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(54) LAMINATED TAPE FOR SHEATHING CABLES

(71) We, SUMITOMO ELECTRIC INDUSTRIES LTD. and SUMITOMO CHEMICAL COMPANY, LIMITED, both Japanese Companies, of No. 15, Kitahama 5-Chome, Higashi-ky, Osaka, Japan, 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 laminated sheathing tape for forming a shielding layer of a cable, the tape being prepared by coating a metallic tape with a resin having a good adhesive property not only for the metallic tape but also for polyethylene which is used for an outer jacketing or protective layer of the cable.

A resin used for such laminated sheathing tape is required to exhibit good processing and mechanical properties during production of the cable, for example, high abrasion-resistance to tape-forming apparatus, and good adhesion for both metallic tape and a jacketing material, such as polyethylene.

Aluminium is usually used for the metallic component of such a metallic tape, and the reasons why the laminate resin is required to have good adhesion for the metallic tape and the polyethylene which is usually used for the jacketing layer are to improve the moisture-resistance of the cable, that is the laminate resin must serve to prevent moisture permeation, to improve the mechanical strength such as the bending property of a unitized sheath (jacketing layer) by strongly laminating the metallic tape to the polyethylene jacketing layer, and to assist the function of the metallic tape to control the shrinkage of the sheath. It should be explained that a plastics sheath has stresses formed therein during extrusion and thus shrinks due to the heat cycle upon exposure to the open air.

As the laminate resin, polyethylene has ordinarily been used, as disclosed for example in British Patent Specification No. 886,417, but polyethylene is lacking in bonding strength to aluminium tape.

This disadvantage of polyethylene is partially overcome by the invention described in U.S. Patent Specification No. 3,233,036 wherein there is described the employment of a resin or polymer containing a carboxyl group to improve the bonding strength to aluminium tape, but such a resin does not have sufficient bonding strength for polyethylene forming a jacketing layer.

An attempt to overcome the two above-mentioned defects is made in U.S. Patent Specification No. 3,586,756, which discloses a so-called two-layer or multi-layer laminate tape, having a layer in contact with a metallic tape, such as aluminium tape, formed of an ethylene copolymer having a carboxyl group capable of being chemically bonded to the metallic tape and, at the opposite side of the ethylene copolymer layer, an outer layer of a resin which has less bonding strength to the metallic tape than does the ethylene copolymer, but which has a higher bonding strength to the jacketing layer than the ethylene copolymer.

When a laminate tape of this kind is used the mechanical properties of the resultant laminate sheathed cable are excellent, but since the laminated tape has a two-layer or multi-layer structure its production is complicated and the production costs are consecutively high, which results in a more expensive cable.

An object of this invention is to allow the production of a laminate sheathed cable having excellent mechanical properties at a reasonable cost by the employment in the sheathing tape of a resin composition which has a sufficient bonding strength to both the metallic tape and to the polyethylene jacketing layer of such a laminate sheathed cable and thus avoids complicated steps of producing a laminate tape as in the prior art reviewed above. The above object is achieved according to the invention by employing an ethylene-glycidyl methacrylate-vinyl acetate terpolymer as resin for laminating to the metallic tape.

The preferred terpolymers for use in the present invention comprise from 0.5 to 20

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mole % glycidyl methacrylate, 0.5 to 20 mole % vinyl acetate, the balance being ethylene. Lesser or greater, especially greater, proportions of glycidyl methacrylate and vinyl acetate may be used but in general optimum properties are exhibited by terpolymers having a composition within the above range.

Desirably the terpolymers used in the invention exhibit a melt index of from 0.5 to 20 by ASTM-1238.

The above-mentioned terpolymers used in this invention may be prepared in various ways. For example, the copolymer may be prepared by copolymerizing ethylene and the other comonomers at a temperature of from 40° to 300°C and under a pressure of from 40 to 5,000 Kg/cm² in the presence of a catalyst capable of yielding free radicals. At the copolymerization of the terpolymer, a chain transfer agent such as ethane, propane, or propylene may be added to the reaction system, if desired.

When such a resin is used for lamination to a metallic tape, the resin shows an excellent bonding strength to both the metallic tape and the jacketing polyethylene layer, providing a laminate tape having excellent

mechanical strength as well as good processibility during the production of the laminate sheathed cable.

