, 4.153]

3.1.54
flame retardant halogen free cable
material such as $EVA/Al(OH)_3$ based compounds for use on cable jackets

3.1.55
flashover
<stage of fire> transition state of total surface involvement in a fire of combustible materials within an enclosure

[SOURCE: ISO 13943:2008, 4.156]

3.1.56
fuel
substance that can react exothermically with an oxidizing agent

[SOURCE: ISO 13943:2008, 4.161]

3.1.57
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 13943:2008, 4.170]

3.1.58
heat flow rate
amount of thermal energy transferred per unit time

[SOURCE: ISO 13943:2008, 4.172]

3.1.59
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 units are kilojoules per gram ($k.J.g^{-1}$).

[SOURCE: ISO 13943:2008, 4.174]

3.1.60
heat release
thermal energy produced by combustion

[SOURCE: ISO 13943:2008, 4.176]

3.1.61
heat release rate
DEPRECATED: burning rate
DEPRECATED: rate of burning
rate of thermal energy production generated by combustion

[SOURCE: ISO 13943:2008, 4.177]

3.1.62
ignitability
ease of ignition
measure of the ease with which a test specimen can be ignited under specified conditions

[SOURCE: ISO 13943:2008, 4.182]

3.1.63
ignitable
capable of being ignited

[SOURCE: ISO 13943:2008, 4.183]

3.1.64
ignited
caused to be in a state of undergoing combustion

[SOURCE: ISO 13943:2008, 4.186]

3.1.65
irritant
<pulmonary> gas or aerosol that stimulates nerve receptors in the lower respiratory tract, which can 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) can occur some hours after exposure.

[SOURCE: ISO 13943:2008, 4.204]

3.1.66
opacity of smoke
ratio of incident light intensity to transmitted light intensity through smoke under specified conditions

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

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

[SOURCE: ISO 13943:2008, 4.243]

3.1.67
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 13943:2008, 4.244]

3.1.68
oxidising agent
substance capable of causing oxidation

[SOURCE: ISO 13943:2008, 4.246]

3.1.69
reaction to fire
response of a test specimen when it is exposed to fire under specified conditions in a fire

[SOURCE: ISO 13943:2008, 4.272]

3.1.70
reference scenario
hazard situation and environment used as a reference for a given test method

3.1.71
small fire attack
thermal attack produced by a small flame such as a match or lighter

3.1.72
smoke growth rate index
SMOGRA index
maximum value of SMOGRA attained during a test period, and SMOGRA is 10 000 × the quotient

3.1.73
smoke hazard
potential for injury and/or damage from smoke

3.1.74
smoke
visible part of fire effluent

[SOURCE: ISO 13943:2008, 4.293]

3.1.75
smoke production
amount of smoke produced per unit time in a fire or fire test

Note 1 to entry: The typical units are square metres (m^2).

[SOURCE: ISO 13943:2008, 4.294]

3.1.76
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 units are square metres per second (m^2s^{-1}).

[SOURCE: ISO 13943:2008, 4.295]

3.1.77
soot
particulate matter produced and deposited during or after combustion

[SOURCE: ISO 13943:2008, 4.298]

3.1.78
toxic
poisonous

[SOURCE: ISO 13943:2008, 4.335]

3.1.79
toxicant
toxin
toxic substance

[SOURCE: ISO 13943:2008, 4.340]

3.2 Abbreviations

The abbreviations are given in Table 1.

Table 1 – Abbreviations

Abbreviation	Definition
CENELEC	European committee for electrotechnical standardisation
CPR(R)	construction products regulation – (European regulation) [5][1]
CSA	Canadian standards association
EN	European standard
FEP	fluorinated ethylene-propylene
FIPEC	fire performance of electric cables [6]
HR	heat release
HRR	heat release rate
ISO	International standards organisation
LSPVC	low smoke flame retardant polyvinylchloride
NEMA	National electrical manufacturers association [4]
NES	naval engineering standard
NFPA	National fire protection association
OD	optical density
PCS	gross calorific potential (calorific potential is a deprecated term and it is now referred to by the term “heat of combustion”)
PE	polyethylene
PP	polypropylene
PTFE	polytetrafluoroethylene
PTFE HFP	polytetrafluorethylene-hexalfluoropropylene copolymer
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.

