PD CLC/TS 50576:2016

BSI Standards Publication

Electric cables — Extended application of test results for reaction to fire

bsi.

National foreword

This Published Document is the UK implementation of CLC/TS 50576:2016.

It supersedes PD CLC/TS 50576:2014 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/20, Electric cables, to Subcommittee GEL/20/18, Electric Cables - Fire testing.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2017

ISBN 978 0 580 93972 3
ICS 13.220.40; 29.060.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 January 2017.

Amendments/corrigenda issued since publication

Date	Text affected

TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

TECHNISCHE SPEZIFIKATION

CLC/TS 50576

December 2016

ICS 13.220.40; 29.060.20

Supersedes CLC/TS 50576:2014

English Version

Electric cables - Extended application of test results for reaction to fire

Câbles électriques - Application étendue des résultats d'essai

Kabel und Leitungen - Erweiterte Anwendung von Prüfergebnissen

This Technical Specification was approved by CENELEC on 2016-10-10.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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European foreword

This document (CLC/TS 50576:2016) has been prepared by CLC/TC 20 “Electric cables”.

The following date is proposed:

- latest date by which the existence of this document has to be announced at national level (doa) [2017-04-10]

This document supersedes CLC/TS 50576:2014.

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association.

This document is meant to be used in conjunction with EN 50575 in order to evaluate the reaction to fire performance of power, control and communication cables.

NOTE For the purposes of this Technical Specification, the term 'electric cables' also covers optical fibre cables.

Introduction

The original project “CEMAC – CE marking of cables” was carried out over a three year period. It brought together cable manufacturers, research and testing laboratories, and research establishments in creating the technical background and developing rules and procedures for extended application of test results (EXAP). More than 200 tests to EN 50399 on more than 100 cables were carried out as part of the project. The final report [1] was published in 2010 and the EXAP rules and procedures developed by the CEMAC project have been used as the basis for this Technical Specification.

A specific EXAP procedure and rules based on the use of safety margins and a cable parameter derived from the extensive CEMAC tests was developed for the most common generic types of power cables used in the European market.

A general EXAP procedure and rules based upon a statistical treatment of the actual test results obtained from a cable family was also developed for any power cables. However, the use of this general procedure and rules will generally require more tests to be carried out than the use of the specific procedure and rules.

Since the CEMAC project report was completed in 2010, the project has been extended to further investigate the performance of optical fibre cables and rules and procedures developed for extended application of test results for these products. An additional report [2] was published in 2015 and the EXAP rules and procedures developed by the further CEMAC project work have been used as the basis for the 2016 revision of this Technical Specification.

General guidance on direct and extended application may be found in CEN/TS 15117 [3].

1 Scope

This Technical Specification gives the procedure and rules for extended application of results of tests carried out according to the test methods described in EN 50399, EN 60332-1-2 and EN 61034-2.

The EXAP rules described apply to EN 50399 test results used for classification in classes $B2_{ca}$,C_{ca} and D_{ca}, additional smoke production classes s1, s2 and s3 and flaming droplets/particles, to EN 60332-1-2 test results used for classification in classes $B2_{ca}$,$C_{ca,}$ D_{ca} and E_{ca} and to EN 61034-2 test results used for classification in classes s1a and s1b.

Cables of diameter 5,0 mm and less should be tested as bundles according to EN 50399. Bundled cables are not included in the EXAP rules applying to EN 50399 test results.

The rules apply to circular and non-circular cables provided that they fall within the scope of the relevant test method.

A specific EXAP rule has been developed for the most common generic power cable families and optical fibre cables. A general EXAP rule has been developed for any power cable families. The general EXAP rule is not applicable to communication or optical fibre cables.

NOTE 1 Multicore power cables with more than 5 cores are sometimes referred to as control cables with a rated voltage but for the purposes of this Technical Specification are considered as power cables.

The general EXAP rule may be applied in the case of hybrid cables provided that the conditions of 6.1 are fulfilled.

The use of the specific EXAP rule gives benefit in the lower number of cables to be tested for a range of cable constructions (product family).

An EXAP is only possible when cables belong to a defined family as defined in this Technical Specification.

NOTE 2 No EXAP procedure and rules have been developed in respect of the results of tests carried out according to the test method described in EN 60754–2. As the parameters (pH and conductivity) for each cable in a family are determined based upon calculation using material test results, this is considered as a matter of direct application. Material test results taken from any one sample of finished cable from a family are sufficient to calculate the parameters for each cable in the family.

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.

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*

EN 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 60332-1-2)*

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

3 Terms and definitions

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

3.1
classification
process defined in EN 13501, whereby the fire performance parameters obtained from the results of one test, or a set of tests, or from a process of extended application, are compared with limiting values for those parameters that are set as criteria for achieving a certain classification

[SOURCE: EN 15725]

3.2
electric cable
all power, control and communication cables, including optical fibre cables and hybrid cables which are a combination of two or more of these cable types

[SOURCE: EN 50575]

3.3
power cable
assembly comprising one or more insulated conductor(s), together with any coverings and protective layers, used for the transmission or supply of electrical energy

[SOURCE: EN 50575]

3.4
control cable
assembly comprising insulated conductors, together with any coverings and protective layers, used for the transmission of control, measuring and indication signals in electric installations

[SOURCE: EN 50575]

3.5
communication cable
assembly of suitably insulated coaxial conductors or twisted pairs of insulated conductors fabricated to meet transmission, mechanical and environmental requirements, and sufficient to allow conveyance of information between two points with the minimum of radiation

[SOURCE: EN 50575]

3.6
optical fibre cable
assembly comprising one or more optical fibres or fibre bundles inside a common covering designed to protect them against mechanical stresses and other environmental influences while retaining the transmission quality of the fibres

Note 1 to entry: May also contain metallic conductors.

[SOURCE: IEV 731-04-01]

3.7
product family
group of products produced by one manufacturer for which the test results for one or more characteristics from one product within the family are considered to be representative for that same characteristic for all other products within this family

[SOURCE: EN 50575]

3.8
extended application of test results
EXAP
outcome of a process (involving the application of defined rules that may incorporate calculation procedures) that attributes, for a cable family, a test result on the basis of one or more test results to the same test standard

3.9
heat release rate
HRR
thermal energy released per unit time by an item during combustion under specified conditions

[SOURCE: EN 50399]

3.10
total heat release
THR
integrated value of the heat release rate over a defined period

[SOURCE: EN 50399]

3.11
smoke production rate
SPR
smoke production per unit time

[SOURCE: EN 50399]

3.12
total smoke production
TSP
integrated value of the smoke production rate over a defined period

[SOURCE: EN 50399]

3.13
flame spread
FS
propagation of a flame front

[SOURCE: EN 50399]

3.14
fire growth rate index
FIGRA
highest value of the quotient between HRR and time

[SOURCE: EN 50399]

4 Extended application of test results (EXAP)

4.1 Product families for EXAP

4.1.1 General

An EXAP is only possible when cables belong to a defined family.

