Unofficial Translation

Thai Industrial Standard

for

PVC Insulated Aluminium Cables

1. Scope

1.1 This standard specifies types, dimensions, requirements, packaging, marking and labelling, sampling and criteria for conformity and testing for PVC insulated aluminium cables with rated voltage not exceeding 750 V and conductor having temperature not exceeding 70 °C, hereinafter called "cables".

1.2 This standard covers only single-core cables installed outside the building with wireholders and insulators.

2. Definition

For the purposes of this standard, the following definitions apply:

2.1 POLYVINYL CHLORIDE or PVC : Combination of materials suitably selected, proportioned and treated, of which the characteristic constituent is the plastomer polyvinyl chloride or one of its copolymers. The same term also designates compounds containing both polyvinyl chloride and certain of its polymers.

2.2 CORE : A single conductor of a cable with its insulations.

2.3 CONDUCTOR : Copper wire of circular cross-section, whether solid or stranded in bundle.

2.4 STANDED CONDUCTOR : A conductor composed of a group of wires or a combination of groups of wires twisted or braided together.

2.5 COMPACT CONDUCTOR : A stranded conductor compacted by mechanical pressure or by any other procedure.

2.6 VOLTAGE : The value of voltage in root mean square.

2.7 LAY LENGTH : The axial length of one complete turn of a helix formed by the core in the case of a cable, or of a wire in the case of a stranded conductor.

2.8 LAY RATIO : The ratio of the length of lay to the mean outside diameter of stranded conductor in the layer of stranding.

2.9 MAXIMUM OPERATING TEMPERATURE : The maximum operating temperature to which any portion of the cable may be exposed under conditions of normal use, and is the temperature resulting from the combined effect of the ambient temperature rise due to the current loading on the conductors.

2.10 MEDIAN VALUE : When several test results have been obtained and ordered in an increasing or decreasing succession, the middle value if the number of available values is odd, and is the mean of the two middle values if the number is even.

3. Types

3.1 Cables shall be classified into 2 types.

3.1.1 Non-compact conductor

3.1.2 Compact conductor

4. Sizes

4.1 Sizes and details of cables shall be as given in Table 1 and Table 2.

Table 1 Details of non-compact conductor cables

(clause 4.1, clause 5.1.2.1, clause 5.2.2, clause 5.5, appendix A and appendix B)

Nominal cross-sectional area mm^2	Actual cross-sectional area from calculation 1) mm^2	Number of wires in conductor	Wire diameter mm	Conductor diameter from calculation 2) mm	Average thickness of insulations mm	Max. resistance of conductor at 20°C ohm/km	Tension of conductor from calculation 3) newton	Mass of conductor (approx) 4) kg/km
10	9.54	1	3.49	3.49	1.1	3.08	1 562	26
10	9.64	7	1.32	3.96	1.1	3.08	1 769	27
16	15.39	1	4.43	4.43	1.1	1.91	2 445	42
16	15.55	7	1.68	5.04	1.1	1.91	2 781	43
25	24.75	7	2.12	6.36	1.3	1.20	4 241	68
35	34.21	7	2.49	7.47	1.3	0.868	5 703	94
50	46.32	7	2.90	8.70	1.5	0.641	7 423	128
50	46.32	19	1.76	8.80	1.5	0.641	8 114	128
70	67.03	19	2.12	10.60	1.5	0.443	11 487	185
95	92.79	19	2.49	12.45	1.7	0.320	15 470	256
120	117.37	19	2.80	14.00	1.7	0.253	18 810	324
120	117.37	37	2.01	14.07	1.7	0.253	20 114	324
150	144.15	37	2.23	15.61	1.9	0.206	24 704	398
185	181.06	37	2.50	17.50	2.1	0.164	30 187	500
240	237.55	61	2.23	20.07	2.3	0.125	38 568	655
300	296.94	61	2.49	22.41	2.5	0.100	46 901	819
400	381.67	61	2.82	25.38	2.7	0.0778	57 948	1 053
500	490.81	61	3.20	28.80	3.1	0.0605	73 194	1 354

