Fire Performance of Data Communication Cables

A publication of the Fluoropolymers Division of
The Society of the Plastics Industry, Inc.

Executive Summary

The Society of the Plastics Industry, Inc. (SPI) Fluoropolymers Division, under the auspices of the Wire and Cable Subcommittee, sponsored a series of tests at the Building Research Establishment/Fire Research Station (BRE/FRS) test facility located in Bedford , England and Underwriters Laboratory (U.L.), Northbrook, IL. These tests, using "real scale" as well as intermediate scale test methods, were conducted on cables used in horizontal concealed spaces ("plenums") above ceilings and below floors in commercial and industrial buildings. Cables tested included those used in the U.S. and Europe.

Extensive testing clearly demonstrates the excellent fire performance advantages of data communication cables made with fluoropolymer materials compared to cables made from low smoke zero halogen materials. Tests on low smoke zero halogen cables revealed a potentially severe fire hazard, based on characteristics such as flame spread, dripping fireballs, smoke and carbon monoxide generation, and temperature increases. Cables made with fluoropolymer materials showed significantly less potential to contribute to the overall fire hazard based on these same criteria.

Conclusions that can be drawn from the results of this study on fire performance of data communication cables include:

- The results obtained in the intermediate scale NFPA 262 cable tests correlated very well with results obtained in the real scale tests simulating cable installations.
- The fire performance of the exposed fluoropolymer cables compared favorably with non-fluoropolymer cables protected in metal trunking (conduit).
- The flame spread, smoke generation, carbon monoxide generation, and temperature increases for exposed fluoropolymer cables were significantly lower than the results obtained on exposed low smoke zero halogen cables.
- Published toxicity data shows no significant differentiation among the fluoropolymer, PVC and polyolefin classes of materials.
- The NFPA 262 and the BRE/FRS test rigs relate to actual installation practices and accurately simulate many potential fire hazard reference scenarios.
- NFPA 262 and the BRE/FRS test rigs are the only demonstrated options to comprehensively assess the fire hazards of cables in horizontal concealed spaces. The IEC 332-1 and IEC 332-3 tests are not relevant options.

Details of the study are contained in this paper. For additional copies contact The Society of the Plastics Industry, Inc. 1801 K Street, N.W., Ste. 600K, Washington, D.C. 20006 or visit the SPI web site at www.datacable.org.

Introduction

The information age has had a dramatic effect upon the installation practices for data communication cables. Worldwide, ceiling (Fig. 1) and floor (Fig. 2) concealed spaces are increasingly used for utilities and ventilation. Many new and refurbished buildings use concealed spaces to run data communication and power cables as well as other building services. These spaces may be above a suspended ceiling or below a raised floor.

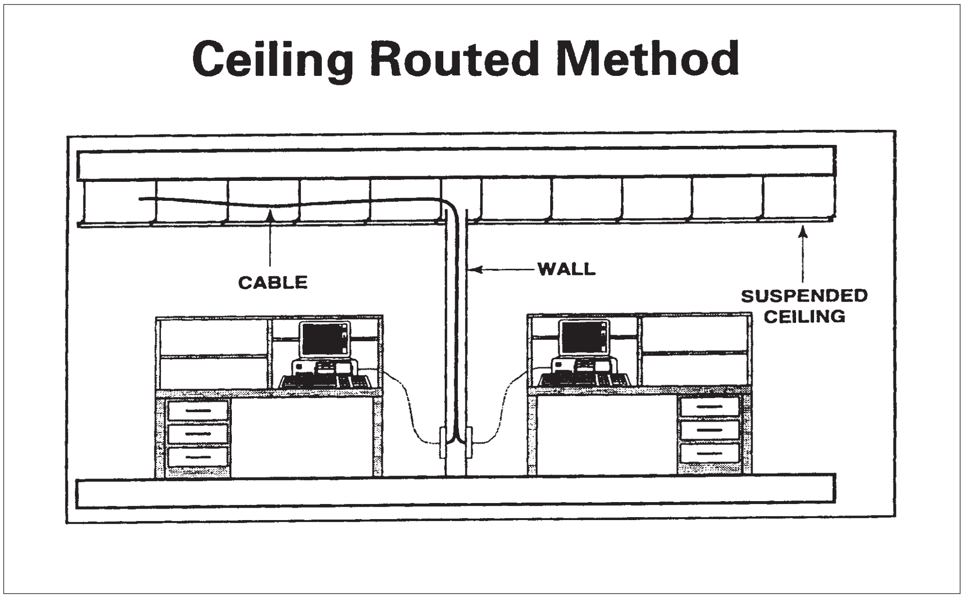

Figure 1 – Ceiling Concealed Space

In many cases, air flows through these spaces. This air may be used for ventilation, heating and cooling. When these concealed spaces contain combustibles they become a potential path for the undetected movement of flame and smoke. The growing use of these spaces for cabling and other combustibles has led to concerns about new fire path and fire load hazards.

The use of data communication networks is growing more the 25% per year in many countries. These networks are recabled, on the average, every three to five years as computer technology evolves and the networking needs increase. As a result, many concealed spaces are filling with multiple generations of cables creating an

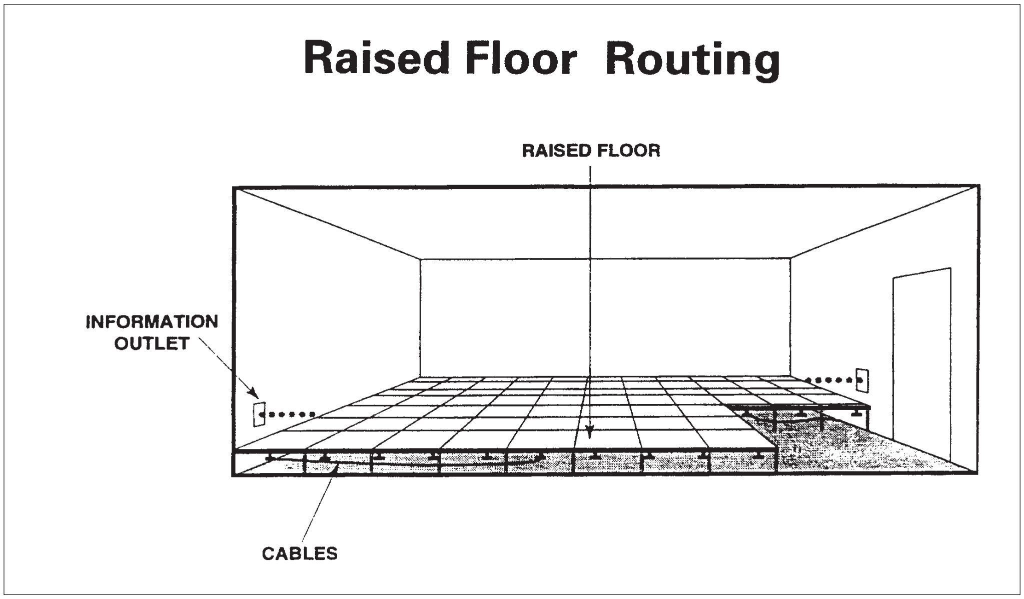

Figure 2 – Floor Concealed Space

uncharacterized fire hazard (Fig. 3). These spaces become a potential path for the undetected movement of flame and smoke during a fire.