The full constructional and material details for the family shall be submitted to the certification body prior to the EXAP being applied.

A change to the colour of design elements (for instance insulation and/or sheath) or to the marking on insulation and/or sheath does not constitute a different cable family.

4.1.2 Product families for power cables

For the application of these EXAP rules and procedures, a cable family shall be defined as follows:

A family of cables is a specific range of products of the same general construction (design elements) and voltage rating.

A change to the conductor construction (rigid or flexible) or form (circular or shaped) shall constitute a different family. EN 60228 Class 1 and Class 2 are rigid conductors and Class 5 and Class 6 are flexible conductors.

An armour or concentric layer shall not be considered solely as a conductor in determining a product family. An armoured or a concentric construction shall be considered as a different family to a construction without such armour or concentric layer. An armour and a concentric conductor are different design elements.

The cable family shall be produced by the same manufacturer using the same materials and the same design rules (for instance International standard, National standard, Company standard based on National or International standard) and varying only in conductor size and number of cores.

NOTE 1 A common design rule is that the thickness of the design elements (for instance insulation and/or sheath thickness) increase with conductor size and cable diameter. These cables, using this common design rule, belong to the same cable family.

If the cable family falls under one of the generic power cable families:

— single core unsheathed;

— single core sheathed (unarmoured);

— multicore sheathed (unarmoured);

— armoured single or multicore;

the specific EXAP with safety margin as a function of classification parameter and class may be applied.

NOTE 2 Concentric constructions are considered as part of the generic armoured family.

4.1.3 Product families for communication cable

For the application of these EXAP rules and procedure, a cable family shall be defined as follows:

A family of cables is a specific range of products of the same general construction (design elements) and varying only in number of conductors and number of units.

The cable family shall be produced by the same manufacturer using the same materials and the same design rules (for instance International standard, National standard, Company standard based on National or International standard).

The cable family shall fall under one of the generic communication cable families:

— U/UTP unscreened overall / unscreened twisted pair;

— F/UTP screened overall / unscreened twisted pair;

— SF/UTP metallic braid and screened overall / unscreened twisted pair;

— U/FTP unscreened overall / screened twisted pair;

— F/FTP screened overall / screened twisted pair;

— S/FTP metallic braid overall / screened twisted pair;

— SF/FTP metallic braid and screened overall / screened twisted pair.

4.1.4 Product families for optical fibre cables

For the application of these EXAP rules and procedure, a cable family shall be defined as follows:

A family of cables is a specific range of products of the same general construction (design elements) and varying only in number of optical fibres and number of units.

The cable family shall be produced by the same manufacturer using the same materials and the same design rules (for instance International standard, National standard, Company standard based on National or International standard).

The following properties are considered to have a negligible influence on the fire behaviour and therefore differences in these properties only do not mean that the cables belong to different families:

— Fibre glass type;

— Fibre type (e.g. single mode or multimode);

— Fibre colour.

4.2 Specific and general EXAP

A specific EXAP rule has been developed for the most common generic power cable and optical fibre cable families and a general EXAP rule has been developed for other power cable families.

The use of the specific EXAP rule gives benefit in the lower number of cables to be tested for a range of cable constructions in a product family.

5 Specific EXAP with safety margin for power cables

5.1 Rules for specific EXAP for EN 50399 test

These rules apply for the classification parameters peak HRR, THR, FIGRA, FS, peak SPR and TSP.

These rules apply to circular and non-circular cables within the limits of the EN 50399 test.

The EXAP is based on two tests. The parameter χ is used as a cable parameter.

χ is defined as:

$$\chi = \frac{c}{d^2} V_{combust} \quad (1)$$

where

d is the cable diameter, in m, (or equivalent diameter for non-circular cables where the equivalent diameter is defined as the sum of twice the major and twice the minor axis divided by 3,14 (π);

$V_{combust}$ is the non-metallic volume per meter of ladder, in m^2;

c is the number of conductors in one cable.

All cables within the same family with a value of the cable parameter between the lowest and highest value of the cable parameters of the tested cables are included in the EXAP. Classification is based on the maximum measured value plus a safety margin:

$$v_{class} = v_{\max} + v_{sm} \quad (2)$$

where

v_{class} is the value used for classification according to respective classification parameter (peak HRR, THR, FIGRA, FS, peak SPR, and TSP);

v_{max} is the maximum, that is the worst, test result of the tests that forms the basis of the EXAP; and

v_{sm} is the safety margin required for the particular classification parameter.

The safety margins for the different classes and classification parameters are given in Table 1.

Table 1 — Safety margins v_{sm} for power cables

	Classification parameter	**Dimension**	**Class**				
			$B2_{ca}$	**C_{ca}**	**D_{ca}**	**s1**	**s2**
v_{sm}	**Peak HRR**	**[kW]**	3	6	40		
	THR	**[MJ]**	1,5	3	7		
	FIGRA	**[Ws^{-1}]**	15	30	130		
	Flame spread	**[m]**	0,15	0,2			
	Peak SPR	**[m^2s^{-1}]**				0,05	0,3
	TSP	**[m^2]**				10	80

These safety margins can be applied to cables with a cable diameter and cable parameter within the ranges indicated in Table 2. For larger cables, see 5.2.

Table 2 — Allowed range of cable diameters and cable parameters for using safety margins as specified in Table 1

	d_{min} [mm]	d_{max} [mm]	χ_{min}	χ_{max}
Armoured	10,0 (>5,0)	62,0	2	82
Unarmoured multicore	9,0 (>5,0)	52,0	4	73
Single core sheathed	6,0 (>5,0)	29,0	2	20
Single core unsheathed	> 5,0	25,0	2	115

The values (>5,0) mm given in the d_{min} column are only applicable in the case where the flame spread for the tested cables with diameters less than those given without parentheses is less than 3,3 m, i.e. if the cables are not fully combusted.

Cables with a diameter of less than or equal to 5,0 mm, shall be bundled according to EN 50399. Bundled cables are not included in the specific EXAP rules as the fire performance changes dramatically with the change of mounting. Therefore these cables need to be tested case by case.

Diameters shall be expressed in mm to one decimal place. Cable parameters shall be calculated and the value rounded to the integer according to Annex B.