Figure 1 of the accompanying drawings is a cross-section of a conventional laminate sheathed cable; and,

Figure 2 is a series of three schematic views illustrating bonding strength test methods referred to in Table 2 for laminate tapes.

As shown in Figure 1, a laminate sheathed cable is composed of cable cores 1, a laminate tape layer 2 consisting of a metallic tape 3 having laminated thereon a resin layer 4 and a jacketing layer 5 composed of a synthetic resin.

The merits of the resin compositions used in this invention will now be illustrated in detail by reference to the following specific examples thereof, G₁ to G₆ being compositions which are compared with other compositions outside the scope of the invention. Since aluminium tape is ordinarily used as the metallic layer in laminate sheathed cables, an aluminium tape is likewise used as the metallic layer to which the compositions were applied.

TABLE 1

(Fundamental Properties of Resins)

Resin	Melt index ASTM-1238	Tensile strength JIS-6760	Elongation JIS-6760	Abrasion coefficient*
E ₁	12.4 g/10 min.	1.48 Kg/mm ²	550%	0.50
E ₂	2.8	1.80	614	0.45
A ₁	5.7	1.62	768	0.70
A ₂	1.7	2.59	763	0.68
S	3.5	2.92	478	0.56
P	7.2	1.27	512	0.40
G ₁	2.0	1.72	615	0.46
G ₂	2.0	1.76	638	0.48
G ₃	2.0	1.67	622	0.48
G ₄	6.0	1.71	661	0.54
G ₅	2.0	1.75	650	0.45
G ₆	12.0	1.60	670	0.55

(*): abrasion coefficient to copper surface

The compositions of the tercopolymers G₁ to G₆ (ethylene-glycidyl methacrylate-vinyl acetate copolymers) were as follows:

Resin	GMA	VA	Ethylene balance
G ₁	0.6	8	
G ₂	2.4	8	"
G ₃	6.0	6	"
G ₄	12.0	6	"
G ₅	2.4	4	"
G ₆	15.0	2	"

GMA: glycidyl methacrylate

VA: vinyl acetate

Units: weight percent

Other resin compositions:

E₁—E₂: ethylene-vinyl acetate copolymers.

A₁—A₂: ethylene-acrylate copolymers.

S: a copolymer of ethylene and a comonomer containing a carboxyl group.

P: polyethylene.

TABLE 2

(Adhesive and other properties of the resins)

(A): Adhesive strength between aluminium tape and the laminate resin; (B): Adhesive strength between the laminate resin and polyethylene; (C): Processibility; (D): Blocking or sticking during storage.

	Resin	(A)		(B)	(C)	(D)
		Sheet (1)* (g/cm)	Laminate Tape (2)* (g/cm)	Sheet (3)* (Kg/cm)	(4)*	(5)*
10	E ₁	341	341	4	bad	observed
	E ₂	394	320	4	good	not observed
	A ₁	1613	433	4	bad	observed
	A ₂	1068	421	4	bad	observed
	S	1559	1055	0	good	not observed
15	P	159	50	5.5	good	not observed
	G ₁	2000	700	4	good	not observed
	G ₂	"	"	"	good	not observed
	G ₃	"	"	"	good	not observed
	G ₄	"	"	"	good	not observed
20	G ₅	"	"	"	good	not observed
	G ₆	"	"	"	good	not observed
	2-layer tape (6)*	—	520	—	good	not observed

(—): Not tested.

(1)*: A sheet of the resin having a thickness of 1.0 mm was attached to a soft aluminium sheet having a thickness of 0.2 mm by pressing the resin sheet onto the aluminium sheet at 180°C and then cooling the assembly to room temperature. The adhesive strength was measured, as shown in Fig. 1(a) by peeling the aluminium sheet from the resin sheet at an angle of 180° and at a peeling rate of 100 mm/min.

(2)*: Resin of a thickness of 0.05 mm was laminated on a soft aluminium sheet having a thickness of 0.2 mm by means of an extruding machine. (The test method for adhesive strength was as described in (1)* above and is illustrated in Fig. 2(b)).

(3)*: A sheet of the resin having a thickness of 1.0 mm was attached to a jacketing polyethylene sheet of low density polyethylene having a thickness of 1.0 mm by pressing the polyethylene sheet onto the resin sheet at 160°C and then cooling the assembly to room temperature. (The test method of the adhesive strength was also as described in (1)* above and as illustrated in Fig. 2 (c)).