A series of large fires have occurred that demonstrate the continuing hazards of highly combustible materials in concealed spaces (Fig 4.):

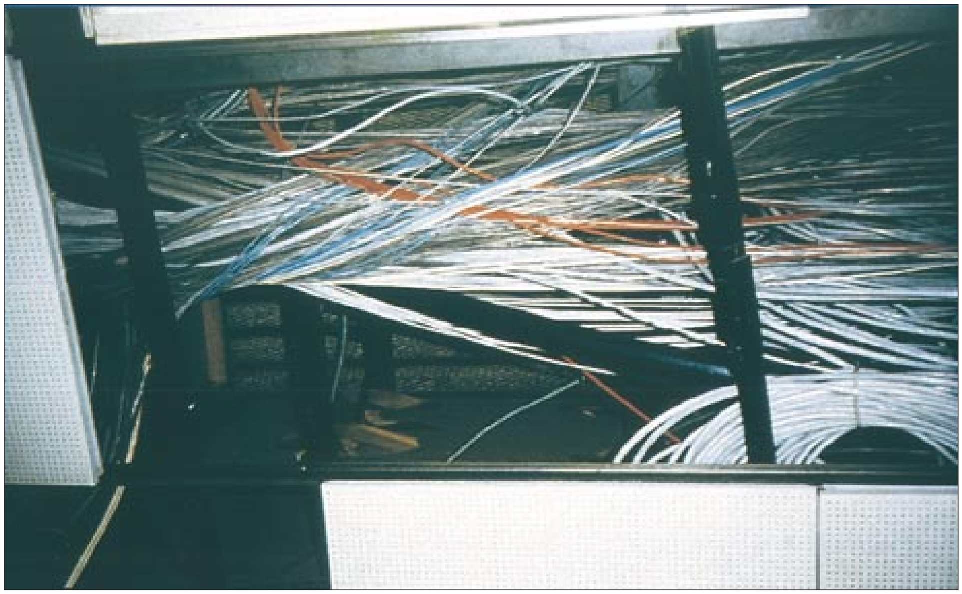

Figure 3 – Uncharacterized Fire Hazard

Figure 4 – Credit Lyonnaise Bank

Dusseldorf Airport, Germany, April,1996	Credit Lyonnaise Bank, France, May, 1997
Rockefeller Center, USA, October, 1996	Heathrow Airport, UK, December, 1997
Garly Building, Hong Kong November, 1996	Montblanc Tunnel, France/Switzerland, March 1999
Bangkok President Tower, Thailand, February, 1997	

This paper presents the results of combustibility testing on data communication cables in three major areas:

- Real Scale Fire Testing
- Intermediate Scale Fire Testing
- Toxicity

Real Scale Fire Testing

A real scale fire test facility was constructed at the British Research Establishment / Fire Research Station in the United Kingdom (Fig. 5, 6).

The real scale test rig was a 7.4m (24.3 ft.) X 5.7m (18.7 ft.) X 4m (13.1 ft.) concrete room with a two hour fire– rated suspended ceiling. The

Figure 5 – BRE/FRS

Figure 6 – BRE/FRS

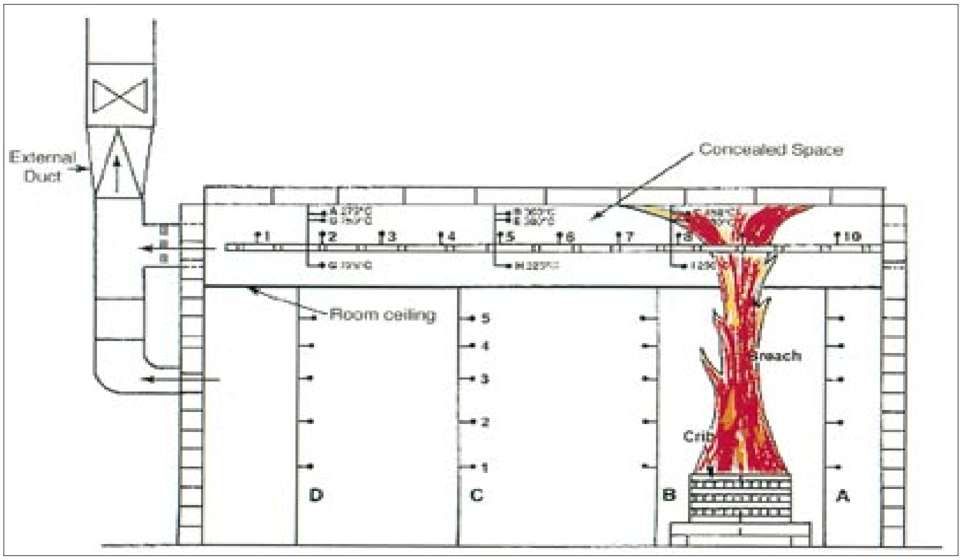

Figure 7 – Real Scale Test Rig

suspended ceiling formed an overhead concealed space of 1m (3.3 ft.) (Fig. 7).

The source fire was a standardized wood crib that generated a nominal 1-megawatt fire over a thirty minute period. A 1-megawatt fire approximates the heat energy released from a burning piece of office furniture[1]. (Fig. 8)

A ventilation system capable of airflow from zero to 4.5 m^3/sec was used. The fire from the crib entered the concealed space through a breach (hole) in the suspended ceiling (Fig. 9) directly over the crib. The fire effluents were then extracted through an exhaust vent at the far end of the concealed space for analysis.

Figure 9 – Breach Hole

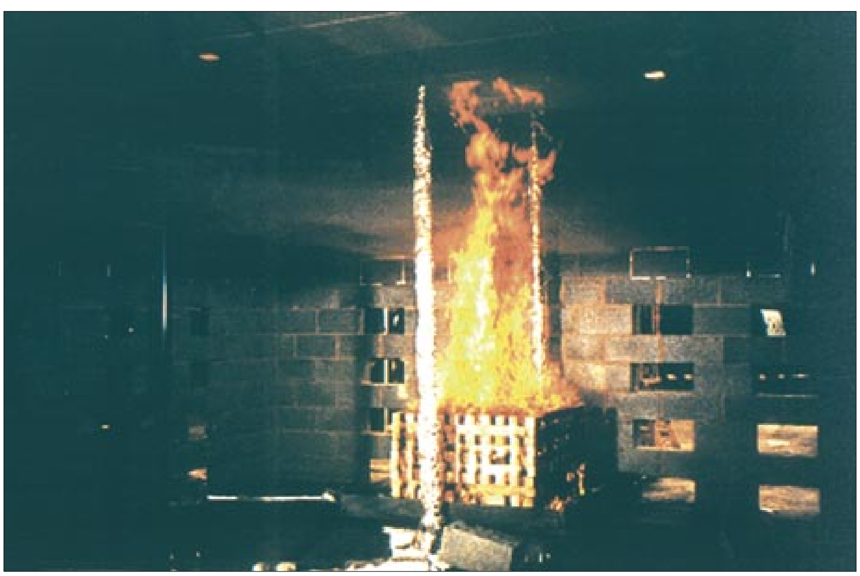

Figure 8 – One Megawatt Fire

1 Clark, F., Hover, J., Caudill, L., Fine, A., Parnell, A., and Butcher, G., "Characterizing Fire Hazard of Unprotected Cables in Over-Ceiling Voids Used for Ventilation"; *Interflam* '93, 1993.

