EN 50399 Standard's Purpose and Fire Simulation

Erse Kablo R&D Engineer, Anıl AYGÖREN

anilaygoren@ersekablo.com.tr

With the Construction Products Regulation (CPR), the necessity of measuring the fire reaction performance of cables during fire gains importance in the pyramid of needs brought by the developing technology and increasing population. In this technical article, we will evaluate the EN50399 test in measurements for CPR, the results of the test values, the factors affecting these results and EXAP calculations.

EN 50399 General Definition, Purpose and Fire Simulation

Due to reasons such as our buildings getting bigger and more complex day by day, the rise of floors under and above the ground in buildings, and crowding of common areas, the evacuation times are extented in emergency situations. This situation requires that more beware of consideration of the scenarios and the consequences during the fire.

The consideration subject about construction products is a fire started in a specific area which can grow over time and eventually reach sudden flame. This scenario includes three fire situations that correspond to the three stages in the development of a fire.

1. The first stage involves starting a fire by igniting with a small flame in a limited area of the product.

2. The second stage is about the growth of the fire. This stage is simulated by a fire started in cables mounted on a vertical ladder.

3. At the stage after a sudden flame, all combustible products contribute to the fire load.

EN 50399 standard covers, evaluates the test and test equipments that will measure the fire reaction performance of the cables in order to be classify under the construction products directive.

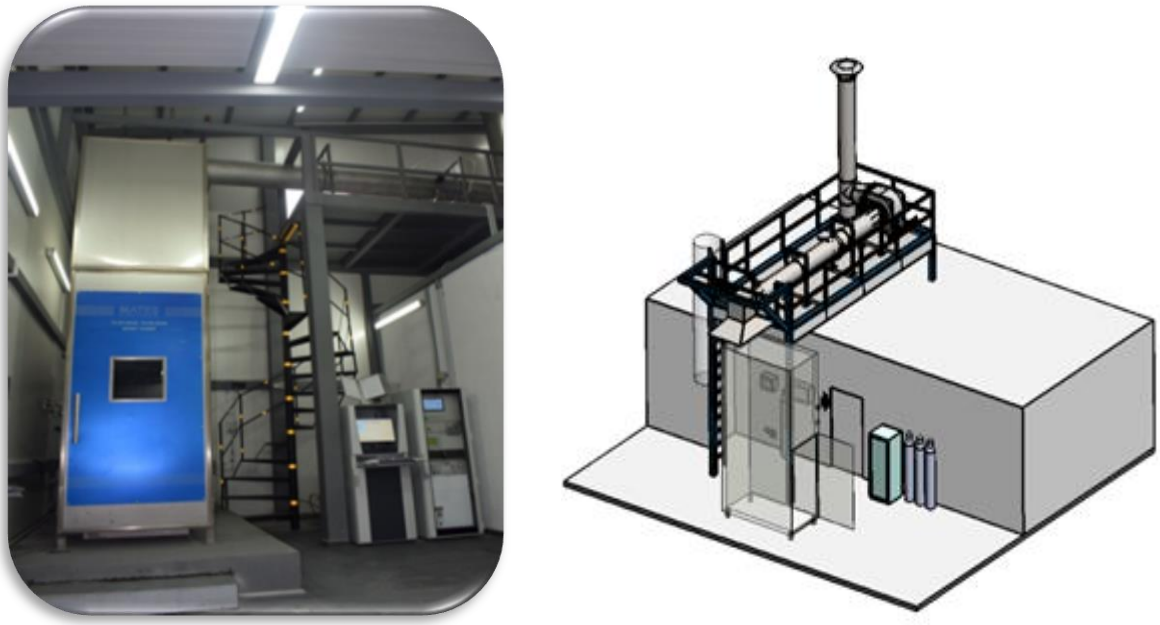


Image 1: EN 50399 Tester Overview

The EN 50399 standard stands out with the criteria measurements made during the testing of existing cable flame performance tests. Compared to existing test methods, this standard provides a more comprehensive evaluation system. The reactions of cables in fire conditions are simulated as close to reality. The test evaluates the possible contribution of a cable laid inside the construction to the growth of the fire and its effect on the generation and spread of smoke in the room where the fire begins or in a specific area if it encounters a direct source of flame. The aim here is to measure the fire reaction performance of cables during a fire according to the established criteria and to determine the potential fire effects by testing.

The test apparatus is based on EN 60332-3-10 however additional equipment is needed to perform the test. The cables are tested by burning them in the cabin after they are mounted on a 4-meter-long ladder. The burner nominal heat release (HRR) level is set at 20.5 kW(*), the air flow rate is set as 8000 ± 400 L/min. The test flame application time is 1200 s. In addition, O_2 consumption, CO_2 generation, volumetric flow in the air outlet duct and smoke generation are measured. The amount of smoke and heat generated in these measurements are used in the calculations.