[1] Figures in square brackets refer to the bibliography.

4 Typical communication cable installations

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.

During the last decade, worldwide demand for information has resulted in increasing transmission data rates and developments in local area networks (LANs). In particular, the growing popularity of structured cabling systems as defined in ISO/IEC 11801, known as information technology cabling. The generic structured wiring cabling system is a hierarchical star network linking campus distributors to different building distributors, which in turn link to individual floor distributors which then connect with telecommunication outlets. On each floor, the riser cable, run in vertical shafts, connects to the distributor which transmits data via the horizontal cables to each outlet. In a typical installation, the outlets are arranged in a matrix layout spaced about 1 m or 2 m, with the horizontal cables run in ceiling or in bigger installations normally under-floor voids. Even in a small office, this leads to a large number of cables run in building voids.

The evolution of cabling (otherwise known as structured wiring) has coincided with a rapid increase in system data rates, from 10 kbps in the early 1980's to 600 Mbps in the late 1990's, and on to 10 GBit Ethernet™. As transmission rates increase, system upgrades to higher performance cables and components are typically necessary. This has led to the installation of many lengths of data cable, mainly in hidden voids.

Copper conductor cables manufactured to the IEC 61156 series and optical cables manufactured to the IEC 60794 series are used in structured wiring. 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. IEC 60695-1-10 gives general guidance on the fire hazards of electrotechnical products.

Typical communication installations in buildings are as shown in Annex A and can be grouped into the following descriptions.

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. Regulations generally require segregation of power cables for electrical safety.
b) Generally, in offices and newer commercial offices, cables are installed in ceiling/under-floor 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 under-floor voids. Again, regulations generally require the segregation of power cables (in conduit or trunking) for electrical safety. In such installations, relatively shallow raised flooring provides the under-floor 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 the void can be packed with communication cables. This void can also be used, in rare occasions, for the provision of environmental air to computer equipment.
d) Under-floor and ceiling voids can have particular airflow dynamics, especially where proper compartmentation was not considered, that could be reflected in the test method. In general, as airflow rate increases or another sufficient fire source energy in any given apparatus, the risk of fire propagation increases.
e) A considerable amount of cables can be installed in vertical riser shafts where a chimney effect could be found 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 Technical Report.

g) In many installations, there can also be a number of cables that run behind and within walls.

h) Large buildings are being designed and constructed worldwide by large multi-national businesses, resulting in similar architecture and distribution of utilities within the structure with raised floors and suspended ceilings creating building voids through which fire and smoke can spread. Over 80 % by length of cables installed in new offices are communication cables and that could increase the fuel load in the event of a fire, an aspect addressed by relevant IEC installation standards (in Europe see EN 50174-2) and local regulations.

i) For the purposes of defining the fire hazards and the fire performance to be specified, the typical installations as described above and shown in Annex A, can be categorized as in Table 2:

Table 2 – Typical cable installation categories

1	Horizontal installations in building voids
2	Vertical installations in riser shafts
3	General installations
4	Exposed work areas
5	Installations where protection of equipment is critical

5 Legislation and regulation

There are many different regional and local regulations. For example:

a) In Germany, the amount of cable allowed in a public building is based on PCS values of 50 MJ/m^2 for halogen free cables and 25 MJ/m^2 for PVC cables. Guidance on the calculation of PCS is given by the German insurers [2].

b) Building codes in the USA have stringent performance requirements. Cables installed in buildings are regulated by the National Electrical Code [3]. The fire performance requirements are specified either in code regulations (e.g. NFPA) as well as 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.

c) In the UK, there is very little regulation for the fire performance of cables, although local regulation (local government, chief engineers) mostly advises 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: means of escape, fire spread and access facilities for the fire service. The IEE wiring regulations (BS 7671) state “cable when installed inside buildings should as a minimum meet IEC 60332-1-2”. BS 7671 also states “when considering areas of higher concern, where risk of fire propagation is higher/long runs with bunches of cable, consideration should be given to cables that pass BS EN 60332 = IEC 60332-3-XX (complete series) dependant on the type of cable matched to the relevant number in the series".

d) 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.

e) Spain has legislation for public buildings, which now concentrates on low smoke considerations as well as increased fire retardancy.

f) In Europe, developments with respect to cables and the Construction Products Directive may have a significant impact on the fire performance requirements for cables. The CPD has now been upgraded in importance to CPR (R) (Construction Product Regulation)[5].

