

COAXIAL CABLE

The present invention relates to fire resistant electric cables and is particularly concerned with fire resistant co-axial cables.

5 There are circumstances in which systems, such as close circuit television monitoring systems, need to be maintained during the critical stages of evacuating a building in the case of a fire. The prime consideration in designing co-axial cables for CCTV systems has hitherto been electronic
10 performance. Known co-axial cables provide satisfactory performance under normal circumstances but such performance is not maintained in the event of a fire. Consequently, close circuit television monitoring systems, which could play a vital role in saving lives and directing the
15 emergency services where they are most needed in the case of a fire, usually fail.

Co-axial cables designed to be fireproof generally include a conductor, a surrounding layer of insulating material, fireproof tape, a screening layer of conducting
20 material and an outer sheath. In use, such co-axial cables are usually firmly secured in place, to walls, ceilings, floors or cable conduits, or the like. The securing means are generally attached firmly to the exterior of the cable.

In the conditions associated with a fire, the
25 temperature of the co-axial cable can rise extremely quickly to very high value, typically 800-950 C, causing thermal expansion of the components of the coaxial cable. Each component will have a tendency to expand according to its co-efficient of expansion and thus each component, being

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made of different material, will expand at a different rate. The inner conductor is usually made of copper and will expand. The insulation, which is of non metallic material, will also expand, but within the confines of the braid causing a build up in pressure. This, together with the fact that the co-axial cable is firmly secured at intervals along its length, can result in distortion of the co-axial cable.

One specific type of distortion is known as knuckling or kinking. This takes place when the longitudinal expansion of the conducting core is hindered or prevented because the core is tightly bound by the surrounding and expanding insulating layer. The insulating layer is unable to expand because it is tightly bound by the screening layer and because of the firm attachment of the co-axial cable to its surroundings. The knuckling effect manifests itself as evenly spaced distortions along that part of the length of the co-axial cable that is exposed to extremely high temperature (950°C for the British Standard BS 6387 category C test). Each distortion consists of a Z-shaped kink in the conducting core (see Figure 2). It will be appreciated that such distortion destroys the concentricity of the cable (the concentric arrangement of conductor, insulator and screening layer desirable for high performance) and results in loss of performance of the co-axial cable.

According to the present invention there is provided a co-axial cable comprising an electric conductor, a surrounding layer of electrically-insulating material and a screening layer of electrically conducting material around the insulating material; the cable including a layer of material adjacent to the conductor which permits

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longitudinal expansion of the conductor in the conditions associated with a fire.

The layer of material permits longitudinal movement of the conductor because it allows the surface of the conductor
5 to move relative to the body of the insulating material.

The cable may include a layer of material which decomposes in a fire leaving an insulating residue.

In one preferred embodiment of a co-axial cable according to the invention the layer of material adjacent to
10 the conductor which permits longitudinal expansion of the conductor comprises a layer of material which melts under the temperature conditions at the conductor/insulator interface prevailing in the event of a fire. Preferably the material will melt at a temperature in the region of
15 180-200°C.

Preferably the material which melts in the event of a fire is a polymeric material such as for example, polyethylene or polypropylene or polybutene. This layer, which can also be termed a skim, will melt forming a layer
20 of molten material which acts as a lubricant allowing longitudinal expansion of the electric conductor without knuckling or kinking.

The layer of material which melts can be applied to the conductor by various methods, but preferably by extrusion.

25 Preferably, the layer of polymeric material will have a high dielectric (e.g. of about 1.56 to 3.1) in its low temperature, non-fused state.

The layer of material adjacent to the core may comprise a layer of tape. The tape may be glass fibre tape with mica
30 platelets thereon; such a tape is commonly known as mica tape. The layer of tape does not grip the conductor

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sufficiently to prevent sliding between the surfaces that form the conductor/tape interface.

The tape may be applied to the conductor by silicon adhesive which deteriorates when subjected to the temperatures associated with the early stages of a fire, Thus the tape is firmly attached to the conductor at normal temperatures but is not firmly attached, and hence will not prevent longitudinal expansion, during the early stages of a fire.

Preferably, the layer of tape will also insulate the core both electrically and thermally.