Note : 1) see appendix B
2) see appendix C
3) see appendix D
4) see appendix E

Table 2 Details of compact conductor cables

(clause 4.1, clause 5.1.3.1, clause 5.2.2, clause 5.5, appendix A and appendix B)

Nominal cross-sectional area mm^2	Actual cross-sectional area from calculation 1) mm^2	Number of wires in conductor	Wire diameter		Average thickness of insulations mm	Max. resistance of conductor at 20°C ohm/km	Tension of conductor from calculation 2)	Mass of conductor (approx) 3) kg/km
			Min mm	Max mm				
10	9.64	6	3.5	4.1	1.1	3.08	1 768	27
16	15.55	6	4.6	5.2	1.1	1.91	2 734	43
25	24.75	6	5.6	6.5	1.3	1.20	4 120	68
35	34.21	6	6.6	7.5	1.3	0.868	5 591	94
50	46.32	6	7.7	8.6	1.5	0.641	7 313	128
70	67.03	12	9.3	10.2	1.5	0.443	10 420	185
95	92.79	15	11.0	12.0	1.7	0.320	14 098	256
120	117.37	15	12.5	13.5	1.7	0.253	18 518	324
150	144.15	15	13.9	15.0	1.9	0.206	22 457	398
185	181.06	30	15.5	16.8	2.1	0.164	28 974	500
240	237.55	30	17.8	19.2	2.3	0.125	37 506	655
300	296.94	30	20.0	21.6	2.5	0.100	45 642	819
400	381.67	53	22.9	24.6	2.7	0.0778	56 992	1 053
500	490.81	53	25.7	27.6	3.1	0.0605	72 195	1 354

Note : 1) see appendix B

2) see appendix C

3) see appendix D

5. Requirements

5.1 Conductor

5.1.1 Non-compact conductor and compact conductor shall consist of hard-drawn aluminium wire which have the mechanical and electrical properties as specified in this standard. Wires shall be clean and free from imperfections imparing their further use.

5.1.2 Non-compact conductor

5.1.2.1 The number of wires shall be as specified in Table 1.

Compliance is checked by inspection.

5.1.2.2 Joints in wires and stranding shall comply with TIS 85.

5.1.2.3 Tolerances on the outside diameter of wire shall be as specified as follows.

Compliance is checked by tests specified in TIS 11.

Diameter of Wire mm	Tolerances
less than 2.50	± 0.025
up to and including 2.50	± 1%

5.1.3 Compact conductors

5.1.3.1 The minimum number of wires shall comply with Table 2.

Compliance is checked by inspection.

5.1.3.2 Joints in wires shall comply with of TIS 85.

5.1.3.3 Strands

(1) Conductor having size not exceeding 150 cm^2, the lay ratio of each layer shall be not less than 11 but not more than 17.5.

(2) Conductor having size exceeding 150 cm^2, the lay ratio of outer layer shall be not less than 8 but not more than 16.

(3) The direction of the lay in same layer may be the same or reversed, but the direction of the outer layer shall be right-hand. The wires in each layer shall be closed and regularly smooth.

(4) In the conductor which have many layer of wires, the lay ratio of the outer layer shall not exceed the lay ratio of the successive layers.

Compliance is checked by inspection and tests specified in TIS 11.

5.1.3.4 The ratio of the diameters of two different wires before compact shall not exceed 2.

5.2 Insulation

5.2.1 The insulation shall be so applied that it fits closely on the conductors, but it shall be possible to remove it easily without damage to the conductors.

5.2.2 The mean value of the thickness of the insulation shall be not less than the mean value specified in Table 1 and Table 2. The thickness at any place may be less than specified mean value, provided that the difference does not exceed 0.1 mm + 10% of the specified mean value.

