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(19)

(54) ELECTRIC CABLES

(71) We, BICC LIMITED, a British Company, of 21 Bloomsbury Street, London WC1B 3QN, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to electric cables and more particularly to cables with polymeric insulation, sheathing or other components that present a low hazard under fire conditions. Cables that present no significant primary fire hazard, in the sense that the insulation cannot be ignited by the effect of an electrical fault in a properly protected circuit are now readily available. There is however a risk that polymeric materials will burn if pre-heated to a high temperature by an external source, such as an external fire, with the disadvantages that: (i) in certain circumstances fire may be transmitted along cable runs to other parts of a building: (ii) dense smoke may be generated; and (iii) since PVC and/or other halogen-containing materials are commonly present toxic and corrosive fumes (such as hydrogen chloride gas and/or hydrochloric acid droplets) may be produced.

In accordance with the present invention, an electric cable comprises at least one polymeric-insulated conductor, a bedding layer surrounding the conductor and made from a composition comprising an ethylene/vinyl acetate copolymer, at least 55% by weight of inert mineral filler and an antioxidant, and an enclosing sheath of low flammability material. Preferably all the components are free of halogen-containing materials or at least substantially so.

If there is more than one conductor one (or exceptionally more than one but not all) of them may be bare.

If the electrical and physical performance requirements of the cable allow it the insulation is preferably also of curable, mineral-filled, plasticised ehtylene/vinyl acetate copolymer composition, but the proportion of filler that is appropriate will be lower than for the bedding. Alternatively suitable compounds based on ethylene-propylene rubbers, cross-linked polyethylene or other halogen-free polymer can be used. Preferably the weight of filler is not in any instance more than 55% of the whole insulating composition.

The bedding composition will commonly include up to 80% by weight of the filler and may include even more. A preferred filler is hydrated alumina of suitable particle size, used alone or mixed with calcium carbonate and/or china clay; a proportion of pigment can be included especially in the insulation where it can be used for colour coding. The proportion of vinyl acetate monomer in the copolymer may vary widely, and the presence of minor amounts of other comonomers is not excluded. Comonomers comprising 25-55% by weight vinyl acetate are preferred. Conventional processing aids for ethylene/vinyl acetate copolymers, such as stearic acid and certain stearates, can be used and may be essential for some copolymers. The compound may also include another polymeric material, especially an ethylene-propylene rubber or ethylene-propylene-diene terpolymer rubber. Curing agents can be included if desired.

A preferred range of compositions comprises, in parts by weight:

Polymer	ethylene/vinyl acetate copolymer	15-40
Filler:	alumina trihydrate with or without calcium carbonate and/or china clay	55-80
Processing aid	stearic acid	up to 5
Curing agents, if required, and antioxidants		up to 5

The sheath is preferably of suitable polymeric material, and may be of the same composition as the bedding; similar compositions based on mixtures of EVA and EPR or EPDM can be used or alternatively compositions based on silicone rubber or flame-retardant grades of cross-linked polyethylene.

A major improvement in properties can be obtained by interposing a heat-barrier layer of suitable low-flammability material between the bedding layer and the sheath. Suitable materials include:

(1) flexible metal tape or foil, in accordance with our copending U.K. Patent Application No. 1801/77 (Serial no. 1583955);

(2) heat-resistant plastics tape, such as polyimides (e.g. those sold under the trademark KAPTON); and

(3) fibre-reinforced bonded mica tape, in accordance with our copending U.K. Patent Application No. 33768/76 (Serial no. 1583954).

The heat-barrier also offers some resistance to emission of volatile materials or smoke from the interior of the cable.

For some types of cable additional components of a conventional kind, for example wire or tape armour and/or a metal sheath, may be included, for example between the parts of a subdivided bedding layer and/or between the parts of a subdivided sheath.

EXAMPLES:

1. Tinned copper strands each made up of seven 0.30 mm diameter wires are insulated with 0.8 mm radial thickness of a conventional insulating compound (hereinafter called compound EPR 1) comprising:

Ethylene/propylene/diene monomer rubber (EPDM)	30-35%
China Clay	50%
Paraffinic Plasticisers	10-15%
Curing agents and antioxidants	5%

(all percentages are by weight of the compound)

Pairs of these insulated conductors are twisted together with a right-hand lay of about 40 mm, and seven such twisted pairs laid up together with a left-hand lay of about 100 mm. An extruded bedding layer with a nominal radial thickness of 1 mm encloses the laid up cores; this bedding layer is of the following compound (compound EVA 1).

60% Ethylene - 40% vinyl acetate copolymer	24%
Hydrated alumina (nominal particle size 1 micrometre)	70%
Processing aid: Stearic acid	2%
Antioxidants (and curing agents if desired)	4%

(All percentages are by weight of the compound)

Over this bedding is applied a copper tape electrical screen made of two tapes each (nominally) 18 mm wide and 0.1 mm thick, breaking joint with the edges of each tape nominally abutted. A second bedding layer 1.5 mm thick and made of compound EVA 1 is extruded over the screen.

A heat barrier is next formed by lapping on two silicone-resin bonded woven-glass reinforced mica tapes. Each tape is 0.15 mm thick and 35 mm wide and applied with its edges nominally abutting, the two tapes breaking joint by half the width of the tape.

An outer sheath of a standard nylon sheathing compound ("Grilon type 6" (trademark)) with radial thickness of 0.4 mm completes the cable, which has an overall diameter of 16.5mm.