   The Construction Products Directive 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 harmonized 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 of cables under the CPR was developed in part with the research by the FIPEC project, in which it was validated against real scale reference scenarios specific for cables.

   It should be noted that the CPR is not intended to harmonize regulation, or to impose regulation where none exists, but it is intended to harmonize the classification of the reaction to fire of products, and the test methods used.

   Self-certification of cable fire performance still exists generally, but the trend is to third party certification. Third party certification is practised in North America, and by the insurance industry, and in some cases required in Europe under the CPR.

6 Approach to fire mitigation

6.1 General

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 is to be avoided.

6.2 Compartmentation (fire compartments)

Compartments should be created within the premises that are separated by vertical and horizontal barriers with appropriate levels of fire performance in order to:

– prevent the spread of fire and its effluent,
– reducing air flow,
– reduce the extent of loss.

The selection of compartment boundaries should take into account the impact of fire within each compartment. See ISO/IEC 14763-2 for advice on cable installations, fire barriers and fire-stops.

The fire performance of items within each compartment, in combination with the fire detection and suppression systems of the compartment, should:

a) meet local and national regulations,
b) reflect the risk to property, personnel and business continuity,
c) be selected to satisfy the needs of the premises' owners, landlords, tenants and insurers.

6.3 Management of fire hazard

Before considering the fire hazard, compartmentation should already have been considered. In cases where the location and contents of specific compartments remove the need to consider fire dangers as described in Table 2, the maintenance of the boundaries of those compartments is critical to the fire performance on the premises as a whole. This is of paramount importance. Installation guidelines should be followed wherever possible.

The fire danger of each compartment should be assessed in accordance with Table 2, which gives an indication of the degree of mitigation that is necessary in a variety of installations.

Besides normal installation types, 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
   i) protection of the building and its personnel,
   ii) business continuity,
   iii) aesthetics and finish,
   iv) electrical and optical performance of the cabling system,
d) the nature of the fire hazard
   i) extent of the fire load within the local area where the cable is being installed, examples:
      1) debris fire waste paper/plastics collection areas, bins or boxes?
      2) furniture, density of the office, open plan?
      3) arson, ground floor access or side streets?
e) chimney effects,
f) forced air environments, coupled with a high fire attack, where the detection level is not up-rated to suit, specialist cable is a consideration, see 9.2.

In such cases, where the detection level is not up-rated to the required level, the use of cables with enhanced fire performance should be considered.

6.4 Cables that pass through several compartments

When economies of scale, speed of installation and overall practicality have to be considered, a most economic 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 fire performance of the cables.

7 Recent project for regulation – The FIPEC [6] project

This was a European commission and industry funded project set up to develop methods for measuring the fire performance of cables. The database generated by the project covered some fifty cables of various copper sizes and materials.

The most frequently used test methods to assess the fire performance of cables in Europe then were the IEC 60332-3 series and the IEC 60332-1 series. An objective of this study was to provide a means by which fire engineering considerations may be introduced to the cables sector of the European marketplace.

Applying the information developed by the FIPEC programme, it was found possible to modify the existing test of the IEC 60332-3 series to include heat release and smoke measurement. Changes to sample mounting, the option of a backboard with a more powerful ignition source and an increased airflow provide a better discrimination between cable performances.

Part of the FIPEC study was to determine the sensitivity of the various test parameters utilized for the test of the IEC 60332-3 series. This demonstrated that the most significant variable was in cable mounting. It was concluded that consideration of non-metallic materials content (the basis by which the quantity of cable sample to be mounted is selected) does not necessarily provide a risk hierarchy. When discussing the “influence of layers”, the report states “cable loading derived categories do not correspond with a risk hierarchy, e.g. a 7 l/m loading may not necessarily be a more severe test than a 1,5 l/m loading. These categories should be unambiguously separate from the inferences of risk assessment.”