5.2.3 Unless otherwise specified, the colour of insulation shall be black.

Compliance is checked by tests specified in TIS 11.

5.3 Indelibility of markings

The markings on cables shall be durable and legible.

Compliance is checked by tests specified in clause 9.1.

5.4 Mechanical properties of wires shall be not less than the specified values in table 3

Compliance is checked by tests specified in TIS 85. In case of compact conductor cables samples shall be drawn from wires before stranded.

Table 3 Mechanical properties of hard rolled aluminium wire

(clause 5.4)

Diameter	minimum ultimate tensile stress newton (kilogram force) per mm^2		minimum elongation before
mm	before stranding	After stranding	stranding
1.25	200.0 (20.4)	190.2 (19.4)	1.2
1.50	193.2 (19.7)	183.4 (18.7)	1.3
1.75	188.3 (19.2)	178.5 (18.2)	1.3
2.00	184.4 (18.8)	175.5 (17.9)	1.4
2.25	180.4 (18.4)	171.6 (17.5)	1.5
2.50	175.5 (18.0)	167.6 (17.1)	1.5
2.75	172.6 (17.6)	163.8 (16.7)	1.6
3.00	168.7 (17.2)	159.8 (16.3)	1.6
3.25	165.7 (16.9)	156.9 (16.0)	1.7
3.50	163.8 (16.7)	156.0 (15.9)	1.7
3.75	161.8 (16.5)	154.0 (15.7)	1.8
4.00	159.8 (16.3)	152.0 (15.5)	1.9
4.25	159.8 (16.3)	152.0 (15.5)	2.0
4.50	158.9 (16.2)	151.0 (15.4)	2.0
4.75	158.9 (16.2)	151.0 (15.4)	2.0
5.00	158.9 (16.2)	151.0 (15.4)	2.0

Note : Wires with diameters differ from table 3, the next higher consecutive diameter shall be used.

5.5 The resistivity of aluminium wire shall not exceed 28.264 Ω mm^2/km at 20°C. The conductor resistance shall not exceed the value specified in Table 1 and Table 2.

Compliance is checked by tests specified in TIS 85. In case of compact conductor cables, sampling shall be drawn from wires before stranded.

5.6 Voltage resistance of cables

When tested in accordance with TIS 11, Insulation shall show no breakdown or flashover.

5.7 Tensile strength and elongation of insulation

5.7.1 Tensile strength and elongation before ageing

The median values of tensile strength shall be not less than 12.5 Mpa.

The median values of elongation shall be not less than 125%.

5.7.2 Tensile strength and elongation after ageing

The difference between the median values before and after ageing shall not exceed 20% of the median values before ageing.

Compliance is checked by tests specified in TIS 11.

5.8 Loss of insulation mass

When the insulation is tested in accordance with TIS 11, loss of mass shall not exceed 2.0 mg/cm^2.

5.9 Heat shock resistance of insulation

When tested in accordance with TIS 11, the insulation shall not crack.

5.10 Pressure test at high temperature of insulation

When the insulation is tested in accordance with TIS 11, the median values of depth of penetration shall not exceed 50% of the mean thickness of test pieces.

5.11 Sunlight resistance

When tested in clause 9.2.1 or 9.2.2, ratio between mean value of tensile strength and elongation before and after the sunlight resistance test shall not be less than 85%.

6. Packaging

6.1 Packing units which may be in drums, rolls or coils shall be agreed upon purchasers and suppliers . (Length of cable per packing unit shall be agreed upon purchases and suppliers)

6.2 For eagh packing unit, adequate protection shall be provided so as to prevent damage during handling and transportations and shall be as agreed upon purchasers and suppliers.

7. Marking and labelling

7.1 On cable, in each packing unit, at the interval of not less than 500 mm, there shall be numbers, letters or markings to indicate the followings which shall be legible, clear and indelible .