The layer of tape permits longitudinal expansion of the conductor and additionally forms a resilient physical barrier to control or curb radial expansion of the conductor. The suppression of knuckling expansion in the region of highest temperature may result in delocalisation of the overall expansion/distortion so that a slight radial expansion or distortion occurs along a considerable length of the conductor either side of the region of highest temperature, but the concentricity of the coaxial cable will still substantially be maintained.

Preferably, the combustion products of the layer of material which decomposes in a fire are retained as an ash around the conducting core in the event of a fire.

Preferably, the ash will have a dielectric strength equal to or exceeding that of the unburnt insulation.

Preferably the insulating material contains inorganic material which forms a residue upon pyrolysis. Preferably the insulating material is a polymeric compound where the primary polymeric constituent is a silicone. A preferred silicone is polydimethyl siloxane.

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The layer of material which decomposes in a fire may be solid in section or it may contain voids or pores. The voids or pores may be formed, for example, by foaming the insulating layer during production of the coaxial cable.

5 By using foam, air or another gas or gases will be introduced to the layer of insulating material. This may improve the dielectric qualities and thus the signal transmission performance of the cable. Alternatively, by using insulating material with a lower dielectric constant
10 the thickness of the insulating layer can be reduced thus reducing the diameter of the coaxial cable while maintaining the transmission performance.

The insulation adjacent the core can likewise be foamed to increase its dielectric performance and lower
15 capacitance.

According to a preferred embodiment the layer of material which permits longitudinal expansion of the core contributes to the dielectric strength at normal working temperature while the layer of the material which decomposes
20 in a fire leaving an insulating residue provides electrical insulation at later stages, i.e. higher temperatures.

It is important that the layer of insulating material possesses a dielectric strength of between 1.5 and 3.1 both in normal use and in a fire. Preferably the dielectric
25 strength will be between 1.5 and 2.26. The layer of material which decomposes, for example silicone rubber, although providing a fairly poor dielectric (about 3.1) at low temperature will, on decomposition, form a layer of ash with an improved dielectric strength (i.e. with a lower
30 dielectric constant) which acts as the insulating layer during the conditions associated with the fire. It is also

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envisaged that the layer of material which permits expansion of the conductor, for example polyethylene, provides an insulating layer of high dielectric strength (dielectric constant of about 1.56 to 2.26) in normal cable use although
5 it will be appreciated that it will not provide insulation in the later stages of a fire when the layer has melted or decomposed completely.

Known co-axial cables containing silicone rubber as insulation may suffer a loss in electrical properties during
10 the early stages of a fire due to evolution of water during decomposition of the silicone rubber. In a preferred embodiment, the layer of material adjacent to the conductor will act as a barrier to prevent loss of electrical properties due to the evolution of water.

15 The screening layer may be formed of a layer or layers of metallic braid, and/or metallic tape or foil placed around the layer or layers of insulating material. In the preferred embodiment, the screening layer is formed by braiding wire, preferably plain soft copper, silver coated
20 or tin-covered copper wires.

Preferably the coverage of the insulated core by the braid is between 60% and 96%.

In the preferred embodiment a layer of porous siliceous material is placed between the layer of insulating material
25 and the screening layer. The siliceous material helps retain the combustion products of the insulating layer around the core in the event of fire. The layer of siliceous material may be formed by any suitable porous material containing silica or silicates. Examples of
30 suitable materials include silica fibre, glass fibre and

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mineral wool. Glass fibre tape is particularly preferred and may be wound helically around the insulated core.

The surface of the porous siliceous material is preferably exposed directly to the insulating layer.

5 Preferably the tape is a woven tape with air spaces to allow for expansion and/or evolution of air and gases. The layer of glass tape or tapes, the number of and construction eg. Size of weave holes etc. will depend on the amount of insulating material. The taped layer in certain formations
10 and construction can reflect heat which will enhance cable properties. Other types may be added which will add to cables heat performance.

Preferably the cable has an outer insulating layer over the screening layer. The outer layer may be a further
15 layer of glass tape and/or a layer of plastics material such as a compound containing PVC but it is preferably of a material that is flame retardant. Either a polymer that is intrinsically fire retardant or a polymer composition that is modified by the addition of ingredients that impart fire-
20 resisting characteristics may be used.

Preferably the material of the outer layer is one which does not give out substantial amounts of smoke or fumes on combustion. Preferably a material that does not contain halogens is used. The material sold under the trade mark
25 OHLS which consists of hydrated alumina in a polyethylene and polyethylene co-polymer composition is particularly suitable.

