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Fire behavior of Twisted Pair communication cables

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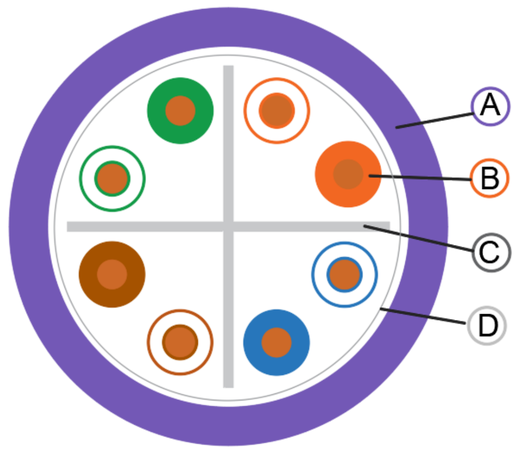
| Background

Unshielded Category 6 twisted-pair (UTP) cabling is a core component of structured building networks, widely used for data and telecommunication applications due to its cost-effectiveness, ease of installation, and sufficient interference resistance. Its deployment has expanded beyond public and industrial buildings to residential settings. While less hazardous than power cables, the composition and quantity of insulation and sheathing can significantly influence fire propagation. This study presents a comprehensive evaluation of UTP cable fire performance using calorimetric analysis, flammability testing, and toxicity assessment. The results provide critical insights for fire prevention and environmental protection.

| Materials

For the purposes of this research, four Category 6 unshielded UTP cables (black, gray, orange, and purple) were used; the cables for some measurements were disassembled into individual components. The gray, purple, and orange cables contain: A – Sheath; B – Sheathed copper conductor; C – Center cross (middle insulator). The black cable also contains: D – Transparent cover. Structures of UTP cables is on the picture.

Cable	Black RAL 9005	Grey RAL 7035	Orange RAL 2003	Purple RAL 4005
Category	CAT 6	CAT 6	CAT 6	CAT 6
Shielding	UTP (U/UTP) unshielded	UTP (U/UTP) unshielded	UTP (U/UTP) unshielded	UTP (U/UTP) unshielded
Conductor type & diameter	Copper wire 0.55 mm	Copper wire 0.55 mm	Copper wire 0.55 mm	Copper wire 0.55 mm
Insulation & conductor diameter	HDPE 0.98 mm	HDPE 0.98 mm	HDPE 0.98 mm	HDPE 0.98 mm
Sheath material	PE (UV stable)	PVC	LSOHFR	LSOH halogen-free, low smoke
Fire reaction class CPR	Fca	Eca	B2ca-s1,d1,a1	Dca-s2,d2,a1
Cable diameter	6.1 mm	6.1 mm	6.6 mm	6.1 mm
Approx. weight	37.5 kg/km	43 kg/km	54.1 kg/km	43 kg/km



| Methods

To assess the flammability and properties of cable materials, methods for determining fire performance characteristics were used, providing information on calorific value, heat release, ignitability, chemical composition, and thermal stability of the materials. Tests were conducted on individual cable components as well as on entire cables under standard laboratory conditions.

Flammability and heat release assessment **Bomb calorimeter:** Determination of calorific value according to ČSN EN ISO 1716. **Cone calorimeter:** Determination of heat release rate, total mass loss, MAHRE, time to ignition, THR, and peak heat release according to ISO 5660 at heat flux of 35 kW/m².

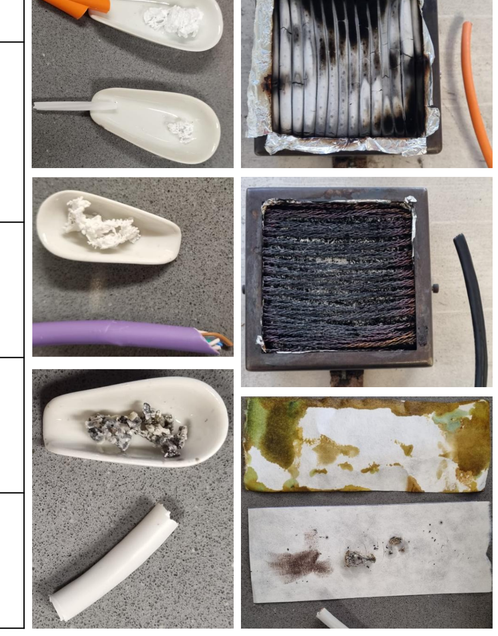
Ignitability assessment **Limiting Oxygen Index (LOI):** Measurement according to ČSN ISO 4589-2 on the outer jackets of cables. **Setchkin furnace:** Determination of flash and ignition temperatures for the entire cable cross-section according to ČSN 64 0149.