(1) The words “PVC 70°C ”

(2) Type

(3) Name or symbol of cables and number of relevant Table 1 or Table 2

(4) Voltage rating

(5) Nominal cross-sectional area

(6) Name of manufacturer or factory or registered trade mark

7.2 On the outside of packing units, there shall be members, letters or marking to indicate the followings which shall be legible, clear and indelible.

(1) The words "PVC 70°C"

(2) Type

(3) Name or symbol of cables and member of relevant Table 1 or Table 2

(4) Voltage rating

(5) Nominal cross-sectional area

(6) Length in metres

(7) Not weight in kilogrammes. In case of drums, total weight shall be included

(8) Month and year of manufacture

(9) In case of drums, there shall be arrows indicating the direction of roll and the position of cable end

(10) Name of manufacturer or factory or registered trade mark

7.3 In case foreign language is used, the meaning shall correspond to that of Thai specified above.

8. Sampling and criteria for conformity

8.1 Lot : Cables of the same type, having the same nominal cross-sectional area of conductors, same number and diameter of conductor wires, and manufacturing or delivering or purchasing at the same period of time.

8.2 Sampling and criteria for conformity shall comply with the sampling plan specified below or with other technically equivalent plan.

8.2.1 Sampling

8.2.1.1 Samples of 30 metres of cables from packing unit of each lot according to running number shall be drawn at random, except otherwise specified on the agreement between purchases and suppliers.

8.2.1.2 For non-compact conductor, samples of 30 metres of wires from packing unit of each lot according to running number shall be drawn at random and subject to testing of clause 5.4 and clause 5.5.

8.2.1.3 For compact conductor, samples of 30 metres of wires before stranded from packing unit of each lot according to the running number shall be drawn at random and subject to testing of clause 5.4 and clause 5.5.

8.2.2 Criteria for conformity

Provided the sample meets all the requirements of clause 4, clause 5, clause 6 and clause 7, that lot of wires shall be deems to comply with this standard.

9. Testing

9.1 Indelibility of marking

Rub the markings on the cable with a piece of cotton cloth soaked in water. Markings shall adhere firmly and be legible.

9.2 Sunlight resistance

9.2.1 Carbon-arc test for 300 hours

9.2.1.1 Test equipments

Test equipments shall be as specified in UL 1581.

9.2.1.2 Specimens preparation

(1) Five specimens, each of appropriate length to be used for tensile strength and elongation before aging test according to TIS 11, shall be cut from cables.

(2) Five specimens, adjacent to specimens in (1), shall be selected and cut and subjected to aging test in 9.2.1.3.

9.2.1.3 Test method

Testing shall be performed in accordance with UL 1581 by

(1) The water spray shall be set to 3 minutes water spray and without water spray for 17 minutes comprising one cycle. The carbon-arc shall be operated through out the cycle. Tests shall be repeated to cover 300 hours.

(2) Water used for testing shall be clean, with pH 6.0 to 8.0 at temperature of $16.0 \pm 5\ ^{\circ}C$. Water that has been used for testing shall be used again except that specific means are used to condition the sprayed water .

(3) The specimens are taken out of the test chamber and allowed to cool down at room temperature without direct contact with sunlight at the period not less than 16 hours and not more than 96 hours. They are, then, subjected to tensile strength and elongation test as specified in TIS 11.

9.2.1.4 Report

Mean values of tensile strength and elongation shall be reported using method of calculation specified in TIS 11.

9.2.2 Xenon-arc test for 420 hours.

9.2.2.1 Test equipments

Test equipments shall be as specified in UL 1581.

9.2.2.2 Specimens preparation

(1) Five specimens, each of appropriate length to be used for tensile strength and elongation before aging test according to TIS 11, shall be cut from cables.

(2) Five specimens, adjacent to specimens in (1), shall be selected and cut and subjected to aging test in 9.2.2.3.

9.2.2.3 Test method

Testing shall be performed in accordance with UL 1581 by

(1) The water spray shall be set to 18 minutes water spray and without water spray for 102 minutes comprising one cycle. The xenon-arc shall be operated through out the cycle. Tests shall be repeated to cover 420 hours.