Two hundred lengths of cable were supported on a steel ladder 7.2m (23.6 ft.) long by 0.38m (1.3 ft.) wide. This represents one generation of cables in a typical one-floor open office layout. The ladder was located midway between the suspended ceiling and the structural roof of the test rig (Fig. 10).

Thermocouples (TCs) arrayed vertically in the burn room provided data for mapping temperature profiles. Thermocouples were also arrayed both vertically and horizontally in the concealed space to provide mapping of temperature and flame spread (Fig 11).

Figure 10 – Length of Cables on Ladder

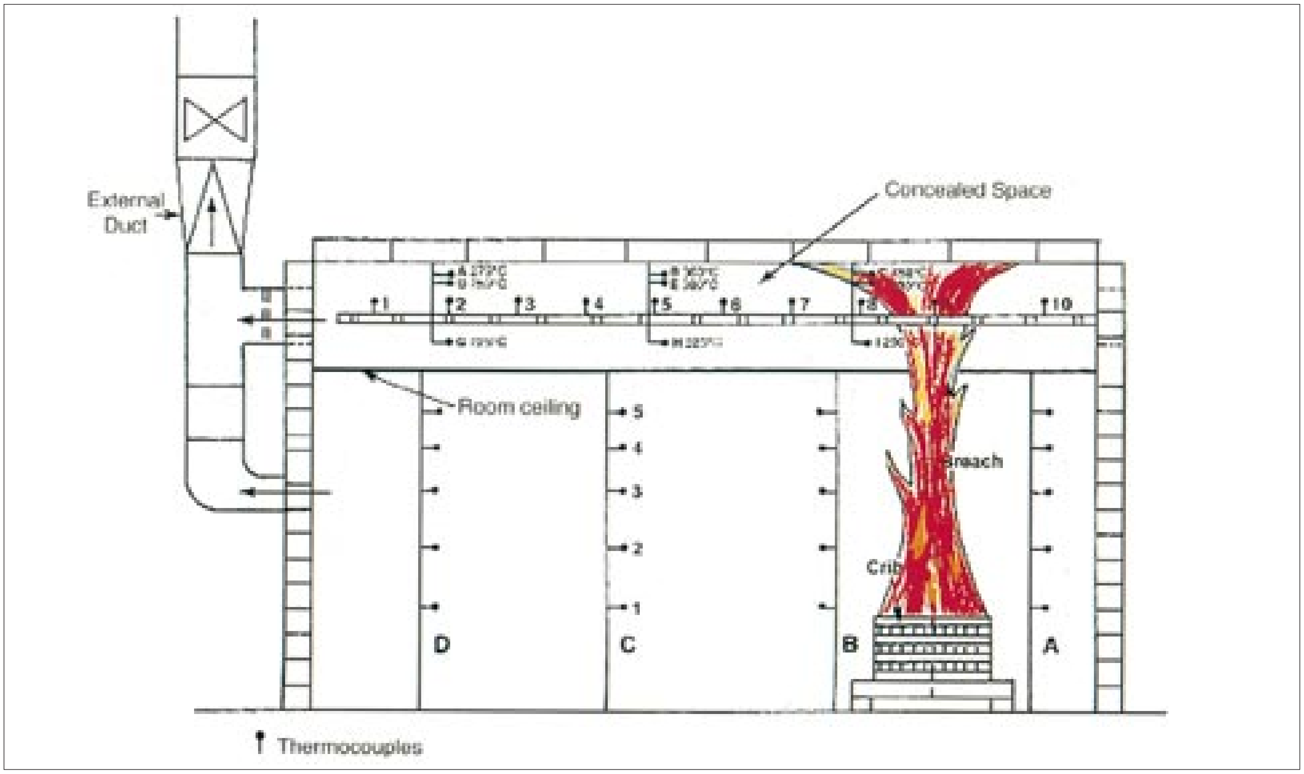

Figure 11 – Thermocouples

Intermediate Scale Fire Test

Intermediate scale tests were conducted at Underwriters Laboratories in Northbrook, Illinois, USA. The test protocol used was NFPA 262 Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use In Air-Handling Spaces, which utilizes a Steiner Tunnel (Fig. 12).

Figure 12 – Steiner Tunnel

This test consists of a 25-foot long ventilated tunnel. The cable is placed on a ladder in the tunnel and is ignited by a gas burner. The resulting flame spread and smoke optical density are measured.

The SPI undertook a program to evaluate data communication cables having various International and North American fire performance ratings to assess the suitability of cables for use in concealed spaces based on the ratings.

Cables Tested

The samples tested were 4 pair, unshielded, twisted pair data communication cables commonly used for computer inter-connects (Fig. 13). The following types of commercially obtained cables were tested:

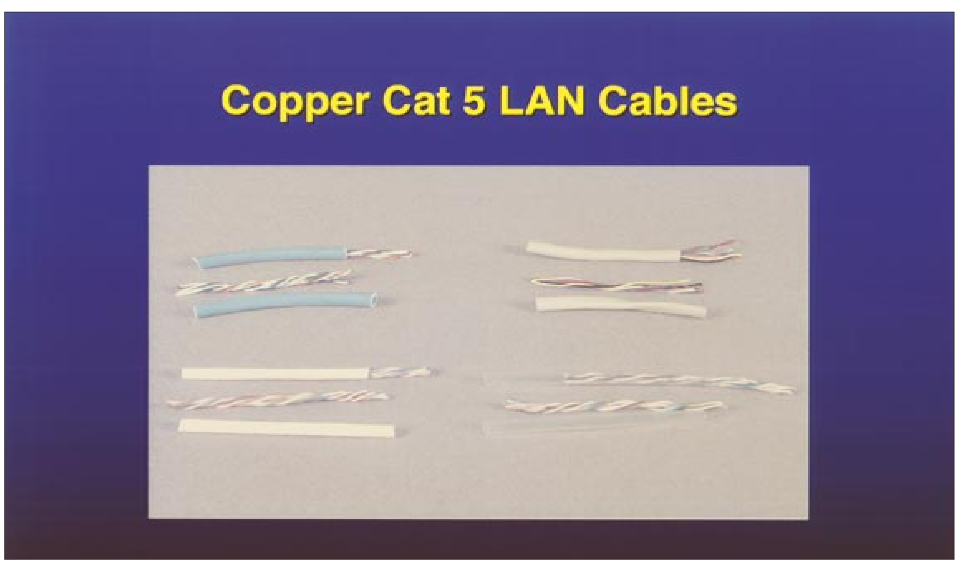

Figure 13 – Test Samples

Type CMX - Polyolefin Insulation / PVC Jacket
Type CMX/T - Polyolefin Insulation / PVC Jacket / encased in metal trunking

Type LSZH1/Type LSZH2 - Polyolefin Insulation / Polyolefin Jacket (designated Low Smoke Zero Halogen – IEC 332–1/IEC 332–3)