The two scenarios (test methods) derived through the FIPEC study do not take non-metallic materials content into account when determining the quantity and configuration of cable sample to be mounted for fire testing. Instead, cable diameter is the prime determinant with, in every instance, a designated separation between adjacent cable samples. Cables having a diameter greater than 5 mm were mounted in a single spaced row, and smaller cables were mounted in non-twisted spaced bundles.

In test method scenario 1, considered to be slightly more severe than the IEC 60332-3 series, the flame attack is 20 kW (pre-mixed flame) and the airflow is increased. In test method scenario 2, considered to be more severe than the IEC 60332-3 series, the flame attack is 30 kW (pre-mixed flame), the airflow is increased and a non-combustible backboard is added.

Conclusions of relevance include the following.

a) The current method and procedures by which cable performance is determined produces a prescriptive requirement that does not enable a graded classification of fire hazard, nor the provision of data by which fire hazard may be assessed.
b) The IEC 60332-3 series is not sensitive enough to differentiate between cables with reasonable fire properties, and those with very good properties needed for high hazard or high-density telecommunication cable installations.
c) The parameter that has the most effect on the test results is the method of mounting the tested cables.

NOTE Although the FIPEC project included only one data cable, private research [6] on 13 structured wiring cables has shown that although not as sensitive as NFPA 262 or EN 50289-4-11, with appropriate cable mounting configurations and performance boundaries, scenario 2 can differentiate the higher performing products.

Note that this project led to the writing of EN 50399, a fully integrated test method, which can, through specified air flow requirements and defined air inlet with the exact location, provide accurate and repeatable calibration before testing starts. These actions have enhanced the value of test results.

8 Fire protection

8.1 Traditional approach

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 heat release, smoke, fire propagation, acid gas and toxicity, but their importance was ranked differently depending on the type of installation, as shown in Table 3 below. For example, in general installations, fire propagation was seen as the most important consideration but where evacuation of people was vital, smoke was ranked higher than propagation. 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.

Table 3 – 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 fire effluent	Heat release/flame spread	Corrosive fire effluent
2	Heat release/flame spread	Smoke fire effluent	Heat release/flame spread
3	Toxic fire effluent	Corrosive fire effluent	Smoke fire effluent
4 (least important)	Corrosive fire effluent	Toxic fire effluent	Toxic fire effluent

To evaluate cable fire performance in relation to the hazards in Table 3, several separate test methods were developed; these specifications usually included a requirement. For example, in test method EN 50399 (using the IEC 60332-1 (all parts), IEC 60332-2 (all parts) and IEC 60332-3 (all parts) test apparatus design and ladder) is developed to include tests for: heat release (total and rate) and smoke (total and rate), software to produce reporting as to the time to the first peak of both heat and smoke is included. In addition, flame spread is also recorded. 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. Another example, IEC 60332-3-24, category C, describes how the 20 kW flame test is used to assess the fire propagation of vertical bunches of cables by measuring the length of char damage after completion of the test. A length of char that is less than 2,5 m is necessary to pass this test. The IEC 61034 series assesses smoke generated by samples of cables exposed to an alcohol fire source in a 3 m^3 enclosure, where a minimum light transmittance of 60 % is required. 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 tests on gases evolved during combustion of materials from cables: determination of acidity (by pH measurement) and conductivity.

Thus, a cable fire performance meeting the requirements of IEC 60332-3-24, Category C, the IEC 61034 series and IEC 60754-2 as shown in Table 4 has, in the past, been deemed to be satisfactory. The other categories, A, B and D (IEC 60332-3-20 onwards) are dependent on the cable's outside diameter; it does not necessarily define levels of severity as cable mounting, discussed before, has a greater influence. Category C has in the past been generally used for structured wiring due to the diameter of the generic cable.