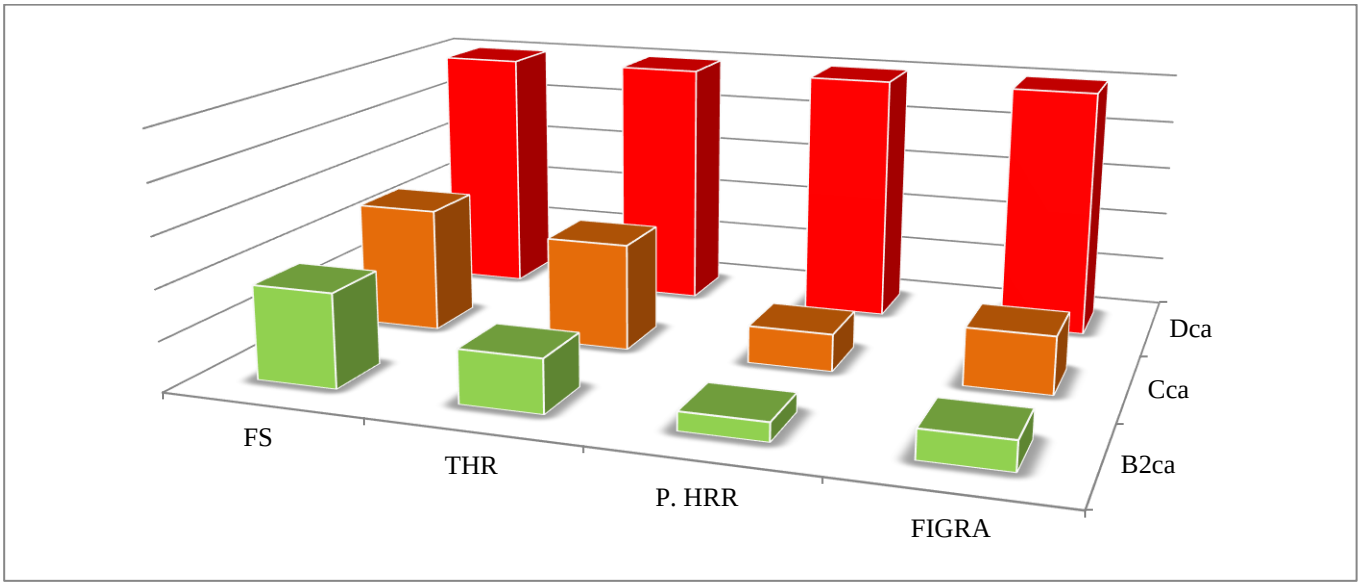
(*) *$B1_{ca}$ class: 30 kW*

When cables are ignited inside the structure, the following parameters are considered to evaluate the combustion behavior in the early stages.

- Heat release rate. Thermal energy released per unit time by an item during combustion under specified conditions. (HRR)
- Total heat release. Integrated value of the heat release rate over a defined period . (THR)
- Fire growth rate index. Highest value of the quotient between HRR and time. (FIGRA)

- Flame spread. Propagation of a flame front. (FS)
- Flaming droplets/particles. Material separating from the specimen during the test and continuing to flame for a minimum period as described in the test method.
- Smoke production rate. Smoke production per unit time. (SPR)
- Total smoke production. Integrated value of the smoke production rate over a defined period. (TSP)

Image 2: View of the tested sample on the ladder (EN 50399)



Graphic 1: Comparison between CPR class test values

Note: Special conditions are applied for class $B1_{ca}$ according to EN 50399.

- **Vertical Flame Spread (H)**

According to EN 60332-1-2, flame spread is evaluated on a single cable exposed to a small amount of flame. The cables which pass this test can be classified as Eca class. It is one of the minimum requirements of $B2_{ca}$, Cca and Dca classes. When the cable is failed in this test, it can be classified as Fca.

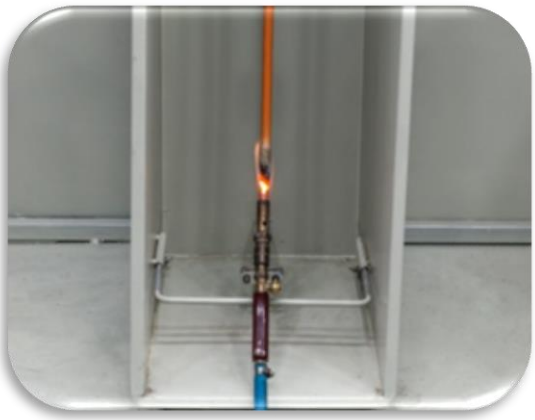


Image 3: EN 60332-1-2 / Vertical Flame Spread Test

- **Additional Classifications (s, d, a)**

Under appropriate weather conditions, the contribution of a burning cable to the generation of smoke, loss of sight in the field of view and burning cable materials to the generation of acidic gases is evaluated.(EN 61034-2 and EN 60754-2)

The smoke released during combustion not only causes poisoning also affects the field of view and prevents reaching the emergency exit. The resulting halogens can have irritating results in the throat and mouth if not limited.Such situations of acid influence significantly impede the evacuation. Prolonged exposure to halogen toxic gases can be fatal but the important factors in this regard are the density of the substances and the amount of absorption. The items measured in this test are the amount of smoke produced per unit time and in total.