(2) Water used for testing shall be clean, with pH 6.0 to 8.0 at temperature of 16.0 $\pm$ 5 $^{\circ}$C. Water that has been used for testing shall be used again except that specific means are used to condition the sprayed water.

(3) The specimens are taken out of the test chamber and allowed to cool down at room temperature without direct contact with sunlight at the period not less than 16 hours and not more than 96 hours. They are, then, subjected to tensile strength and elongation test as specified in TIS 11.

9.2.2.4 Report

Mean values of tensile strength and elongation shall be reported using method of calculation specified in TIS 11.

Appendix A

Tension test of stranded conductors

(Table 1 and Table 2)

A.1 Tension test of stranded conductors shall be performed according to the agreement of purchasers and suppliers using samples from stranded conductors. Distance between clamps of tension test machine shall not be less than 1 metre when the specimen is put in place. Stranded conductor shall withstand tension of no less than 95% of tension specified in Table 1 and Table 2.

Appendix B

Calculation of Actual cross-sectional area of conductor

(Table 1 and Table 2)

The actual cross-sectional area calculated using the data from IEC 220 and formular as follows:

$$\frac{n\pi d^2}{4} = \frac{AK_1K_2K_3}{Rdc}$$

where : $\frac{n\pi d^2}{4}$ = actual cross-sectional area, in square millimetres

A = resistivity of aluminium wire = 28.264 ohms square millimetres/kilometre at $20^{\circ}C$

n = number of conductor wires

d = diameter of conductor wire, in millimetres

Rdc = resistance at $20^{\circ}C$, in ohms/kilometre

K_1 = factor, based on the diameter of wires in the conductor and whether the wire is coated.

Values of K_1 are as follows :

Maximum diameter of conductor wire mm	K_1	
	solid conductor	stranded conductor
more than 0.05 to 0.10	-	1.12
more than 0.10 to 0.31	-	1.07
more than 0.31 to 0.91	1.05	1.04
more than 0.91 to 3.60	1.04	1.03
up to 3.60	1.04	-

K_2 = factor, based on method of stranding

1.02 for stranded conductor

1.00 for solid conductor

K_3 = factor, based on the method of core binding. The value is 1.00 for single core and flexible cord and multiple core and flexible cord without core binding

Appendix C

Calculation of diameter of conductor wires

(Table 1)

Diameter of conductor wires can be calculated from the formula :

$\frac{n\pi d^2}{4}$ = actual cross-sectional area of conductor, in square millimetres

where : d = diameter of calculation (appendix B)

n = number of wires

Appendix D

Calculation of tension of conductors

(Table 1 and Table 2)

Tension of conductor = π x (diameter of wire)^2 x 0.95 (mumber of wires not more than 37) or

= x 0.90 (mumber of wires not more than 37) or

= x minimum ultimate Tensile stress according to TIS 85

Appendix E

Calculation of mass of conductors

(Table 1 and Table 2)

$$\text{mass of conductors} = D \times \frac{n\pi d^2}{4} \times L \times \text{effective lay loss}$$

where : D = Density of aluminium at $20^{\circ}C$ = 2.705 grams per cubic centimetres

$\frac{n\pi d^2}{4}$ = Actual cross-sectional areara from calculation in square centimetre

L = Length in kilometres

Effective lay loss can be calculated from the formula :

$$LL_i = \sqrt{1 + \left(\frac{\pi D_i^2}{\text{©}^{TM}\prod\sqrt{L_i}}\right)}$$

$$\sqrt{\sqrt{\prod}}$$

where : LL_i = lay loss in layer i of conductors

D_i = diameter of layer i of conductors

L_i = lay length of layer i of conductors

$$LL_{eff} = \frac{1 + \sum n_i L L_i}{N}$$

where : LL_{eff} = effective lay loss

n_i = number of conductors in layer i

N = total number of conductor