Figure 1 shows a theoretical example indicating how v_{class} for the classification parameter TSP is assessed for a typical cable family. Tests are performed for cables with $\chi = 10$ and with $\chi = 50$. The maximum result is TSP = 300 m^2 which is obtained for $\chi = 50$. Therefore $v_{max} = 300\ m^2$. v_{sm} for TSP Class s2 is 80 m^2 according to Table 1. The value for classification would be $v_{class} = 300\ m^2 + 80\ m^2 = 380\ m^2$. This is below the limit 400 m^2 for smoke Class s2. Therefore, for TSP, all cables in the family with $10 \leq \chi \leq 50$ can be considered to fulfil the requirement for Class s2. In order to classify the cables as s2 they would also need to fulfil the requirements for s2 for peak SPR.

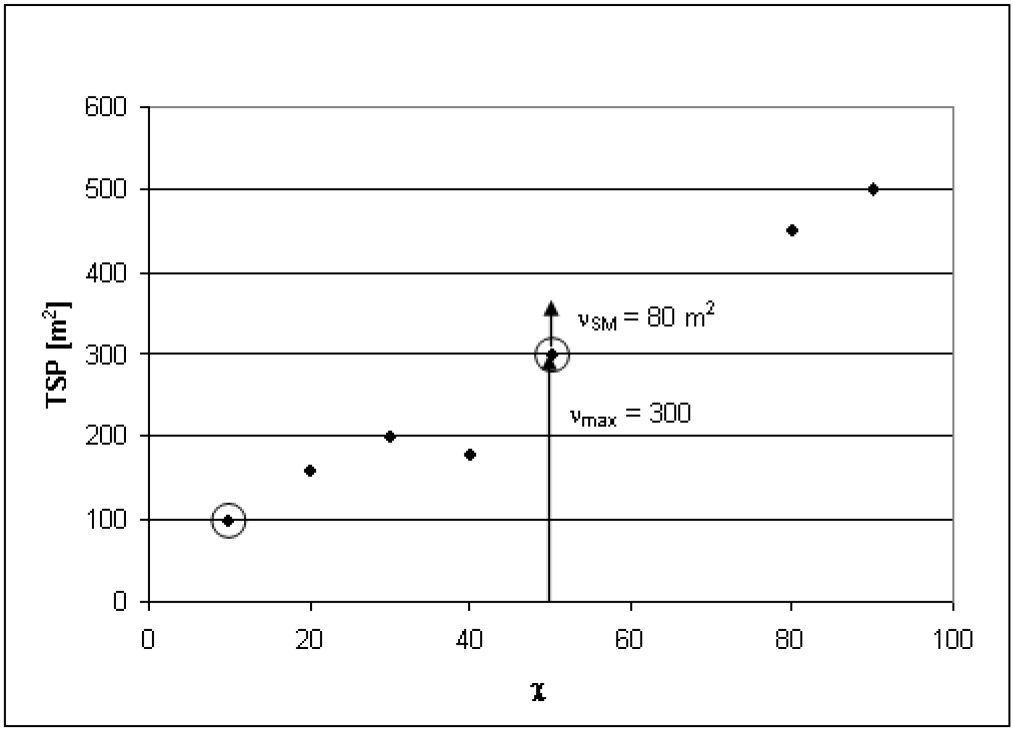


Figure 1 — Assessment of v_{class} for the classification parameter TSP (theoretical example)

A checklist for the use of the specific EXAP rules is given in Annex A.

5.2 Extension to cables larger than the tested range

Power cables larger than the CEMAC tested range are not included in the applicable range for safety margins in Table 2. However, it has been shown that, provided not all cables within a family are completely combusted, reaction to fire performance is better for larger cables than for smaller cables. There is, therefore, a possibility for EXAP based on extrapolation to larger diameters for cable families listed in Table 2. The condition for this extrapolation is that fire performance actually improves with increasing diameter which is fulfilled if the classification for a large diameter cable is $B2_{ca}$ or C_{ca}.

If a cable with diameter d_{max} in the range given in Table 3 is tested and classified $B2_{ca}$ or C_{ca} then all cables with $d > d_{max}$ can be classified according to the result for the tested cable with diameter d_{max}.

Table 3 — Allowed ranges of d_{max} for EXAP applied for larger cables

Armoured cables	**d_{max} = 56,0 to 62,0 mm**
Unarmoured multicore cables	**d_{max} = 47,0 to 52,0 mm**
Single core sheathed cables	**d_{max} = 26,0 to 29,0 mm**
Single core unsheathed cables	**d_{max} = 22,0 to 25,0 mm**

6 General EXAP for power cables

6.1 Rules for general EXAP for EN 50399 test

These rules apply for the classification parameters peak HRR, THR, FIGRA, FS, peak SPR and TSP.

For cable types not belonging to any of the cable families defined by Table 2, no safety margins have been determined. For such cables safety margins can be generated from the test results of the tested cables. In this case at least three cables shall be tested.

The general EXAP is also based on the cable parameter χ. Therefore the cables in the cable family need a well-defined diameter which means that the cable cross section shall be circular or non-circular within the limits defined in EN 50399. Furthermore the cables need a well-defined non-zero number of metallic conductors. As a result, the general EXAP rules can only be applied for power cable families having at least one metallic conductor. For other type of cable families it is not possible to carry out an EXAP.

The safety margin v_{sm} is a function that:

— increases with increased dispersion of the measured values;

— increases with increased range of the cable parameter χ;

— decreases with increased number of tests; and

— decreases with increased monotonicity of the measured values.

The safety margin shall be calculated as:

$$v_{sm} = \frac{\sigma\left(\chi_{\max} - \chi_{\min}\right)}{(n-1)\chi_{\min}(1+m)} \tag{3}$$

where

σ is the standard variation of the measured values,

χ_{min} and χ_{max} are the limiting cable parameters in the tested range,

n is the number of tested cables, $n \geq 3$, and

m is a measure of the monotonicity of the measured values.

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(v_i - \bar{v}\right)^2} \tag{4}$$

$$m = 1 - \frac{\left(\sum_{i=1}^{n-1}\left|v_{i+1} - v_i\right|\right) - \left|v_n - v_1\right|}{\sum_{i=1}^{n-1}\left|v_{i+1} - v_i\right|} \tag{5}$$

where

v_i is the test result of the i-th cable, with the cables ordered in ascending order of χ,

$\bar{v}$ is the average value of the test results of the n cables.

In the exceptional case that all values are identical, the parameter m is by definition set to 1.