Type CMP - Fluoropolymer Insulation / Fluoropolymer Jacket

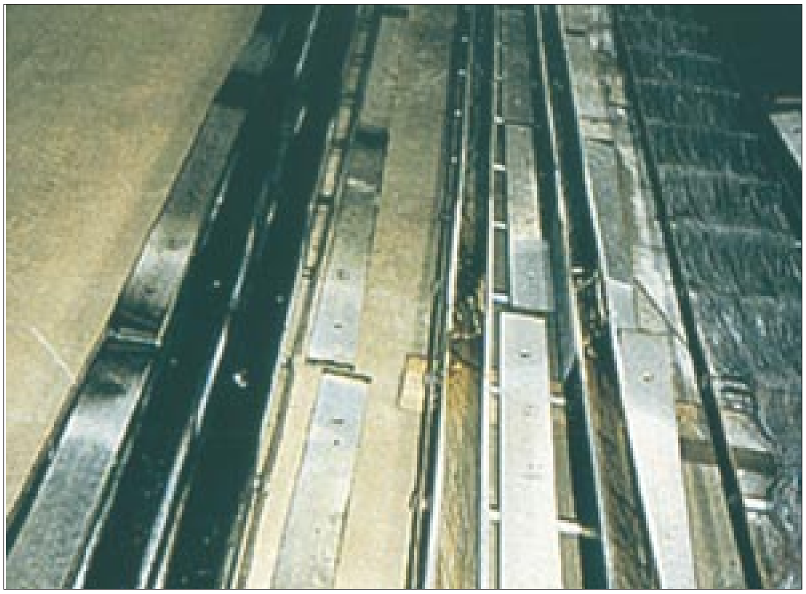

Figure 14 – Metal Trunking

CMX and CMP refer to designations for cables meeting test standards in North America. For commercial buildings, the fire performance of CMX cables protected in metal conduit was the original benchmark, under the National Electrical Code, used to develop the flame spread and smoke generation requirements for the unprotected CMP cable designation.

The fire performance of CMP cables is such that they are permitted to be installed in concealed spaces without conduit.

Test Results

The CMX cable was tested in capped rectangular metal trunking (CMX/T) (Fig. 14) as used in the U. K. It was also tested without trunking or conduit.

In the full scale tests, CMX in metal trunking and CMP rated cables had no flame spread while the CMX and the LSZH1 and LSZH2 cables burned to the end of the BRE/FRS real scale rig unexpectedly creating dripping fire balls and pool fires in the overhead ceiling (Fig. 15).

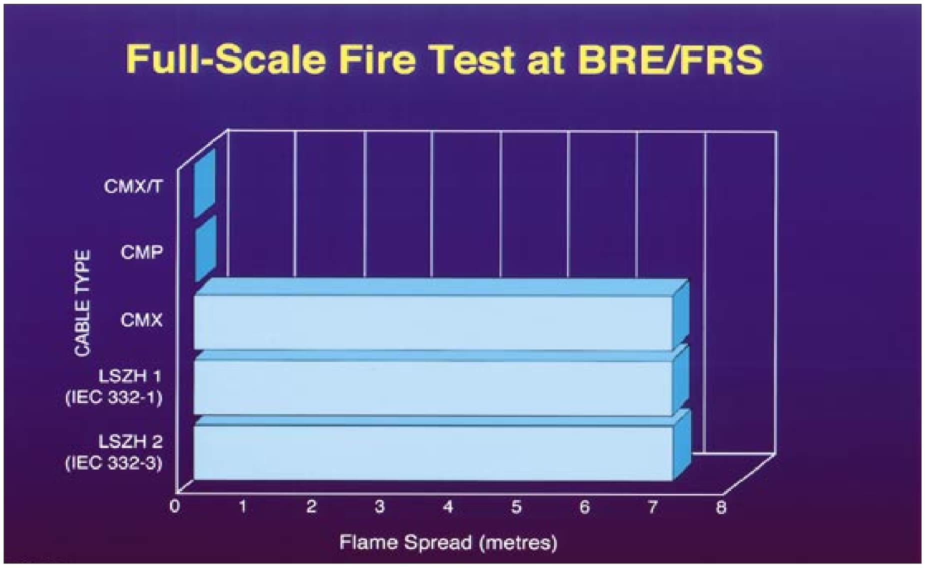

Figure 15 – Full Scale Tests

In the NFPA 262 test, the CMX in trunking and the CMP exposed cable showed very little flame spread. The CMX exposed and LSZH1 and LSZH2 cables burnt to the end of the test apparatus (Fig. 16).

LSZH1 and LSZH2 were next and the CMX produced the most smoke (Fig. 17).

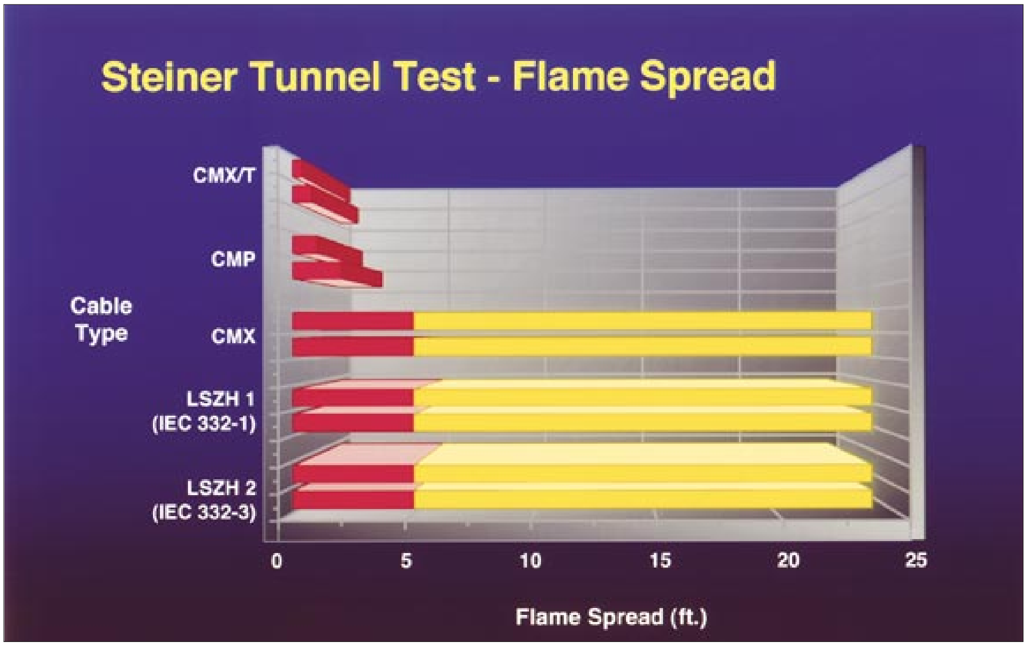

Figure 16 – Flame Spread

NOTE: Values in yellow exceed the allowable limits of NFPA 262 Steiner Tunnel Test.