2. This is the same as example 1 except that the nylon sheath is replaced by a sheath 1.0 mm thick (increasing the overall diameter to about 17.5 mm) of compound EVA 1.

3. This cable is the same as examples 1 and 2 up to an including the first bedding layer. Over this is applied a single glass/mica tape of the same kind and size as in the preceding examples but applied with 20% overlap. Two copper tapes (also of the same dimensions as in the preceding examples) are applied directly over the glass/mica tape, without a second bedding layer. This cable is completed by an outer sheath of a conventional commercially-available flame-retardant silicone rubber compound ("Silastic 1603" (trademark)) with a radial thickness of 1.8 mm (overall diameter about 16 mm).

4. The conductors, insulation and stranding of this cable are as in example 1. A bedding

layer of compound EVA 1 is extruded over the laid-up cores to a radial thickness of 5 mm. Two "Kapton" (trade mark) polyimide tapes, 0.08 mm thick and nominally 30 mm wide, are lapped on to the bedding layer, breaking joint. A sheath, 1.8 mm thick, of the same silicone rubber compound as used in example 3, completes a cable with an overall diameter of about 23.7 mm.

5. The cores of this cable are screened concentric pairs, with a tinned copper inner conductor 1.53 mm in diameter, inner dielectric of compound EPR 1 with a radial thickness of 1 mm, outer conductors made of thirty-five 0.3 mm diameter tinned copper wires lapped on with a lay of around 38 mm, outer dielectric also of compound EPR 1 and also 1 mm thick, and a braided screen made up of tinned copper wires each 0.15 mm in diameter, applied 16 spindles 4 ends with a lay of 11 mm, two-over-two-under.

Seven such cores are laid up with one axial core and the remaining six surrounding it and having a right-hand lay of about 230 mm. A bedding of compound EVA 1 is extruded over the laid-up cores and has a radial thickness of 2.5 mm. Two layers of the same polyimide tapes as in example 4 are lapped in the same manner on the bedding, and an outer sheath of the same silicone rubber compound as in examples 3 and 4, with a radial thickness of 2 mm, completes a cable with an overall diameter of around 30 mm.

6. This is exactly the same as Example 5 except that the polyimide tapes are omitted, slightly reducing the overall diameter.

7. This is exactly the same as Example 5 except that the silicone rubber sheath is replaced by a sheath of compound EVA 1 with a radial thickness of 1.5 mm (overall diameter 29 mm).

8-11. These are substantially identical with examples 1-4 respectively except that the stranded conductors are replaced by solid tinned-copper wires of 0.85 mm diameter and the radial thickness of the insulation is 0.6 mm.

12. This is the same as Example 2 except that the heat barrier is formed by two "Kapton" (trade mark) polyimide tapes, 0.08 mm thick and nominally 30 mm wide, lapped onto the bedding layer, breaking joint.

WHAT WE CLAIM IS:

1. An electric cable comprising at least one polymeric-insulated conductor, a bedding layer surrounding the conductor and made from a composition comprising an ethylene/vinyl acetate copolymer, at least 55% by weight of inert mineral filler and an antioxidant, and an enclosing sheath of low-flammability material.

2. An electric cable comprising: at least one polymeric-insulated conductor; a bedding layer surrounding the conductor and made from a composition comprising an ethylene/vinyl acetate copolymer, at least 55% by weight of inert mineral filler and an antioxidant; a heat-barrier layer of low-flammability material around the bedding layer; and an enclosing sheath of low-flammability material.

3. An electric cable as claimed in Claim 2 in which the heat-barrier layer is of flexible metal tape or foil.

4. An electric cable as claimed in Claim 2 in which the heat-barrier layer is of heat-resistant plastics tape.

5. An electric cable as claimed in Claim 2 in which the heat-barrier layer is of polyimide tape.

6. An electric cable as claimed in Claim 2 in which the heat-barrier layer is of fibre-reinforced bonded mica tape.

7. An electric cable as claimed in any one of the preceding claims in which all the components are free of halogen-containing materials, or at least substantially so.

8. An electric cable as claimed in any one of the preceding claims in which the insulation is of cured mineral-filled ethylene/vinyl acetate copolymer composition with not more than 55% by weight of inert mineral filler.

9. An electric cable as claimed in any one of the preceding claims in which the filler consists of or comprises hydrated alumina.

10. An electric cable as claimed in any one of claims 1 - 8 in which the bedding comprises, in parts by weight:

Ethylene/vinyl acetate copolymer	15-40
Alumina Trihydrate with or without calcium carbonate and/or china clay	55-80
Stearic acid	up to 5
Curing agents, if required, and antioxidants	up to 5

11. An electric cable as claimed in any one of claims 1 - 9 in which the sheath is of the same composition as the bedding.

12. An electric cable as claimed in any one of claims 1 - 9 in which the sheath is of EPR or EPDM compounded with at least 55% by weight of an inert mineral filler and other

conventional ingredients.

13. An electric cable as claimed in any one of claims 1 - 9 in which the sheath is based on a mixture of EVA with EPR or EPDM, at least 55% by weight of inert mineral filler, and other conventional ingredients.

14. An electric cable as claimed in any one of claims 1 - 9 in which the sheath is of a silicone rubber or of a flame-retardant grade of cross-linked polyethylene.

15. An electric cable substantially in accordance with any one of Examples 1 - 4.

16. An electric cable substantially in accordance with any one of Examples 5 - 7.

17. An electric cable substantially in accordance with Example 8.

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