— **Selection of cable parameter, *n* = 3 cables**

The cable parameter of the tested cables with a value of the cable parameter between χ_{min} and χ_{max} cannot be chosen arbitrarily. If three cables are tested, the cable parameter of the third cable shall fall in the following range:

$$\chi_{3\min} = \frac{1}{2}\left(\chi_{\max} + \chi_{\min}\right) - 0{,}1\left(\chi_{\max} - \chi_{\min}\right) \tag{6}$$

$$\chi_{3\max} = \frac{1}{2}\left(\chi_{\max} + \chi_{\min}\right) + 0{,}1\left(\chi_{\max} - \chi_{\min}\right) \tag{7}$$

If the cable family does not contain a cable with a cable parameter within the range given above, then a cable with a cable parameter closest to the given range shall be chosen, provided that the cable parameter is within the range ± 20 % of the average of the calculated χ_{3min} and χ_{3max}. In such cases the cable parameter of the third cable shall fall in the following range:

$$\chi_{3\min} = \frac{1}{2}\left(\chi_{\max} + \chi_{\min}\right) - 0{,}2\left(\chi_{\max} - \chi_{\min}\right) \tag{8}$$

$$\chi_{3\max} = \frac{1}{2}\left(\chi_{\max} + \chi_{\min}\right) + 0{,}2\left(\chi_{\max} - \chi_{\min}\right) \tag{9}$$

If this provision cannot be met, then the cable family shall be redefined into one or more families such that the provisions can be met.

— **Selection of cable parameters, *n* > 3 cables**

If four or more cables are tested the cable parameter shall fall in the following range:

$$\chi_{ni,\min} = \frac{i-1}{n-1}\left[\chi_{\max} + (n-2)\cdot\chi_{\min} - \frac{n-3}{2}\left(\frac{\chi_{\max} - \chi_{\min}}{n-2}\right)\left(1 - \frac{0{,}8}{2^{(n-3)}}\right)\right] + \chi_{\min}(2-i) + \frac{1}{2}\left(\frac{\chi_{\max} - \chi_{\min}}{n-2}\right)\left(1 - \frac{0{,}8}{2^{(n-3)}}\right)(i-3) \tag{10}$$

$$\chi_{ni,\max} = \frac{i-1}{n-1}\left[\chi_{\max} + (n-2)\cdot\chi_{\min} - \frac{n-3}{2}\left(\frac{\chi_{\max} - \chi_{\min}}{n-2}\right)\left(1 - \frac{0{,}8}{2^{(n-3)}}\right)\right] + \chi_{\min}(2-i) + \frac{1}{2}\left(\frac{\chi_{\max} - \chi_{\min}}{n-2}\right)\left(1 - \frac{0{,}8}{2^{(n-3)}}\right)(i-1) \tag{11}$$

where

n is the total number of cables tested, including the cables with the extreme cable parameters χ_{min} and χ_{max};

i is a counter for the cables tested, where i = 2, 3,…, n-1;

i = 1 and i = n are reserved for the extreme cable parameters, that is, $\chi_{n1} = \chi_{min}$ and $\chi_{nn} = \chi_{max}$;

$\chi_{ni,\,min}$ is the minimum cable parameter for the i-th cable;

$\chi_{ni,\,max}$ is the maximum cable parameter for the i-th cable.

Except for the determination of safety margin, the classification is performed in the same way as described in 5.1. The EXAP is only valid for cables within the range $\chi_{min} \leq \chi \leq \chi_{max}$.

– **Example of selection of cable parameters, *n* > 3 cables**

Example of selection of cables in a cable group with cable parameter χ_{min} = 9 and χ_{max} = 52. The manufacturer wishes to select 5 cables to be tested.

The cables represented by χ_{min} = 9 and χ_{max} = 52 shall be tested and three in the following χ - ranges:

Cable no 2: $\chi_{52,min}$ = 11 and $\chi_{52,max}$ = 23

Cable no 3: $\chi_{53,min}$ = 25 and $\chi_{53,max}$ = 36

Cable no 4: $\chi_{54,min}$ = 38 and $\chi_{54,max}$ = 50

6.2 Example of use of general EXAP (FIGRA) where *m* = 1

Three cables are tested. The cable parameters (χ) of the cables are χ_1 = 6, χ_2 = 22, and χ_3 = 33. FIGRA for these cables is measured as v_1 = 38,5 W/s, v_2 = 40,5 W/s, and v_3 = 103,4 W/s, respectively. This gives:

σ = 30,1 W/s

m = 1

v_{sm} = 33,9 W/s and finally

v_{class} = 137,3 W/s

This shows that the value for classification that shall be used for FIGRA is 137,3 W/s. This is lower than the classification criterion 150 W/s for Class $B2_{ca}$. Therefore, for FIGRA, all cables in the family with $6 \leq \chi \leq 33$ can be considered to fulfil the requirement for Class $B2_{ca}$. In order to classify the cables as $B2_{ca}$ they would also need to fulfil the requirements for $B2_{ca}$ for flame spread, peak HRR, FIGRA and for EN 60332-1-2.

The example is taken from actual CEMAC tests on a cable family. The experimental results are shown in Figure 2 where the red circles indicate the cables used in the example.