(4)*: The surface of the resin film was abraded or grazed by, for example, a laminate tape-forming apparatus, as occurs in the production of cable. The extent of the abrasion depended upon the mechanical properties of the resin or the kind and the content of the comonomer or comonomers in the resin.

(5)*: The rolled laminate tape suffered blocking during storage. The extent of the blocking depended upon the kind, the content

of the comonomer or comonomers, and the melt index of the resin.

(6)*: The laminate tape prepared by the method described in the U.S. Patent Specification No. 3,586,756.

As is clear from the results shown in Tables 1 and 2, the ethylene-vinyl acetate copolymers (Resin E₁ and Resin E₂) were particularly weak in their adhesion to aluminium tape, and the ethylene-acrylic acid ester copolymers (Resin A₁ and Resin A₂) although good in their adhesion to the aluminium tape, were poor in processibility during cable manufacture and blocking-resistance.

Moreover, when polyethylene (resin P) was used as the laminate resin, the adhesion to the aluminium tape was weak and when the carboxyl group-containing resin (Resin S) was used as the laminate resin the adhesion to the jacketing layer was also weak.

Accordingly, Resins E₁, E₂, A₁, A₂, P and S are unsatisfactory in one or more properties for use as a laminate material for sheathing tape for cable.

From a comparison of the properties of compositions G₁—G₆ and the comparative compositions the above examples and shown in the Tables, it can be seen that the resins used in the present invention, that is the ethylene-glycidyl methacrylate-vinyl acetate terpolymers, are superior to conventional resins in all points, that is, in adhesive strength to aluminium tape and jacketing polyethylene layer and in processibility during the production of cable.

In addition, laminate sheathed cables were prepared by using the resins shown in Table 1 as laminate resins, and the bending property of the cable and the adhesive strengths between the aluminium tape and the jacketing polyethylene layer of each cable were measured; the results are shown in Table 3.

TABLE 3
(Properties of Cable)

	Resin	Adhesive strength (Kg/cm ²)	Number of bends required for cracks to appear in aluminium tape.
10	P	0.95	10—15
15	S	1.55	20—25
	E ₁	1.65	20—25
	G ₁	3.01	30—35
	G ₂	3.30	35—40
	G ₃	3.44	35—40
20	G ₄	3.62	35—40
	G ₅	3.25	35—40
	G ₆	3.40	35—40
	2-layer tape	3.05	30—35

In the Table 3, the adhesive strength was measured as in Table 2 and the bending test was conducted by bending the cable at an angle of 180° over a mandrel having a diameter twelve times that of the cable. One two-directional bending motion was counted as one bend.

As is shown in Table 3, the cables of this invention had almost the same properties as those of the cable prepared using the two-layer laminated tape. Thus, it will be understood from those results that the cables of this invention are excellent in mechanical properties as well as excellent from the economic viewpoint.

WHAT WE CLAIM IS:—

1. A laminated sheathing tape for forming the shielding layer of a laminate sheathed cable and comprising a metallic tape and a resin laminated thereon, the resin being an ethylene glycidyl methacrylate-vinyl acetate terpolymer.

2. A tape as claimed in Claim 1, in which the metallic tape is aluminium tape.

3. A tape as claimed in Claim 1 or Claim 2, wherein the terpolymer is derived from 0.5 to 20 mole % glycidyl methacrylate, 0.5 to 20 mole % vinyl acetate, and the balance from ethylene.

4. A tape as claimed in any preceding Claim, in which the terpolymer exhibits a melt index of from 0.5 to 20 by ASTM-1238.

5. A tape as claimed in Claim 1 or Claim 2, in which the resin has one of the compositions G₁ to G₆ as herein defined.

6. A laminated sheathed cable in which the shielding layer is formed of a tape as claimed in any one of Claims 1 to 5.

7. A cable as claimed in Claim 6, in which the shielding layer is coated with an outer jacket.

8. A cable as claimed in Claim 7, in which the outer jacket is formed of polyethylene.

9. A cable as claimed in Claim 6 and substantially as herein described.

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G ₁	3.01	30—35
G ₂	3.30	35—40
G ₃	3.44	35—40
G ₄	3.62	35—40
G ₅	3.25	35—40
G ₆	3.40	35—40
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