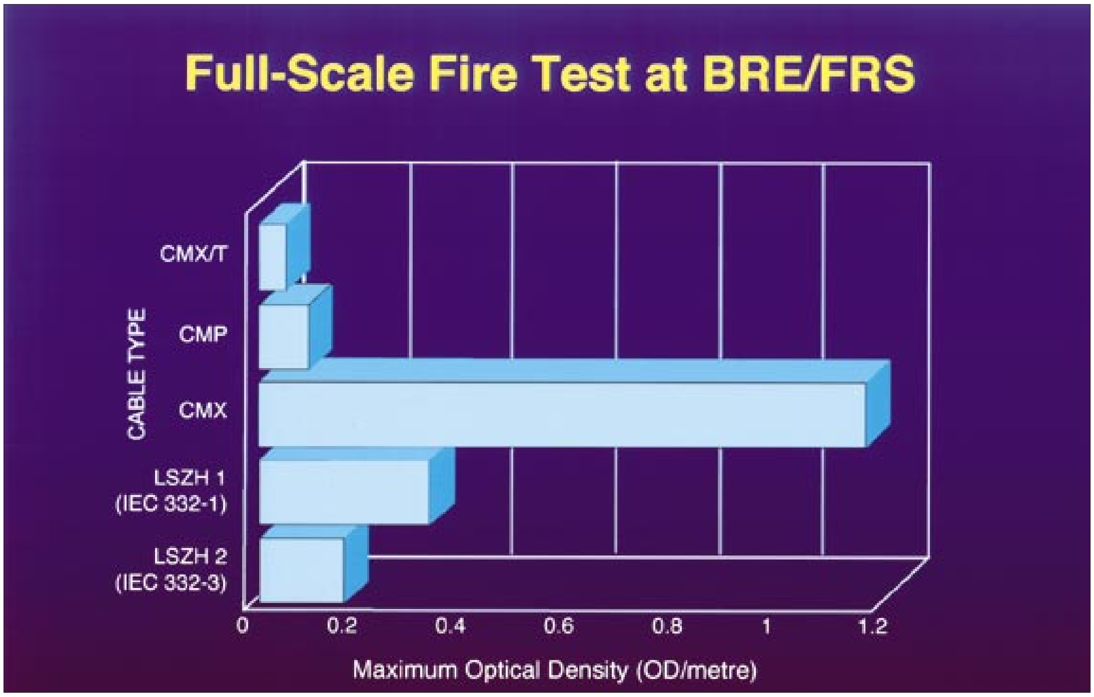

Figure 17 – Smoke

In the NFPA 262 tests, CMX in metal trunking and CMP had the least amount of smoke generation passing the NFPA 262 requirement. The LSZH1 and LSZH2 were significantly higher and the CMX exposed was the highest and failed the NFPA 262 requirements (Figs. 18 and 19).

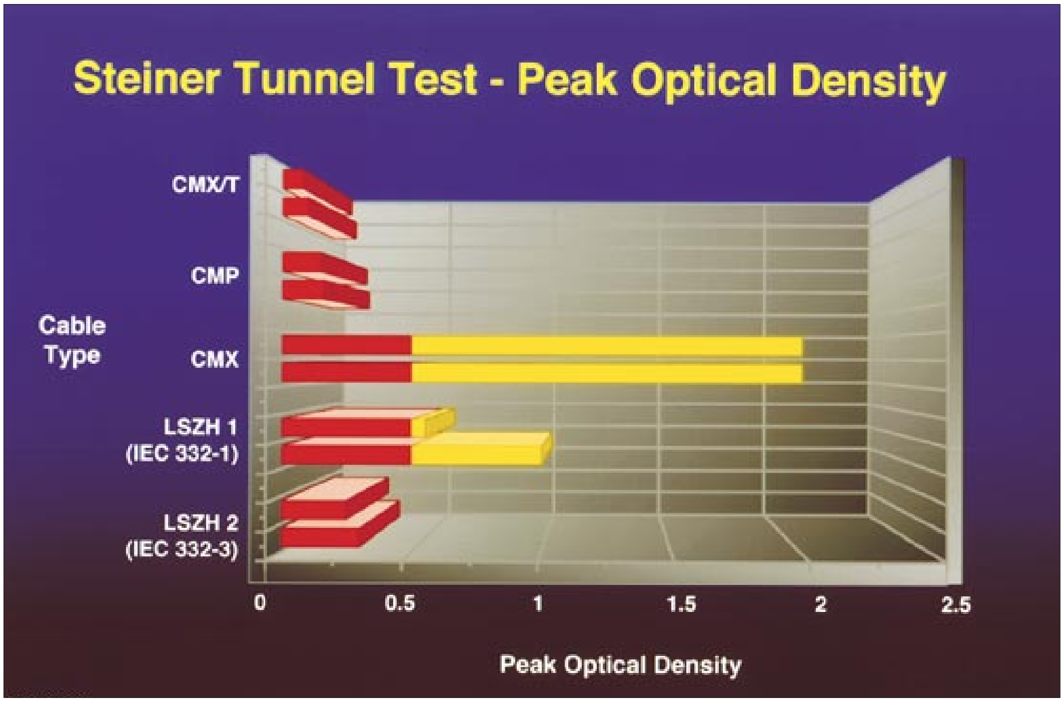

Figure 18 – Peak Optical Density

NOTE: Values in yellow exceed the allowable limits of NFPA 262 Steiner Tunnel Test.

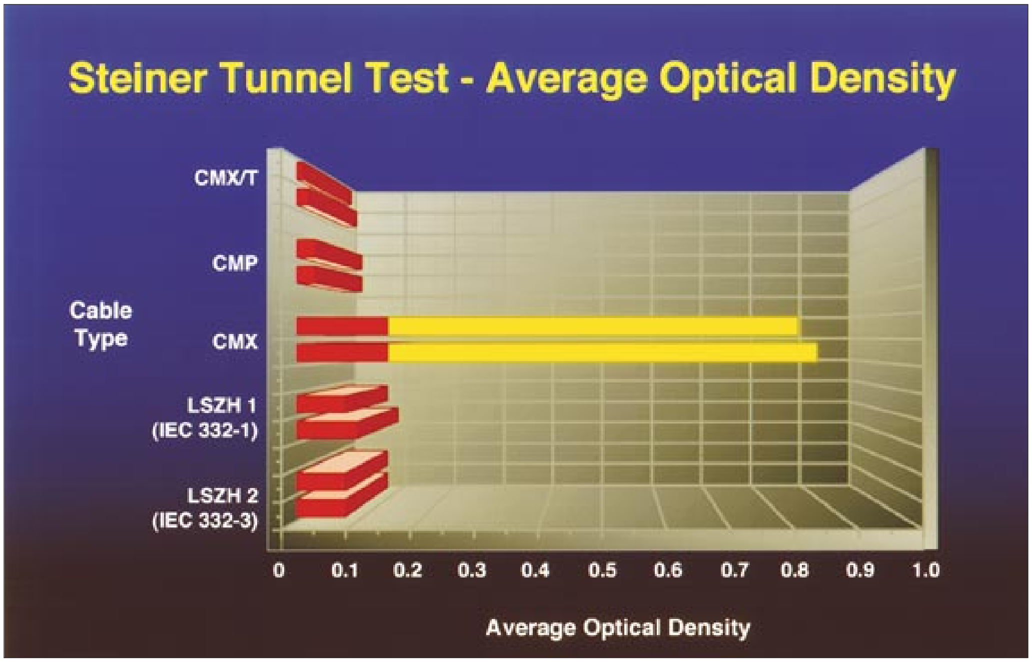

Figure 19 – Ave. Optical Density

NOTE: Values in yellow exceed the allowable limits of NFPA 262 Steiner Tunnel Test.