Table 4 – Cable fire performance requirements

Parameter	Test method	Requirement
Integrated test	EN 50399	Char, heat, rate of heat, smoke, rate of smoke production, FIGRA, SMOGRA
Fire propagation	IEC 60332-3-24, Category C	Char less than 2,5 m at completion of the test
Smoke	IEC 61034 series	Minimum light transmittance 60 %
Acid gas	IEC 60754-2	pH not less than 4,3 Conductivity not more than 10 μS/mm

8.2 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. 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 building evacuation, fire fighter safety, smoke, heat, flame re-ignition, flashover, flashback and structural collapse.

Guidance concerning the threats to life from fire hazard is given in ISO 13571. General guidance on the fire hazard of electrotechnical products is given in IEC 60695-1-10. Guidance on the fire hazard assessment of electrotechnical products is given in IEC 60695-1-11.

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, lighting fittings and cabinet fans. Power equipment fires can cause riser cable fires, rubbish fires have caused fires in computer room cabling and lighting fitting faults have caused fires in concealed ceiling voids.

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) 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 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), IEC 61034, for example, for light transmittance which is the 3 m^3 test and is independent to the criteria by which the primary reaction to fire parameters are measured. EN 50399 can measure smoke rate and total smoke production: it is recommended that smoke measurement for construction products like cables should be part of an integrated testing protocol as in EN 50399.

   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 3 m^3 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.

b) Heat: Heat is a fire hazard not previously addressed by IEC cable standards.

   Generally, cables would be involved in a developing 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 which become 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/TR 60695-8-2.

c) Flame spread: Some test methods measure flame spread during the test, and others measure char length after the test. Some sheathing materials are designed to char in order to restrict flame propagation, in which case the char length after the test can be greater than the flame spread during the test. It is now recognized 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, 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/TS 60695-9-2.

d) 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 the IEC 60754 series and EN 50267-2-3 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 no 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 series is 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 have the disadvantage that they do 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 IEC 60754 or EN 50267. IEC/TS 60695-5-2 gives a summary of corrosivity test methods, including comments on their relevance.

   IEC/TS 60695-5-2 is a summary of test methods for the corrosion damage effects of fire effluent, including comments on their relevance.

e) 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.

g) 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, Clause 6 of ISO 19706:2011 discusses generation and nature of effluent.

8.3 Fire hazards of cables

Data from cable fires and from research indicate that the following fire hazards and fire parameters need to be considered in cable specifications:

– ease of ignition,
– heat – total heat release, rate of heat release, peak heat release, flashover, structural integrity,
– fire propagation – flame spread, flaming particles/droplets,
– fire effluents – smoke, toxins (asphyxiants and irritants), corrosivity,
– effects on electrotechnical performance.

9 Test methods

9.1 Review

During the last ten years, many amendments and additions have been made to test methods. 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. These cover: ignitability, heat release, surface spread of flame, smoke, corrosivity and toxicity. A summary is given in Annex A of IEC 60695-1-10:2009. Cable test methods can be grouped and ranked in terms of severity as shown in Table 5. A further review of the current status of these various test methods is shown in Annex C.

Table 5 – Test methods

Most severe	NFPA 262	EN 50399 30 kW	CSA FT6
	UL 1666		EN 50399 (20 kW) Integrated
	IEC 60332-3 series	IEC 60332-3 series	
	UL 1685 (method 1)		
Least severe	IEC 60332-1 series	UL VW-1	IEC 60332-1 series

9.2 NFPA 262/EN 50289-4-11

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 4 apparatuses worldwide (3 in the USA and 1 in Japan) that have undergone extensive harmonization.

EN 50289-4-11 is the European test method derived from NFPA 262, and 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 e.g. 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 retardant.

9.3 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 assuring 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.

9.4 IEC 60332-3 series

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 real scale scenario.

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 communication cable horizontal installations.

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.

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 in results even on the same cable types;
– some apparatus to apparatus variation by design and interpretation of layout;
– some limited harmonization, 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 but 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.

9.5 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 of touching cables, 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.

9.6 UL 1685/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.

9.7 Other considerations

9.7.1 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, e.g. cables using thinner thickness of higher performance materials would need a larger number of cables to keep the combustible content constant. 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.