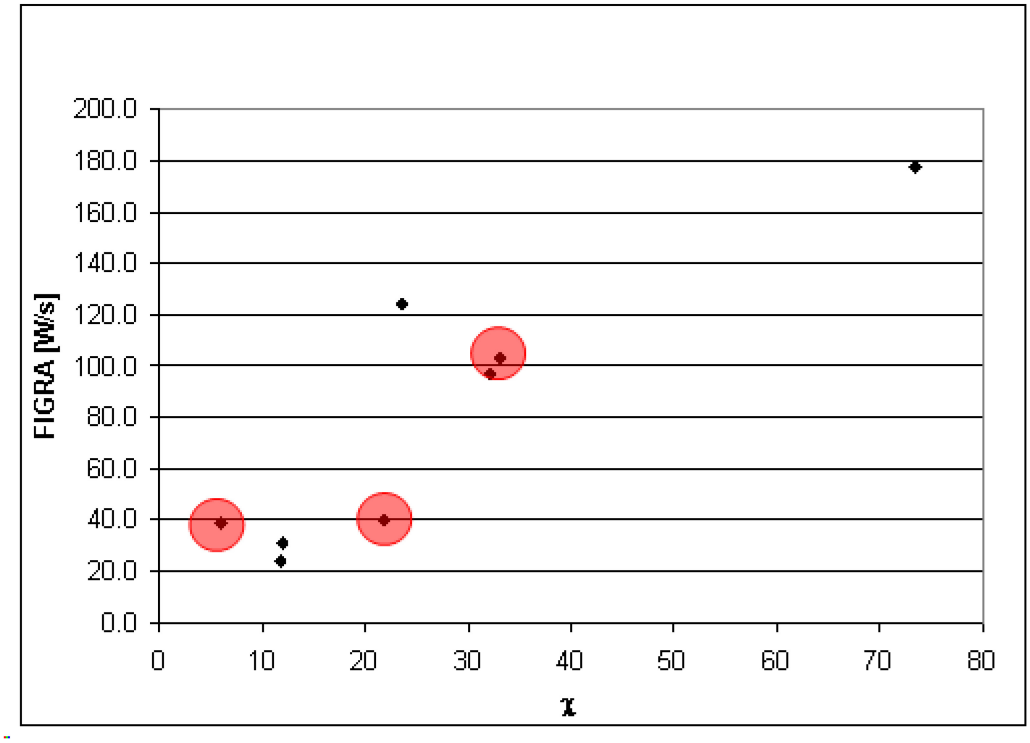


Figure 2 — FIGRA results for cable family

The full range of experimental results is indicated with diamonds whereas the red circles indicate the cables used for the general EXAP procedure in the example.

6.3 Example of use of general EXAP (TSP) where *m* = 1

Three cables are tested. The cable parameters (χ) of the cables are $\chi_1 = 9$, $\chi_2 = 18$, and $\chi_3 = 33$. TSP for these cables is measured as $v_1 = 16{,}3\ m^2$, $v_2 = 16{,}3\ m^2$, and $v_3 = 45{,}4\ m^2$, respectively. This gives:

$\sigma = 13{,}7\ m^2$

$m = 1$

$v_{sm} = 9{,}1\ m^2$ and finally

$v_{class} = 54{,}5\ m^2$

This shows that the value for classification that shall be used for TSP is $54{,}5\ m^2$. This is higher than the classification criterion $50\ m^2$ for Class s1. Therefore, cables in the family with $9 \leq \chi \leq 33$ cannot be considered to fulfil the requirement for Class s1.

The example is taken from actual CEMAC test results on a cable. The experimental results are shown in Figure 3 where the red circles indicate the cables used in the example.

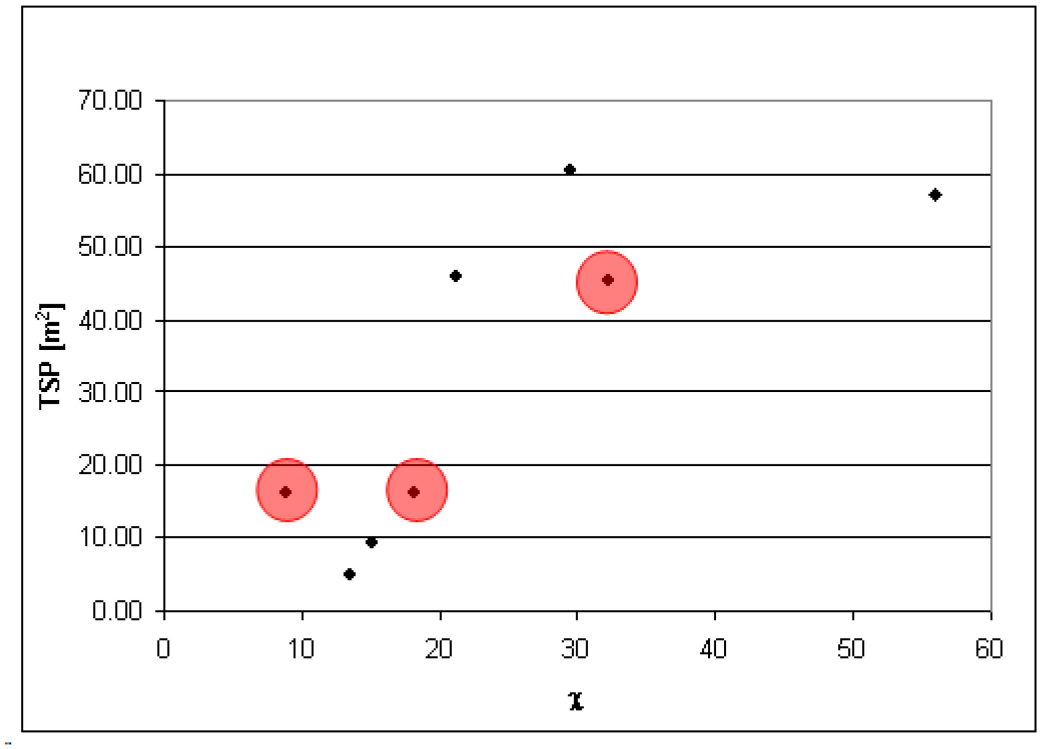


Figure 3 — TSP results for cable family

The full range of experimental results is indicated with diamonds whereas the red circles indicate the cables used for the general EXAP procedure in the example.

6.4 Example of use of general EXAP (TSP) where m is less than 1

Three cables are tested. The cable parameters (χ) of the cables are $\chi_1 = 9$, $\chi_2 = 15$, and $\chi_3 = 21$. TSP for these cables is measured as $v_1 = 16{,}3\ m^2$, $v_2 = 9{,}5\ m^2$, and $v_3 = 45{,}9\ m^2$, respectively. This gives:

$\sigma = 15{,}8\ m^2$

$m = 0{,}69$

$v_{sm} = 6{,}3\ m^2$ and finally

$v_{class} = 52{,}2\ m^2$

This shows that the value for classification that shall be used for TSP is $52{,}2\ m^2$. This is higher than the classification criterion $50\ m^2$ for Class s1. Therefore, cables in the group with $9 \leq \chi \leq 21$ cannot be considered to fulfil the requirement for Class s1.

The example is taken from actual CEMAC test results on a cable. The full range of experimental results (indicated with diamonds) are shown in Figure 4 where the red circles indicate the cables used in the example.