The LSZH cables produced temperatures in the concealed space of 800 to 1000 degrees centigrade (Fig. 20). These temperatures can cause structural damage to steel frame buildings (Fig. 21).

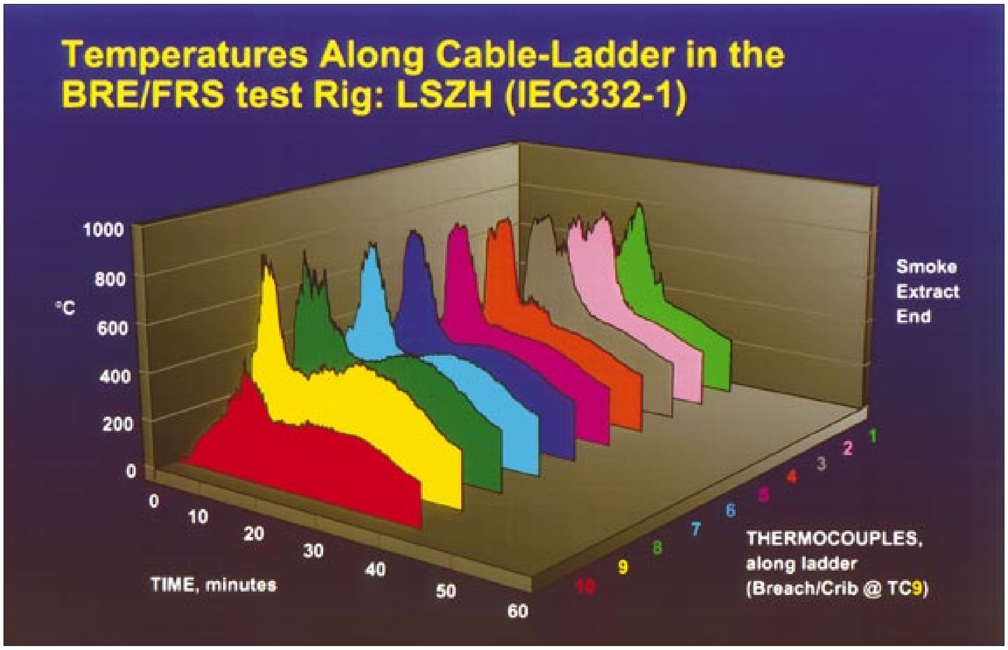

Figure 20 – LSZH Cables

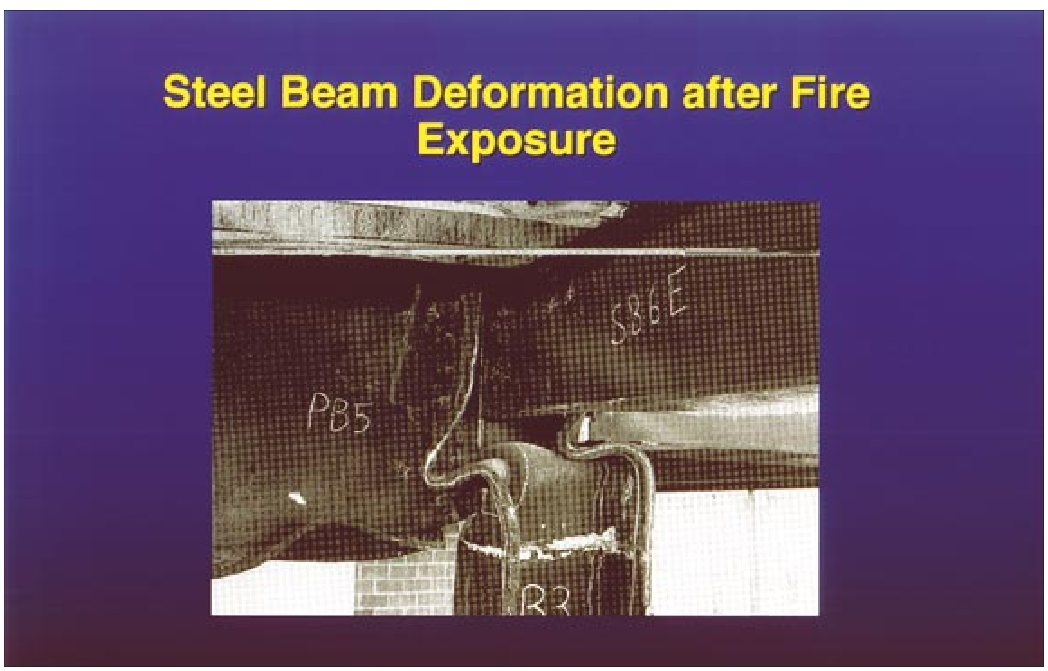

Figure 21 – Structure Damage

The CMP cables only generated a temperature increase of 10 degrees centigrade above the calibration runs which were performed without any cables (Fig. 22).

The CMP cables showed no visual flame propagation.

Toxicity

In the BRE/FRS real-scale tests, the LSZH1 and LSZH2 cables produced approximately three times the carbon monoxide level as the CMP cable under the same fire conditions[2] (Fig. 23).