9.7.2 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.

9.7.3 Conditioned environment

Only one test method calls for the test apparatus to be installed in a conditioned environment, and the harmonization 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 need a conditioned environment and for which tests it is not important. For good practice, a conditioned environment is recommended. EN 50399 in comparison uses specialized calibration procedures before starting the testing that can only be achieved by a stable environment.

9.7.4 Real scale scenario

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

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

9.8 Test method conclusions

The main cable test methods could be the four test methods, as follows.

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 of 20 min is recommended.
b) The tests EN 50399, IEC 60332-1, IEC 61034-2 and EN 50267-2-3 are now the harmonized (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 (for cables > 5 mm OD) is one that shows good repeatability and reproducibility, something that the European legislation demands before allowing the regulation to become a legal harmonized 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.
c) For ignitability, the IEC 60332-1 series offers an appropriate test for communication cables.
d) For installations with equipment critical to business continuity, a suitable corrosivity test is one that directly measures functional impairment.

10 Fire performance requirements

10.1 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 (*Fire Hazard Testing*), and the parameters addressed in the IEC 60695 series of publications. 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.

10.2 Heat

The importance of heat release as a fire performance parameter is recognized by EN 13501-1 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 permittivities 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 6.

Table 6 – Typical communication cable materials

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 8?
Insulation	FEP, PTFE, PTFE-HFP	5,1

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 shall 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 recommended requirements and test methods for heat are shown in Table 7.

Table 7 – Recommended requirements for heat

Test method			Installation	Peak[a] HRR kW	Total HR[a]	
Reference	Heat source kW	Airflow			600 s MJ	1 200 s MJ
EN 50289-4-11	88	7 m^3/min	Horizontal	90	20	40
EN 50399	30	8 $m^3 \cdot min^{-1} \pm 0,4\ m^3 \cdot min^{-1}$	Vertical/Horizontal	20	N/A	15
EN 50399	20	8 $m^3 \cdot min^{-1} \pm 0,4\ m^3 \cdot min^{-1}$	Vertical/Horizontal	60	N/A	30
EN 50399	20	8 $m^3 \cdot min^{-1} \pm 0,4\ m^3 \cdot min^{-1}$	General	400	N/A	70

[a] Recommended values

10.3 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 13501-1 defines smoke in terms of total smoke production and SMOGRA index but, applying the same logic as with FIGRA index, an approach specifying peak smoke production and total smoke production is preferred.

The recommended requirements and test methods for smoke are shown in Table 8.

Table 8 – Recommended requirements for smoke

Test method				Installation	Peak SPR[a] m^2/s	Total SP[a]	
Reference	Flame type	Heat source kW	Airflow			600 s m^2	1 200 s m^2
EN 50289-4-11	Diffusion	88	7 m^3/min	Horizontal	0,35	75	80
EN 50399	Pre-mix	30	8 $m^3 \cdot min^{-1} \pm 0,8\ m^3 \cdot min^{-1}$	Vertical	0,25		50
EN 50399	Pre-mix	20	8 $m^3 \cdot min^{-1} \pm 0,8\ m^3 \cdot min^{-1}$	Vertical	0,25		50
EN61034	Diffusion	1 l alcohol	Natural	Horizontal	Light transmittance > 60 %		

[a] Recommended values

10.4 Propagation

Propagation is defined by flame spread. The 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 the IEC 60332-3 series.

10.5 Ignitability

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

10.6 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/TS 60695-5-2.