Optionally, further layers such as armoured layers can be added to further physically protect the cable.

30 An embodiment of the invention will now be described with reference to the accompanying drawings in which:

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Figure 1 is a perspective view of a co-axial cable in accordance with the invention, with parts cut away; and

Figure 2 shows a cut away view of a conventional cable that has experienced knuckling.

5 Referring first to Figure 2, this shows a conventional cable which consists of a conductor 10, an insulating layer 12 and a layer of copper braid 14. The cable has been exposed to fire and, because the conductor 10 was prevented from expanding during the initial phase of a fire, knuckling
10 of the cable has occurred at points 21.

In figure 1 the co-axial cable 1 includes an electric conductor 10 of plain soft copper. Examples of other suitable materials are copper covered steel, silver covered copper and tin coated copper. Adjacent to the conductor
15 there is a layer of polyethylene 11. The layer of polyethylene 11 is surrounded by a layer of silicone insulation 12 which is surrounded by a further layer of glass tape 13, helically wound around the insulation 12.

A layer of copper braid 14 is deployed around the
20 further layer of glass tape 13, a layer of braided copper wires surrounds the layer of copper braid 14. The layers 14 and 15 should provide at least 85% coverage of the further layer of glass tape 13. A second layer of glass tape 16 surrounds the braid 15. The co-axial has an outer plastic
25 sheath 17 of material that is preferably flame retardant and produces low smoke and fumes and limited halogens. The material identified by Delta Crompton Cables Limited by the Trade Mark OHLS is suitable.

A cable according to the invention has a layer of
30 polyethylene 11 referred to as a skim. In a fire, the polyethylene melts providing a fluid layer of lubricant

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which enables the electrical conductor to expand longitudinally without distortion. The thickness of the skim is between 0.1 and 0.3 mm; sufficient polythene to ensure that the conductor is completely surrounded with a fluid layer when the skim melts in the early stages of a fire.

The multi layer system provided by layers 11, 12 and 13 will also aid in binding and cushioning of the core and the prevention of knuckling.

10 In a second embodiment the polyethylene layer 11 is replaced by a glass tape layer 11 which prevents distortion of the conducting core by allowing longitudinal expansion of the conductor and cushioning and physically binding the co-axial cable such that kinking or knuckling is prevented.

15 In the event of a fire the silicone insulation 12 decomposes to form a solid ash which continues to insulate the conducting core 10. The ash has a dielectric constant equal to or lower than that of the silicone rubber.

Example

20 A cable according to the invention was manufactured with the following dimensions:

Description of layer:-		Total OD
Solid copper core	0.6mm plain soft	0.6mm
Polyethylene skim	0.2mm radial thickness	1.0mm
25 Silicon Rubber ins	1.7mm radial thickness	4.4mm
Glass tape	19mm 25% overlap	4.82mm
Copper braid	16 bobbins x 8 ends	5.55mm
Outer sheath	OHLs 1.3 radial thickness	8.15mm

30 The cable described above was tested for capacitance, impedance, insertion loss and velocity ratio and gave satisfactory results.

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The values at normal temperatures (20°C) were as follows:

	Nominal's
Resistance of core 0.6mm PS	61ohms/Km
Capacitance	73pf/m
5 Impedance	75ohms
RLR	>10dB's
Attenuation	<3.5dB/100m @ 10Mhz
Velocity Ratio	0.614
Dielectric Constant	2.65

10 The cable withstood the following tests:

Test 1: Firetest to BS6387 Cat C, W and Z , Cat. C is heating the cable to 950°C for 3 Hours @ 300 Vac 25mA; Cat W is heating the cable to 650°C for 30mins, (with water applied to the cable for 15mins); Cat Z is heating to 950°C
 15 for 15mins (with a physical shock applied every 30secs).

Test 2: Video link, BS6387 Burn Cat C as above for 3 hours with no picture loss.