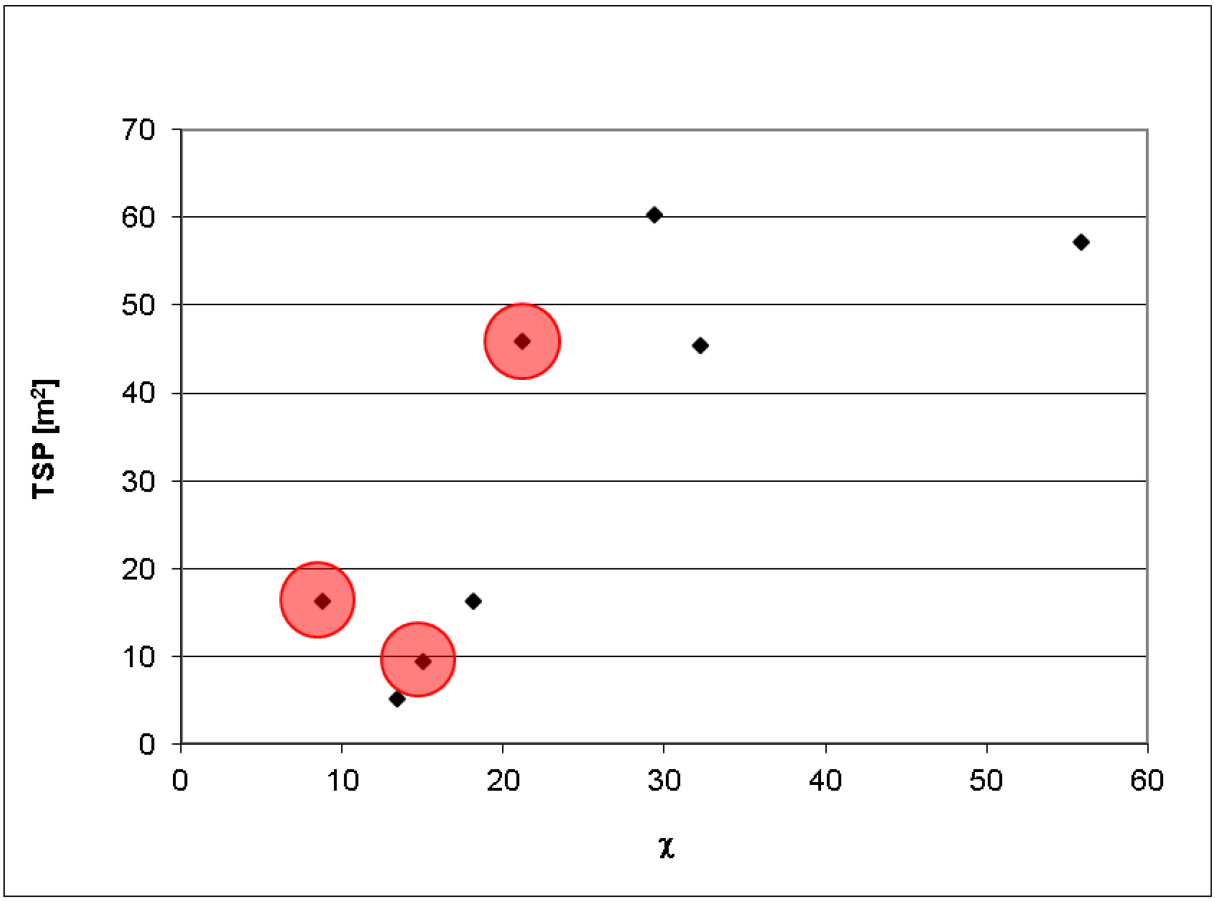


Figure 4 — TSP results for cable family

7 Specific EXAP with safety margin for optical fibre cables

7.1 Rules for specific EXAP for EN 50399 test

The EXAP is based on two tests. The parameter χ is used as cable parameter. It is defined as:

$$\chi = \frac{n}{d^2} V_{combust} \tag{12}$$

where

d is the cable diameter, in m, (or equivalent diameter for non-circular cables);

$V_{combust}$ is the combustible volume per meter of ladder, in m^2;

n is the number of units in one cable.

A unit is defined as a combustible tubular item which may contain one or several fibres. The optical fibre with an outer diameter of approximately 250 µm is not considered a unit, nor is the outer jacket of the cable. A tubular item is not considered a unit if it contains other units. Examples of units can be: tight buffered fibre, microbundle, flextube, unitube and loose tube. The number of tubes attempt to describe the same feature as the number of tubular insulations around the conductors in a power cable.

All cables within the same family with a value of the cable parameter between the lowest and highest value of the cable parameters of the tested cables are included in the EXAP. Classification is based on the maximum measured value plus a safety margin:

$$v_{class} = v_{\max} + v_{sm} \tag{13}$$

where

v_{class} is the value used for classification according to respective classification parameter (peak HRR, THR, FIGRA, FS, peak SPR, and TSP);

$v_{\max}$ is the maximum, that is the worst, test result of the tests that form the basis of the EXAP; and

v_{sm} is the safety margin required for the particular classification parameter.

The safety margins for the different classes and classification parameters are given in Table 4.

Table 4 — Safety margins v_{sm} for optical fibre cables

	Classification parameter	Dimension	Class				
			$B2_{ca}$	C_{ca}	D_{ca}	s1	s2
v_{sm}	**Peak HRR**	**[kW]**	3	6	40		
	THR	**[MJ]**	1,5	3	7		
	FIGRA	**[Ws^{-1}]**	15	30	130		
	Flame spread	**[m]**	0,15	0,2			
	Peak SPR	**[m^2s^{-1}]**				0,05	0,3
	TSP	**[m^2]**				10	80

8 EXAP rule for EN 50399 test for flaming droplets/particles for power, control and communication (copper or optical fibre) cables

For flaming droplets/particles, cables within the cable parameter range for either the specific or general EXAP shall be classified according to the worst result for the tested cables within this range.

9 EXAP rule for EN 60332-1-2 test for classes $B2_{ca}$,C_{ca}, and D_{ca} for power, control and communication (copper or optical fibre) cables

The test procedure of EN 60332-1-2 is designed such that the results are not unduly influenced by cable size.

The EN 60332-1-2 was found to be not significant in cable classification for the entire cable population of the CEMAC project.

The same cable samples as selected for the EN 50399 test by the EXAP procedure applied (specific or general) shall be tested according to EN 60332-1-2 and cables within the cable parameter range shall be classified according to the worst result for the tested cables within this range.

Cables with a diameter smaller than allowed by Table 2 (including those that would be tested as bundles according to EN 50399) may be added to the family classification on the basis of testing the smallest diameter cable in the family.

Cables with a diameter larger than allowed by Table 2 may be assessed using the extrapolation rule given in 5.2 provided that the conditions stated in 5.2 are met.

Cables with a diameter larger than allowed by Table 2 not meeting the conditions stated in 5.2 may be added to the family classification in accordance with the following rule:

— largest cable tested with diameter greater than 25 mm and less than or equal to 50 mm then all cables with diameter up to 50 mm included;

— largest cable tested with diameter greater than 50 mm and less than or equal to 75 mm then all cables with diameter up to 75 mm included;

— largest cable tested with diameter over 75 mm then all cables with diameter over 75 mm included.