10.7 Flaming droplets

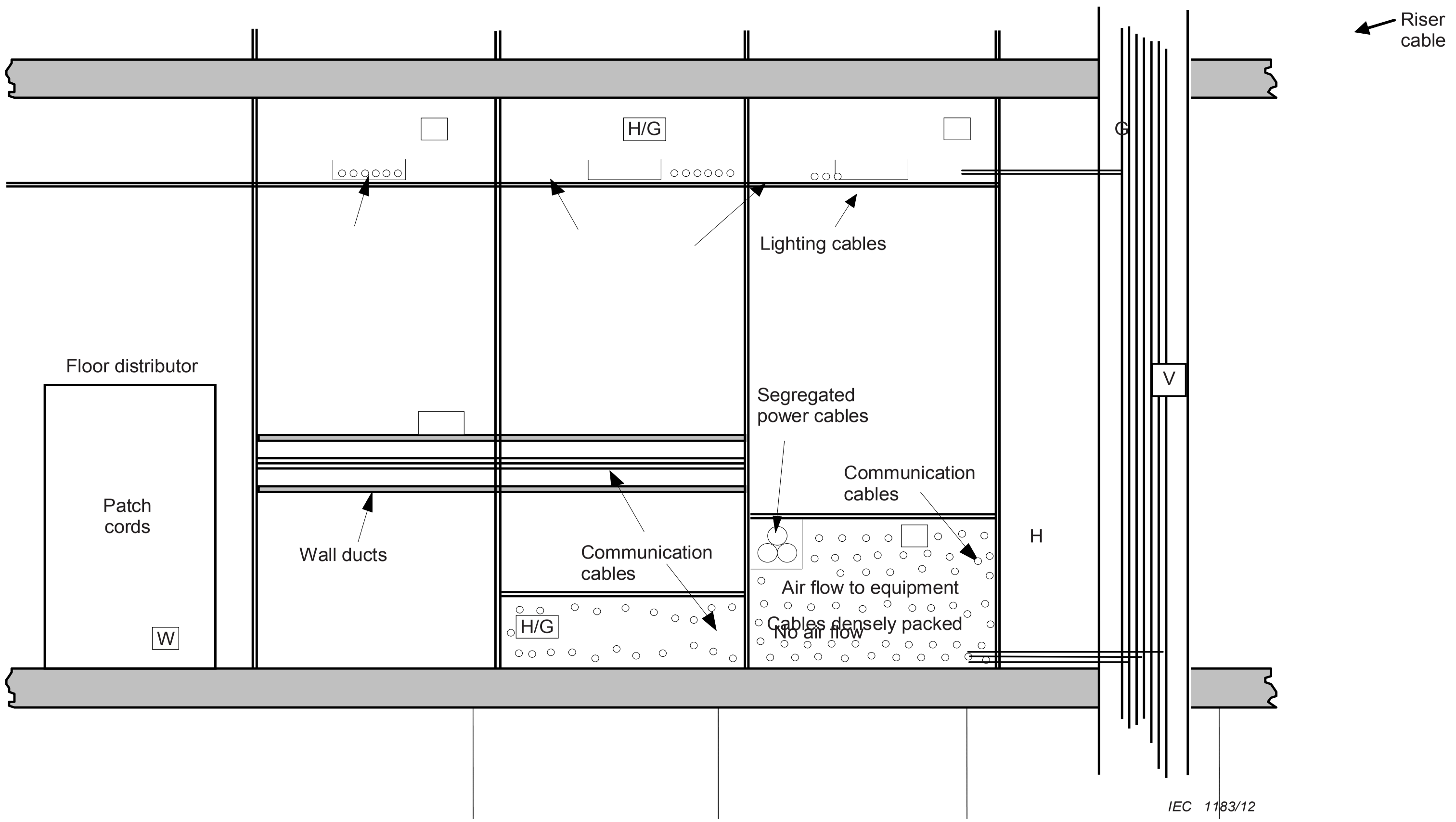
EN 13501-1 requires the observation of any material separating from the samples during the EN 50399 test, and a measurement of the duration of any flaming. Flaming droplets can be a source of fire spread, and it is recommended that in tests to EN 50289-4-11 and EN 50399, the maximum duration of any such secondary flaming be specified as 10 s.

10.8 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 TC 89 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.