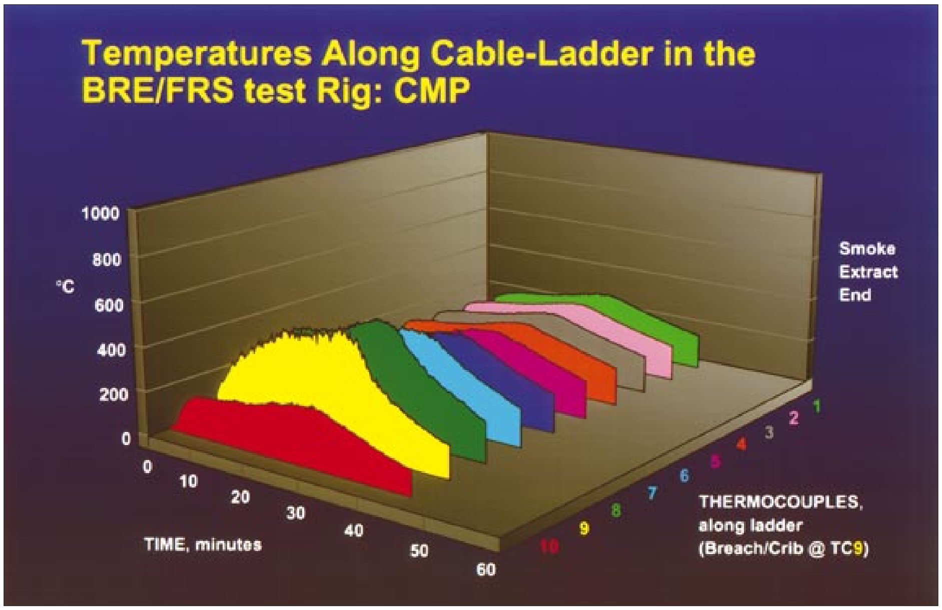

Figure 22 –No Visible Flame Spread

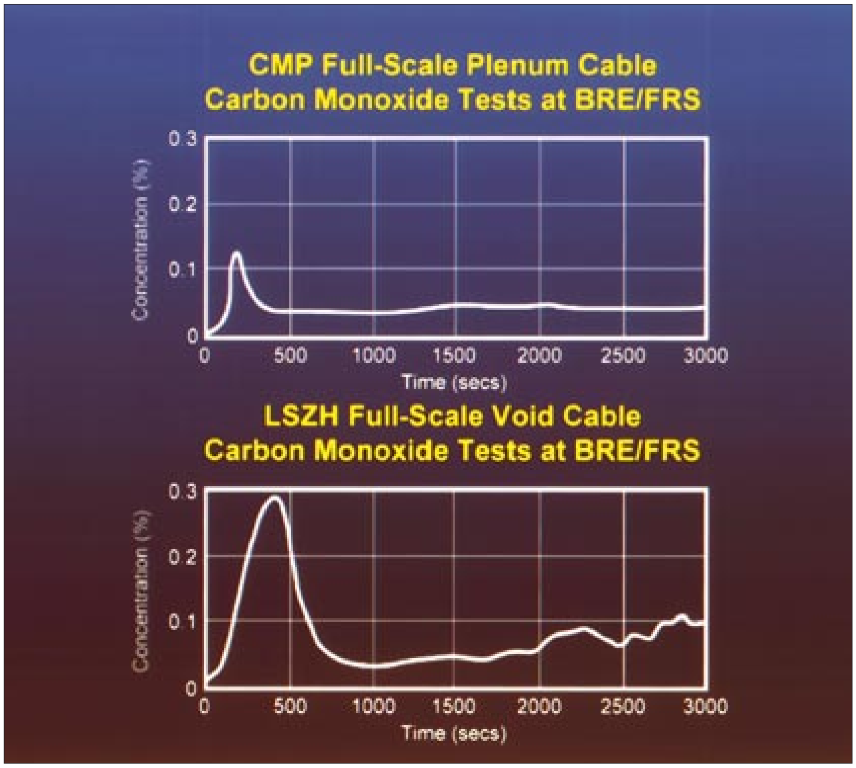

Figure 23 – Carbon Monoxide

2 Carbon monoxide (CO) is documented as the most common cause of fatalities in fires. Hirschler, M. M., Debanne, S. M., Larsem, J. B., and Nelson, G. L., Carbon Monoxide and Human Lethality: Fire and Non-Fire Studies, Elsseevier Applied Science, 1993.:

The National Electrical Manufacturers Association (NEMA), in response to New York state regulations, developed a statistical database utilizing a modified University of Pittsburgh toxicity protocol. This resulted in developing classes for materials used in the insulation and jacketing of wire and cable products. As one can see (Fig 24), there is essentially no difference in the toxic potency among the fluoroplastics, PVC and Polyolefin classes of materials[3].

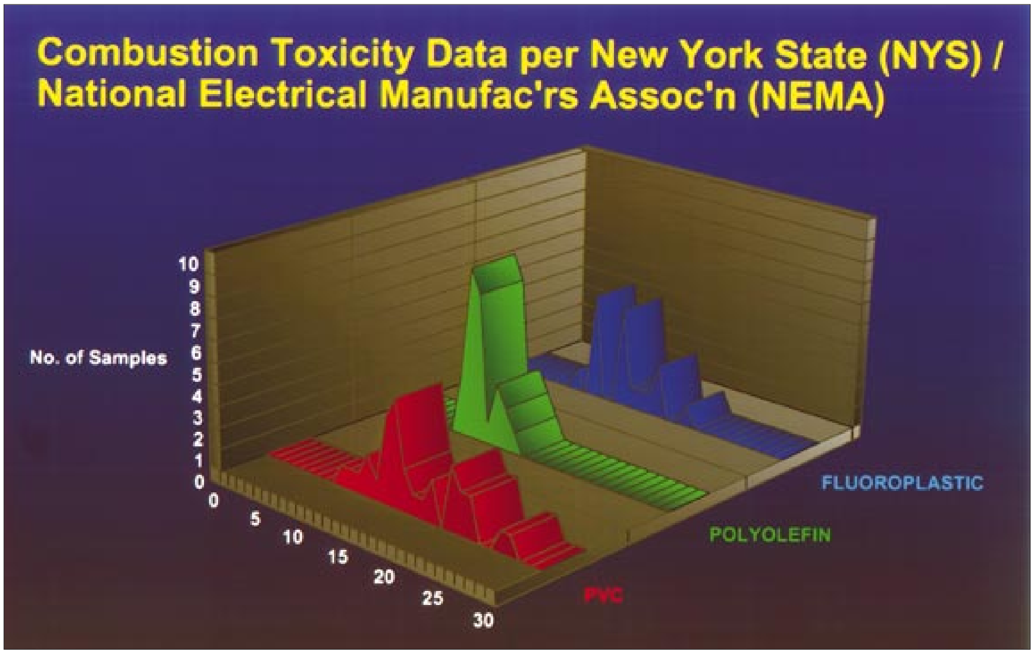

Figure 24 – Combustion Toxicity

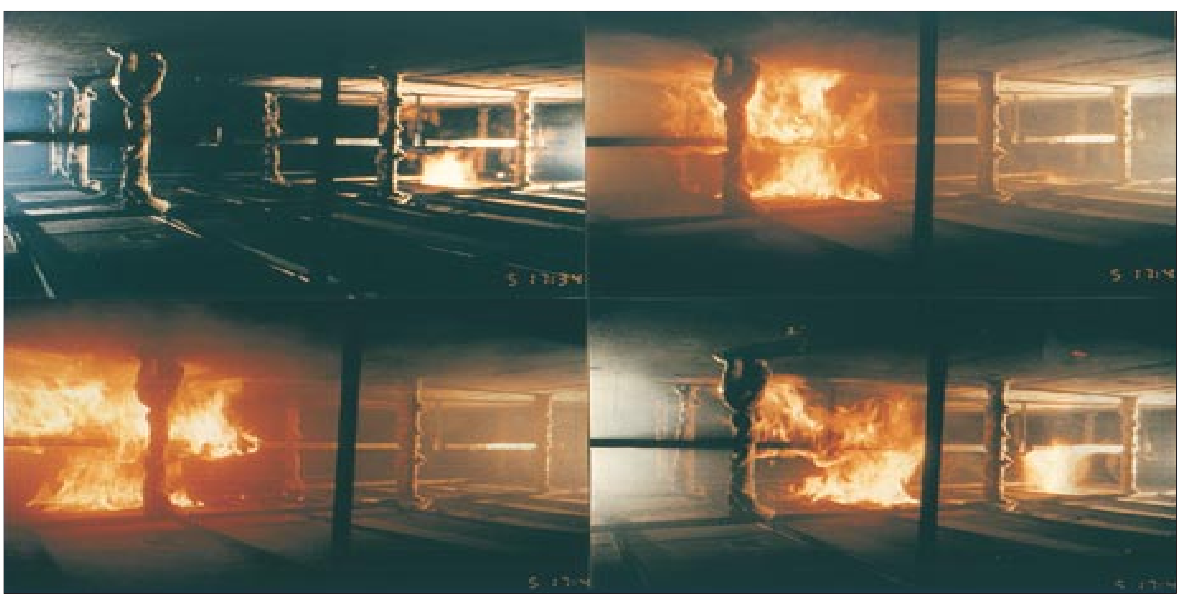

Figure 25 – Flame Propagation, Dripping Fire Balls,and Pool Fires.