NOTE Clause 9 applies to both circular and non-circular cables in accordance with the requirements of EN 60332–1–2

10 EXAP rule for EN 60332-1-2 test for class E_{ca} for power, control and communication (copper or optical fibre) cables

Provided that the cables belong to a defined family in accordance with 4.1, the EXAP is based on two tests: the cable with the smallest diameter and the cable with approximately the largest diameter (where the cable chosen for test shall have a diameter within (D - 20 %) of the largest cable diameter in the cable family, where D is the largest diameter cable in the cable family).

The cable family shall be classified according to the worst result for the tested cables.

Cables with a diameter larger than that tested may be added to the family classification in accordance with the following rule:

— largest cable tested with diameter greater than 25 mm and less than or equal to 50 mm then all cables with diameter up to 50 mm included;

— largest cable tested with diameter greater than 50 mm and less than or equal to 75 mm then all cables with diameter up to 75 mm included;

— largest cable tested with diameter over 75 mm then all cables with diameter over 75 mm included.

— largest cable tested with diameter less than or equal to 25 mm then only cables with diameter up to 25 mm included

NOTE Clause 10 applies to both circular and non-circular cables in accordance with the requirements of EN 60332–1–2.

11 EXAP rule for EN 61034-2 test for classes s1a and s1b for power, control and communication (copper or optical fibre) cables

Provided that the cables belong to a defined family in accordance with 4.1, the EXAP is based on two tests:

Maximum cable diameter d_{max} in the cable family	**Selection of samples for** EN 61034–2 **test**
$d_{max} \leq 20$ mm	Select the cables with the smallest and largest value of the cable parameter, in accordance with the EXAP rule for the EN 50399 test.
20 mm < $d_{max} \leq 40$ mm	Select the cables with the smallest and largest value of the cable parameter in accordance with the EXAP rule for the EN 50399 test. If one of these cables has the largest cable diameter within the family the samples are representative for all diameters. If not, the sample with the larger cable diameter should be replaced by the cable with the largest cable diameter within the family
$d_{max} > 40$ mm	Select the cables with the smallest and largest value of the cable parameter in accordance with the EXAP rule for the EN 50399 test. If one of the cables has a cable diameter in the range of 35 to 40 mm, the samples are representative for all diameters. If not, the sample with the larger cable diameter should be replaced by the cable in the family with outer diameter 20 to 40 mm, closest to 40 mm.

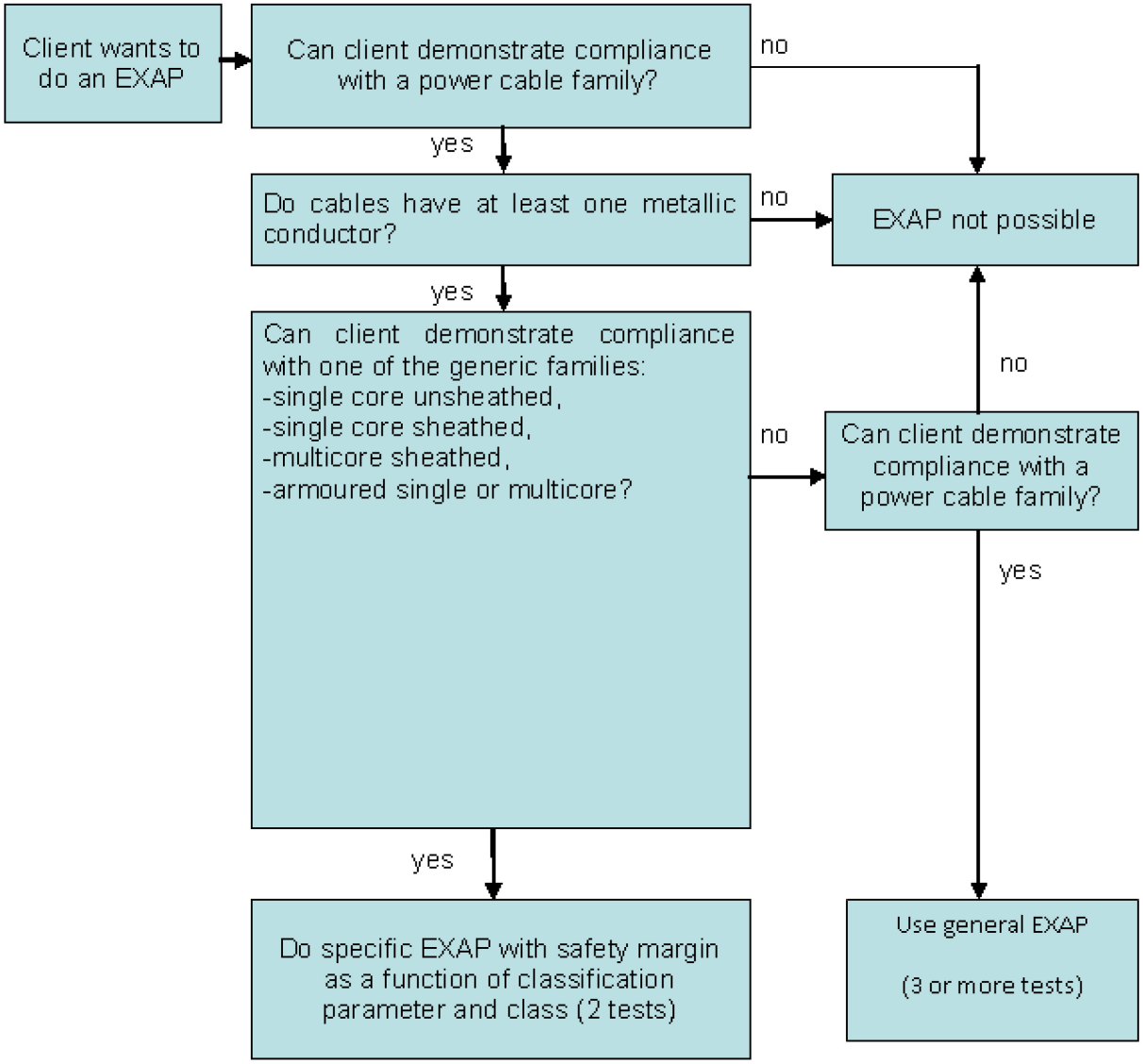
The lowest measured value for the light transmittance shall be used for classification.

Annex A
(informative)

Flow chart and checklist for specific EXAP for power cables

A.1 Basic EXAP procedure flow chart

The basic EXAP procedure is described in the flow chart in Figure A.1.



NOTE It is always possible to use the general EXAP for any power cable family.