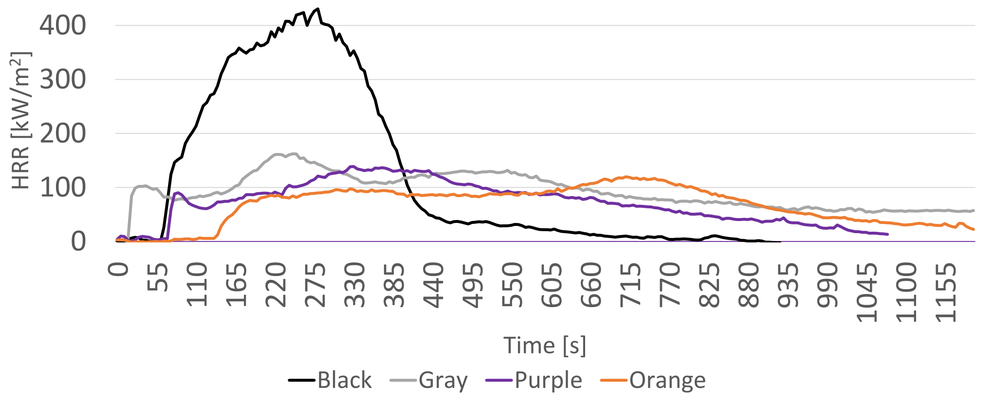
Analytical techniques **TGA/DSC (thermal analysis):** Simultaneous measurement of mass changes (TGA) and heat flow (DSC) from 30–750 °C at 20 K/min with an air flow of 50 ml/min. **FTIR:** ATR analysis of individual cable components without sample destruction, and analysis of gaseous decomposition products during thermal degradation in a circular furnace (570 °C), 10 m gas cell at 170 °C, sleeves at 120 °C. Resolution 1 cm^{-1}, 32 scans. **CHN analysis:** Quantitative determination of carbon, hydrogen, and nitrogen content in samples, applied in chemistry, pharmacy, and environmental studies.

| Results

The individual cable materials were tested using different methods, and the results were compared. Interestingly, the LOI and FIT of the outer jacket of the purple cable are higher than those of the orange flame-retardant cable; nevertheless, SIT measurements confirm the flame retardancy of the orange cable. The results also show that, although some parts of the cable may be equally or more flammable than others, the overall flammability of the entire cable is lower when assessed as a whole.

Cable	Cable part	Calorific value average [MJ/kg]	Limiting Oxygen Index [vol. %]	FIT [°C]	SIT [°C]	peak HRR [kW/m²]	MARHE [kW/m²]	Time to ignition [s]	Mass lost [g]
Black	Outer sheath	46,039	17,5	421	430	430,65	265,86	65	26,19
	Center cross	46,307	-						
	Internal conductor insulation	45,967	-						
	Transparent packaging	22,505	-						
Gray	Outer sheath	17,384	26,9	401	405	162,34	114,83	17	28,52
	Center cross	46,414	-						
	Internal conductor insulation	45,800	-						
Orange	Outer sheath	11,726	36,4	436	469	119,76	76,87	140	24,39
	Center cross	25,375	-						
	Internal conductor insulation	45,946	-						
Purple	Outer sheath	15,524	39,2	455	458	138,81	91,39	71	20,13
	Center cross	46,432	-						
	Internal conductor insulation	45,872	-						





| Conclusion

For a comprehensive assessment of a cable's flammability, it is necessary to consider all its components and their interactions during burning. Individual partial results can be misleading, as they do not always reflect the overall flammability of the cable. Therefore, the cable should be evaluated using multiple methods, since relying on a single method may lead to incorrect conclusions. Similarly, the cable's composition must be taken into account – it consists of different parts, each of which may exhibit distinct measured values, and only a comprehensive evaluation provides an accurate picture of the properties of the entire cable.