Image 4: EN 61034-2 / Measurement of Smoke Density Test

Image 5: EN 60754-2 / Determination of Gas (Ph and Conductivity)

EN 61034-2 / Smoke Density (s)	
s1	TSP $\leq$ 50 mm²
	Peak SPR $\leq$ 0,25 m² /s
s1a	EN 61034-2 $\geq$ %80 (Light Transmittance)
s1b	EN 61034-2 $\geq$ %60 < %80 (Light Transmittance)
s2	TSP (Total Smoke Production) $\leq$ 400 mm²
	Peak SPR $\leq$ 1,5 m²/s
s3	not cover s1 or s2

Table 1

EN 60754-2 / Acidity (a)		
	Conductivity	pH
a1	< 2,5µS / mm	> 4,3
a2	< 10 µS / mm	> 4,3
a3	not cover a1 or a2	

Table 2

EN 50399 / Flame Droplets (d)	
d0	No flaming droplets / particles
d1	No flaming droplets / particles present in more than 10 s in 1200 s
d2	not cover d1 or d2

Table 3

Evaluation of Test Results

Classification is made using data obtained from reaction to fire tests on power, control and communication cables. (EN 13501-6) Classification can be obtained by testing for a particular product or product family. A classification to cover the product family is carried out in accordance with the EXAP calculations mentioned in the following section.

Products classified according to a given class are considered to provide all the requirements of the lower classes.

EXAP Calculations

The results of the standard fulfillment tests performed on a product included in the product family are also cover for other products in that product family.EXAP (Extended Application), calculated according to the CLC/TS 50576 standard, is a process that is concluded within the scope of certain rules based on one or more test results for the same test standard in a cable family. All cables within the same family that have a cable parameter value between the lowest and highest value of the cable parameters are included in EXAP.

Note: Cables with a diameter of 5.0 mm and less must be tested in bundles according to EN 50399. Bundled cables are not included in the EXAP rules applied to EN 50399 test results.

Also in this standard, there are rules for determining cable families.

- Family members must have the same general structure (design elements) and voltage rate.
- Conductor classes must be the same. (Divided into Class1/2 and Class 5/6)
- The screen or armor on the product creates a different cable family.
- The product family changes in the standard difference (including the manufacturer's specifications.
- In communication cables which screen structures change from cables within the same standard fall into different family groups (U/UTP, F/UTP, S/FTP…)

The fire characteristics of each cable are expressed as the cable parameter "χ".Its intended use is to estimate the monotonic trend of fire parameters obtained during the EN 50399 standard test of cables in the same cable family.

$$x = \frac{c}{d^2} V_{combust}$$

d **:** the cable diameter (m)
Vcombust **:** the non-metallic volume per meter of ladder (m²)
c **:** the number of conductors in one cable

Classification is based on the maximum measured value and safety margin. Even if the EN 50399 test result is achieved in the targeted class, the family's fire reaction performance class may decrease due to safety margins in accordance with the EXAP rules.

$$\nu_{class} = \nu_{max} + \nu_{sm}$$

ν_{class} : The value used for classification according to respective classification parameter (peak HRR, THR, FIGRA, FS, peak SPR, and TSP)

ν_{max} : The maximum, that is the worst, test result of the tests that forms the basis of the EXAP

ν_{sm} : The safety margin required for the particular classification parameter

Example for different classes and classification parameters safety margins νsm.

	Classification Parameter	Unit	Class				
			$B2_{ca}$	C_{ca}	D_{ca}	s1	s2
ν_{sm}	Peak HRR	kW	3	6	40		
	THR	MJ	1,5	3	7		
	FIGRA	Ws^{-1}	15	30	130		
	FS	m	0,15	0,2			
	Peak SPR	m^2s^{-1}				0,05	0,3
	TSP	m^2				10	80

Table 4: νsm

Factors Affecting Results

Cables are quite complex and extensive due to the variety of types, sections, processes and materials used. As a result of EN 50399 tests that we conducted in our own laboratory as Erse Kablo, we observed that there are a lot of variables that affect the results of fire reaction performance.

The sheath polymer is crucial because of the sheath polymer is the first structure to meet the flame. Choose of sheath polymers should be determined according to the targeted CPR result depending to the fire load created by the polymers in the inner layers.

The extrusion method, the parameters of the cable design, the insulation thicknesses, the colorants etc can significantly affect the results. However, the way the test is performed also has an important role in achieving the targeted performance. One of the factors affecting performance is the way it is mounted to the ladder (it should be connected in a straight line.).

Acronyms

HRR : Heat Release Rate
THR : Total Heat Release
SPR : Smoke Production Rate
TSP : Total Smoke Production
FIGRA: Fire Growth Rate Index
FD : Flaming Droplets
FS : Flame Spread

Keywords: *construction products regulation (CPR), EN 50399 test, weak current cables, reaction to fire, cable design, reaction to fire tests*