Figure A.1 — Flow chart of the EXAP procedure

A.2 Checklist for specific EXAP

— Choose the specific family of cables for which classification is required.

— Check that the family complies with the definition of a product family given in the EXAP rules and is one of the identified generic families.

— Calculate the nominal tabulated overall diameter for each cable in the family.

— Calculate the non metallic volume per metre for each cable in the family.

— Determine the number of cables on the test ladder for each cable in the family using the formulae in EN 50399.

— Calculate the non metallic volume per metre test ladder for each cable in the family.

— Calculate the cable parameter for each cable in the family.

— Check that the cable diameters and cable parameters are within the limits given for the identified generic family given in the EXAP rules.

— If any cable diameter or cable parameter falls outside the limits, either

  a) redefine the family so all fall within the limits;

  b) use the general EXAP procedure.

— Note that cables larger than the tested range may in most cases be included in the classification by extrapolation.

— Note that multicore cables (above 5 cores) will normally fall outside the range and should be considered a separate family assessed using the general EXAP procedure.

— Test according to EN 50399 a cable with the lowest and a cable with the highest cable parameter (subject to the diameter limits given in the EXAP rules).

— Record the largest measured value for each classification parameter from the tests.

— Add the appropriate safety margin to each value.

— Determine the classification by reference to the limit values in the EC decision or classification standard for cables (EN 13501-6 [4]).

— The classification determined applies to the whole cable family.

Annex B
(normative)

Rounding of numbers

The following rules apply when rounding numbers for values that require to be rounded to one or more than one decimal place. This may occur, for instance, in calculating the average value of several measurement results, or the minimum value by applying a percentage tolerance to a given nominal value. In these cases, rounding shall be carried out to the number of decimal places specified in the relevant clauses.

The method of rounding shall then be

a) if the last figure to be retained is followed, before rounding, by 0, 1, 2, 3 or 4, it shall remain unchanged (rounding down);

b) if the last figure to be retained is followed, before rounding, by 9, 8, 7, 6 or 5, it shall be increased by one (rounding up).

To illustrate these rules, the following practical examples are given

— a) Rounding down

Examples

2,12	≈	2,1	rounded	to	one	decimal	place
2,444	≈	2,4	rounded	to	one	decimal	place
2,444	≈	2,44	rounded	to	two	decimal	places
25,047	≈	25,0	rounded	to	one	decimal	place
25,044	≈	25,04	rounded	to	two	decimal	places

— b) Rounding up

Examples

2,17	≈	2,2	rounded	to	one	decimal	place
2,454	≈	2,5	rounded	to	one	decimal	place
2,445	≈	2,45	rounded	to	two	decimal	places
25,057	≈	25,1	rounded	to	one	decimal	place
25,045	≈	25,05	rounded	to	two	decimal	places

Annex C
(informative)

Background information on EN 60332-1-2 and EN 61034-2 testing

C.1 Background information regarding EN 60332-1-2 testing

The test procedure of EN 60332-1-2 is designed such that the results are not unduly influenced by cable size". For convenience, in cases where a EN 50399 test is carried out, the same samples are tested for EN 60332-1-2. For cases where a EN 50399 test is not carried out (Class E) an alternative procedure is required.

It is generally accepted through many years of experience with the EN 60332-1-2 test that the most critical cables are the smallest. Whilst it is accepted that a smaller and larger cable from a family should be tested for classification, some flexibility on the choice of the larger cable should be possible.

The EN 60331-1-2 moderates the influence of cable size by specifying different flame application times according to the diameter of the cable under test.

Table C.1 — Time for flame application

Overall diameter of test piece [a] mm	**Time for flame application** s
$D \leq 25$	60 ± 2
$25 < D \leq 50$	120 ± 2
$50 < D \leq 75$	240 ± 2
$D > 75$	480 ± 2

[a] For non-circular cables in which the major to minor axis ratio is less than 3, the nominal minor axis shall be used as the overall diameter (*D*).

For non-circular cables in which the major to minor axis ratio lies between 3 and 16, the overall diameter (*D*) shall be taken as the sum of the major and minor axis divided by 3,14 (π).

For cables in which the major to minor axis ratio exceeds 16, the test criteria shall be given in the product standard or, if not, agreed between manufacturer and purchaser.

C.2 Background information regarding EN 61034-2 testing

As defined in EN 13501-6 (Table 1 — Classes of reaction to fire performance for electric cables), for the additional classification on smoke production for the classes $B2_{ca}$ to D_{ca}, the classification s1, s2 or s3 derives from the test EN 50399. To reduce the number of tests necessary for the qualification of a product family, TS 50576 defines rules for identifying representative cable samples for the EN 50399 test.

For the class s1 only, there is an additional possibility for smoke classification s1a and s1b which requires an additional test according to EN 61034-2. Analysis of results achieved within the CEMAC project confirms existing experience which has been used to develop an EXAP rule.

The number of test pieces for EN 61034-2 are as in Table C.2:

Table C.2 — Number of test pieces for EN 61034–2

Overall diameter of the cable (D) in mm	Number of test pieces
D > 40	1
20 < D ≤ 40	2
10 < D ≤ 20	3
5 < D ≤ 10	N1
Where N1 = 45/D test pieces. The value of N1 shall be rounded downwards to the integer to give the number of test pieces.	

Using this procedure, existing results and experience with EN 61034-2 test clearly indicate that within a product family the result of EN 61034-2 does not depend much on the cable diameter of the product sample.

This is especially true for cable diameter below 20 mm. For cable diameter above, the most stringent test conditions are for cable diameter close to 40 mm, as the two test pieces in this diameter range representing normally the highest amount of combustible material and highest cable surface.

Table C.3 — Evaluation of EN 61034–2 tests on product families

Maximum cable diameter dmax in the cable family	*Remarks*
d_{max} ≤ 20 mm	*low dependency of light transmittance from cable diameter in the diameter range up to and including 20 mm*
20 mm < d_{max} ≤ 40 mm	*Light transmittance will decrease with increasing diameter between 20 to 40 mm (two test pieces in the range 20 to 40 mm)*
d_{max} > 40 mm	*Light transmittance will decrease with increasing diameter. Most critical cable diameter are just below 40mm (two test pieces, above 40 mm only one test piece)*

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[3] CEN/TS 15117, *Guidance on direct and extended application*

[4] EN 13501-6, *Fire classification of construction products and building elements - Part 6: Classification using data from reaction to fire tests on electric cables*

[5] EN 15725, *Extended application reports on the fire performance of construction products and building elements*

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[7] EN 60228, *Conductors of insulated cables (IEC 60228)*

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