Annex A
(informative)

Procedure for mounting cable – Typical communication cable installations



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

Figure A.1– Procedure for mounting cable – Typical communication cable installations

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		
		Horizontal installations with forced air	**Vertical riser installations**	**General/horizontal installations**
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/TS 60695-5-2)		
All other installations	Ignitability	**IEC 60332-1 series**		

Annex C
(informative)

Review of test methods

Table C.1 – Ignitability

Test method	UL VW-1	IEC 60332-1 series and for small fibre cables IEC 60332-2-2
Cable orientation/mounting	Vertical single wire or cable	Vertical single wire or cable
Test duration	Variable, 1,5 min to 6 min	Variable, 1 min to 8 min
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
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	Maximum burn distance 25,4 mm Maximum 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	IEC 60332-1-3 Does not test for flaming droplets IEC 60332-2-2 may be suitable for very small optical cables

Table C.2 – Vertical tests (1 of 3)

Test method	UL 1685/CSA FT4	IEC 60332-3
Cable orientation and mounting	Vertical tray, 2,5 m long 300 mm wide 1 layer 152 mm wide cables spaced 0,5 × overall diameter For CSA FT4, cables are bundled	Vertical ladder, 2,5 m long, 500 mm wide Multiple layers non-metallic 1,5 l/m for Category C, 0,5 l/m for Category D Layer width 300 mm
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
Notes	Similar to IEC 60332-3 series 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 For cable with much larger outside diameter or copper conductor IEC 60332-3 Cat A F/R, A and B could be used

Table C.2 – Vertical tests (2 of 3)

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
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 ± 800) 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 described in 2.3.1 of the FIPEC Final Report (ISBN 0 9532312 5 9)
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
Notes		

Table C.2 – Vertical tests (3 of 3)

Test	EN 50399 (30 kW)
Cable orientation and mounting	Vertical 500 mm wide single layer single cable spacing
Test duration	20 min
Heat source	30 kW burner
Airflow	7 m^3/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 described in 2.3.1 of the FIPEC Final Report (ISBN 0 9532312 5 9)
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	

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

Table C.4 – Indirect measurement of smoke

Test method	IEC 61034 series (3 m^3)
Cable orientation/mounting	Horizontal, single or bunched depending on cable diameter 1 m lengths of cable mounted horizontally above the fuel source
Test duration	Approximately 40 min
Heat source	Ethanol/methanol/water mix, contained in metal tray below cable
Airflow	Convection
Test specimen conditioning	Test chamber in open laboratory conditions Test chamber temperature 25 °C before test Cables conditioned for 16 h at 23 °C
Test runs	1 or 3 depending on results
Requirements if not specified in the cable specification	Minimum light transmission 60 %
Real scale reference scenario	None
Major attribute	None
Test used for	–
Advantages	Available in Europe Cumulative method (with possibly higher sensitive)
Disadvantages	No controlled environment Not representative of actual cable installations in buildings (represents cables in underground railway tunnels) Sample selection is arbitrary No relationship to smoke measurements in an integrated test Heat source insufficient – can only scorch sheath and not test complete cable

Annex D
(informative)

Fire performance requirements

Table D.1 – Fire performance requirements

Test method	Installation	Peak HRR	Total HR		Peak SPR	Total SP		Peak OD	Average OD	Flame spread
			600 s	1 200 s		600 s	1 200 s			
		kW	MJ max.	MJ max.	m^2/s min.	m^2/s min.	m^2/s min.			M max.
EN 50289-4-11	Horizontal voids With forced air	90	20	40	0,35	75	80	0,5	0,15	1,52
EN 50399 (30 kW)	Horizontal voids With forced air	20	n/a	10	0,25	n/a	50	n/a	n/a	1,75
EN 50399 (20 kW)	Areas of high concern	30	n/a	15	0,25	n/a	50	n/a	n/a	1,5
EN 50399 (20 kW)	Vertical riser/horizontal	60	n/a	30	1,0	n/a	240	n/a	n/a	n/a
	General/ horizontal	400	n/a	70	0,75	n/a	160	n/a	n/a	n/a

Table D.2 – Single cable burn test

Test method	Installation	Corrosion	Burn length
IEC 60332-1 series	Exposed work area	–	425 mm

Although the above criteria represent a performance hierarchy, it should be noted that as the test methods are different, the criteria may be different from test to test. When considering best practice, the test results should be taken in context and not as a pass or fail. The type of installation will determine which test is appropriate and how to qualify the cable performance requirement.

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