20 The cable was then subjected to fire tests. The first test was according to BS6387 Cat. C, W and Z. A 300V ac 25mA current was passed through the cable whilst it was subjected to a temperature of 950°C for three hours. The cable continued to pass the current throughout the test
 25 without failure. Then tested to Cat. W & Cat. Z, also without failure. The second test performed according to BS6387 Burn Cat. C involved passing a video link signal through the cable at 950°C for 3 hours. the signal was maintained throughout the test with no picture loss. During
 30 the burn period when the silicone insulation material was decomposing, the Return Loss Ratio was maintained with only minuscule deterioration. By comparison, a conventional

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data communication/co-axial cable failed completely under the same test conditions within fifteen seconds of the test. Only very slight knuckling of the cable was shown.

5 The co-axial cable of the present invention can be used in applications where a co-axial cable is required to continue to perform in the event of a fire, such as CCTV, data cables and other applications.



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C L A I M S :

1. A co-axial cable comprising an electric conductor, a surrounding layer of electrically-insulating material and a screening layer of electrically conducting material around the insulating material; wherein the cable includes a layer of material adjacent to the conductor which permits longitudinal expansion of the conductor in the conditions associated with a fire.
2. A cable according to claim 1 wherein the layer of material adjacent to the conductor comprises a material which melts under the temperature conditions prevailing in the event of a fire.
3. A cable according to claim 2 wherein the layer of material adjacent to the conductor melts at a temperature in the region of 180-200°C.
4. A cable according to any preceding claim wherein the layer of material adjacent to the conductor comprises a layer of polymeric material.
5. A cable according to claim 4 wherein the polymeric material is one of polyethylene or polypropylene or polybutene.
6. A cable according to claim 4 or 5 wherein the layer of polymeric material has a dielectric constant of from 1.56 to 3.1 in the non molten state.

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7. A cable according to any of any preceding claim wherein the layer of material adjacent to the conductor is applied to the conductor by extrusion.

8. A cable according to claim 1 wherein the layer of material adjacent to the core comprises a layer of tape.

9. A cable according to claim 8 wherein the tape is glass fibre tape with mica platelets thereon.

10. A cable according to claim 8 or 9 wherein the layer of tape insulates the core both electrically and thermally.

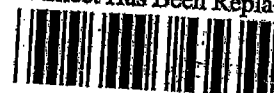
11. A co-axial cable according to any preceding claim further includes a layer of material which decomposes in a fire leaving an insulating residue.

12. A cable according to claim 11 wherein the combustion products of the layer of material which decomposes in a fire leaving an insulating residue are retained as an ash around the conducting core in the event of a fire.

13. A cable according to claim 12 wherein the ash has a dielectric strength equal to or exceeding that of the layer of electrically insulating material.

14. A cable according to any of claims 11 to 13 wherein the insulating residue has a dielectric constant of from 1.5 to 3.10.

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15. A cable according to any of claims 11 to 14 wherein the layer of material which decomposes in a fire comprises an inorganic material which forms a residue upon pyrolysis.

16. A cable according to claim 15 wherein the inorganic material is a silicone rubber.

17. A cable according to any of claims 11 to 16 wherein the layer of material which decomposes in a fire is solid in section.

18. A cable according to any of claims 11 to 16 wherein the layer of material which decomposes in a fire contains pores.

19. A cable according to any of claims 11 to 18 wherein the layer of material adjacent to the conductor which permits longitudinal expansion of the core contributes to the dielectric strength at normal working temperature while the layer of the material which decomposes in a fire leaving an insulating residue provides electrical insulation at higher temperatures such as those associated with a fire.

20. A cable according to any preceding claim wherein the screening layer is a layer or layers of metallic braid, and/or metallic tape or foil placed around the layer(s) of insulating material.

21. A cable according to claim 20 wherein the screening layer is formed of braided wire.

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22. A cable according to claim 21 wherein the wire is one or more of plain soft copper, silver coated or tin-covered copper.

23. A cable according to any preceding claim further comprising a layer of porous siliceous material between the electrically insulating layer and the screening layer.

24. A cable according to claim 23 wherein the layer of porous siliceous material is glass fibre tape.

25. A cable according to claim 23 or 24 wherein the surface of the porous siliceous material is exposed directly to the insulating layer.

26. A cable according to claim 24 wherein the glass fibre tape is a woven tape.

27. A cable according to any preceding claim further comprising an outer insulating layer over the screening layer.

28. A cable according to claim 27 wherein the material of the outer layer is one which does not give out substantial amounts of smoke or fumes on combustion.

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