[3] Toxic potency should be evaluated in the context of a total fire hazard assessment where the combustion behavior of materials and products are also considered.

Conclusions

The high temperatures, flame propagation, dripping fire balls, and pool fires, were surprising with the LSZH1 and LSZH2 cables (Fig. 25).

The CMP cable did not burn, generate high temperatures, or have significant smoke production. This performance was similar to CMX cable in capped metal trunking.

The data obtained in the in the intermediate scale Steiner Tunnel tests (NFPA 262) relates well to the results conducted in the full-scale BRE/FRS tests.

The fire performance of the exposed CMP cable was comparable to the CMX cable protected in metal trunking in both the NFPA 262 and real scale BRE/FRS tests.

The flame spread, smoke opacity and temperature increases for CMP cables were significantly lower than the results for LSZH1 and LSZH2 cables.

The carbon monoxide generation of the LSZH cable was three times higher than fluoropolymer CMP cable.

Published NEMA toxicity data showed no significant differentiation between classes of materials.

The NFPA 262 and the BRE/FRS test rigs relate to actual installation practices and accurately simulate the potential fire hazard reference scenarios.

NFPA 262 and the BRE/FRS test rigs are the only options to comprehensively assess the fire hazards of cables in horizontal concealed spaces. The IEC 332–1 and IEC 332–3 tests were not found to be relevant.

Based on intermediate and full-scale testing a revised fire performance hierarchy is justified (Fig. 26) which utilizes the NFPA 262 test to assess cable fire performance for certified use in ventilated horizontal concealed spaces, world wide.

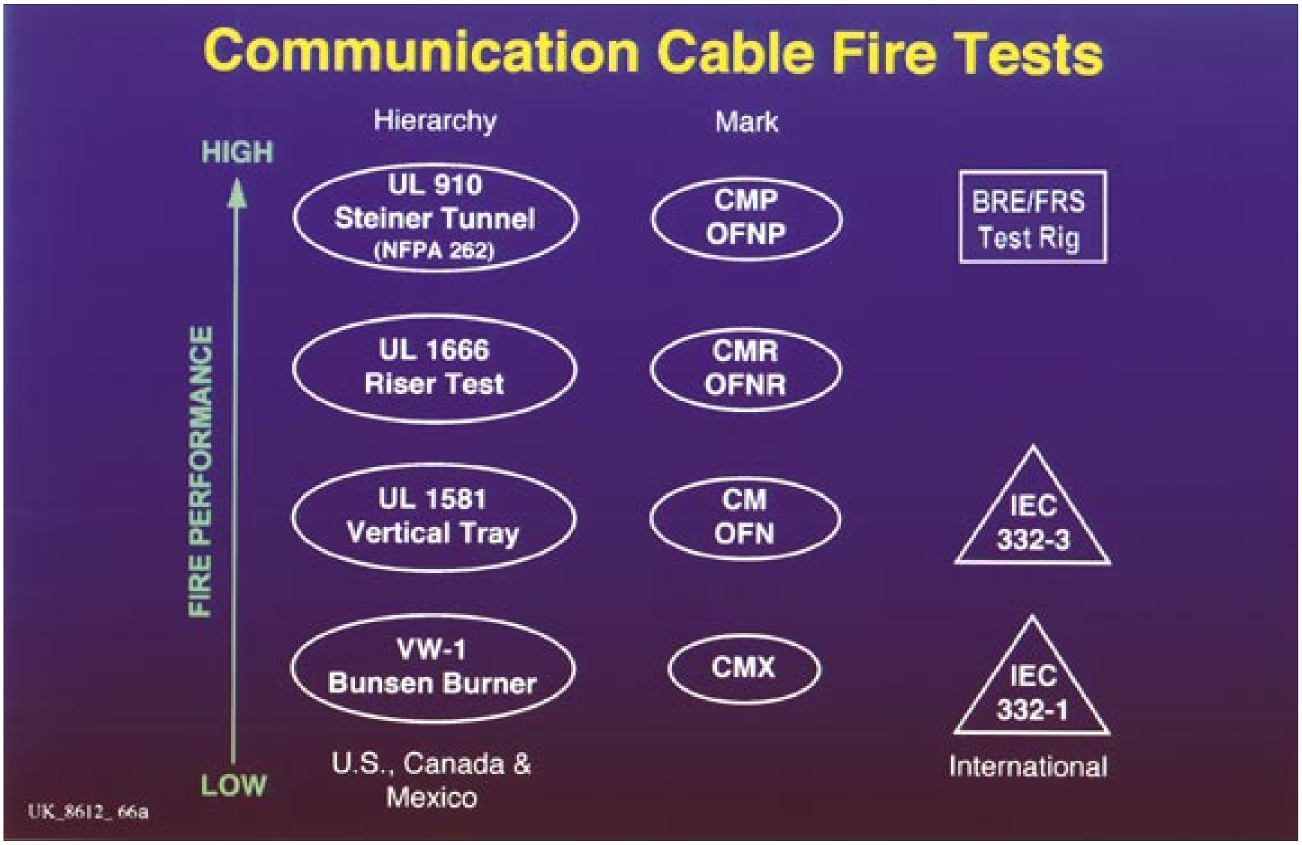

Figure 26 – Fire Performance Hierarchy

References

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2. "Test for Fire and Smoke Characteristics of Wires and Cables," NFPA 262-1990,. National Fire Protection Association. Quincy. Mass., USA, 1990.

3. cf. -"Standard Test for Surface Burning Characteristics of Materials," ASTM E84-87, ASTM, Philadelphia PA, USA- 1987.

4. L. Przybyla,. E. J. Coffey, S. Kaufman, A Yocum, J. Reed and D. Allen, "Low Smoke and Flame Spread Cables", Journal of Fire and Flammability 12, 177 (1987).

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7. See Figure 20 for a relative ranking of fife performance among various fire tests, ref NFPA 70 and UL reports.

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10. National Electrical Manufacturers Association, 1987, "Registration Categories of the National Electrical Manufacturers Association for Compliance with the New York State Uniform Fire Prevention and Building Code," R. Anderson, P. Kopf, pub., Arthur D. Little, Inc.

11. These fires included the Dusseldorf Airport in April '96, the Paris Credit Lyonnais Bank in May '96, the New York Rockefeller Center in October '96, the Hong Kong Golden Mile, Garly Building in November '96, the Bangkok Presidential Tower (36-story office complex) in February '97 and Heathrow Airport in December '97, London, Earlham Street, fall '99 among many others.

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