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SPECIFICATION FOR

PVC INSULATED CABLES FOR OVERHEAD TELECOMMUNICATION LINES

SRI LANKA STANDARDS INSTITUTION

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SLS 986 : 1993

Gr. 8

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Sri Lanka.

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SPECIFICATION FOR PVC INSULATED CABLES FOR OVERHEAD TELECOMMUNICATION LINES

FOREWORD

This standard was approved by the Sectoral Committee on Basic standards in Electronic Engineering and was authorized for adoption as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 1993-01-21.

This standard prescribes requirements and methods of test for conductors and insulation of overhead telecommunication cables.

All values given in this specification are in SI units.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the results of a test or an analysis shall be rounded off in accordance with SLS 102. The number of figures to be retained in the rounded off values shall be the same as that of the specified value in this standard.

Guidelines for the determination of a compliance of a lot with the requirements of this standard based on statistical sampling and inspection is given in Appendix A.

In the preparation of this standard, the assistance derived from the following publications is gratefully acknowledged.

BS 174 : 1970 — Hard drawn copper and copper cadmium wire for telegraph and telephone purposes

IEC 189-1 : 1986 — Low-frequency cables and wires with p.v.c. insulation and p.v.c. sheath
Part 1 : General test and measuring methods

1 SCOPE

This standard specifies dimensions, quality of hard drawn copper wire and insulating material for cables for overhead telecommunication lines.

2 REFERENCES

SLS 102 Presentation of numerical values.
SLS 428 Random sampling methods.
SLS 580 Basic environmental testing procedures.
SLS* 988 PVC insulation and sheath of electric cables.

3. DEFINITION

For the purpose of this standard following definitions shall apply.

3.1 piece : A single length of wire without joint or splice of any description in the finished wire.

3.2 test sample : A sample taken for test in accordance with this specification .

4 REQUIREMENTS

4.1 Conductor

4.1.1 *Material*

The wire shall be made from high conductivity copper of purity not less than 99.9 per cent.

4.1.2 *Dimensions*

The wire shall be drawn in continuous length complying with appropriate conductor diameters given in Table 1.

4.1.3 *Mechanical properties*

The mechanical properties of the wire shall comply with the requirements of Table 1 when tested as in 6.3.3.

TABLE 1 : Physical, mechanical and electrical properties

Nominal Cross Sectional area	Diameter of Conductor			Minimum breaking load of conductor	Resistance of Conductor at 20°C *		Maximum overall diameter of cable
	standard	max.	min.		standard	max.	
mm^2	mm	mm	mm	N	ohm/km	ohm/km	mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.33	1.30	1.31	1.29	540	13.361	13.661	4.81
2.27	1.70	1.72	1.68	920	7.829	7.986	5.20
4.91	2.50	2.53	2.48	1990	3.620	3.694	6.03

* *Resistance values are calculated from resistivity of 0.01777 micro-ohm metre at 20 °C. This value is equivalent to a conductivity of 97 per cent internationally accepted standard value for annealed copper. Maximum values of resistance are calculated from minimum diameters.*

4.1.4 *Electrical properties*

The resistance per unit length expressed at 20 °c shall not exceed the maximum value given in Table 1. Resistance conversion factors for correcting at other temperatures are given in 6.5.1.

4.1.5 *Finish*

The wire shall be approximately circular in section, smooth, and free from spills, splits, scale and other defects which would adversely affect the properties of the wire.

4.2 Insulation

4.2.1 *Material and application*

The insulation material shall be Type 5 Polyvinyl chloride (PVC) specified in SLS 988. The insulation shall be applied to fit closely to the conductor without adhering to it. It shall be possible to strip the insulation from the conductor easily without damage to the insulation remaining with the conductor.

The stripping properties of insulation shall be checked by means of a normal stripping pliers.

In particular cases, however, for example where mechanical stripping devices are being used, a controlled method of test may be required. In such cases, the method of test shall be as agreed between the purchaser and the manufacturer.

4.2.2 *Thickness*

The insulation shall be continuous having a thickness as uniform as possible and not less than 1.5 mm, when measured in accordance with 6.2.2.1. However, the thickness at any one place may be less than the value specified provided that the difference does not exceed 0.25 mm.

4.2.3 *Colour of Insulation*

The insulation shall be black in colour.

4.3 Maximum overall diameter of the cable

The maximum overall diameter of the conductor shall be equal or less than the relevant value specified in Table 1.

5 PACKING AND MARKING

5.1 Cables shall be either wound on reel or drum or coiled, and packed and labelled.

5.2 The label which shall be securely attached to the reel, drum or coil shall contain at least the following information:

a) Name and/or trade mark of the manufacturer;
b) Nominal diameter of conductor of the cable;
c) Length of cable contained in the coil, reel or drum;
d) Country of manufacture; and
e) Any other information as agreed between the purchaser and the manufacturer.

5.3 The means of identifying the manufacturer shall be provided on the cable preferably at regular intervals of 50 cm. This may be done by embossing or printing.

NOTES

1 The continuous length of cable may be 100 m or as agreed between the purchaser and the manufacturer.

2 Attention is drawn to certification facilities offered by SLSI. See the inside back cover of this standard.

6 TESTS

6.1 Standard conditions for testing

Unless otherwise specified, all tests shall be carried out under the conditions specified in SLS 580 : Part 1 : 1983.

Before any measurements are made, the cables shall be stored at the measuring temperature for a time sufficient to allow the entire cable or wire to reach that temperature.

6.2 Dimensions

6.2.1 *Selection and preparation of samples*

6.2.1.1 Insulation

Samples of cable, approximately 100 mm in length, shall be taken at both ends of the cable. One sample shall be taken at each end. The conductor shall be withdrawn, care being taken not to damage the insulation. Each test sample shall consist of a thin slice of insulation. The slice shall be cut with a suitable device along a plane perpendicular to the longitudinal axis of the conductors.

6.2.1.2 Finished cable

Samples of finished cable, approximately 100 mm in length, shall be taken at both ends. One sample shall be taken at each end.

6.2.2 *Measurement of dimensions*

6.2.2.1 Minimum thickness of insulation

samples prepared as in 6.2.1.1 shall be measured. Each test sample shall be placed under a measuring microscope with the plane of the cut at right angles to the optical axis.

The minimum thickness shall be found and measured.

NOTE

The microscope or the micrometer shall be capable of measuring the thickness to within 0.01 mm.

6.2.2.2 Diameter of finished cable

Both samples taken as in 6.2.1.2 shall be measured. The measurement shall be made with a micrometer in two directions at right angles in the middle of the sample. The setting of the micrometer shall be such that the cable is a sliding fit between the anvils. The mean of the two values measured with the micrometer, shall be rounded off to the nearest tenth of a millimetre.

6.2.2.3 Mean thickness of insulation

Each sample shall be placed under a measuring microscope with the plane of the cut at right angles to the optical axis.

The mean thickness of the insulation shall be determined by measuring the thickness along four radii at right angles, the first measurement being made along the radius corresponding to the minimum thickness.

The mean value of the measurements shall be determined in millimetres to two decimal places. This value shall be considered to be the mean thickness of the insulation.

NOTE

This measurement enables one of the factors occurring in the calculation of the cross-sectional area of the insulation to be determined. It shall be made on samples selected, marked and prepared for the tensile tests. (see 6.3.2.1).

The microscope shall be capable of measuring the thickness to within 0.01 mm.

6.3 Mechanical tests

The mechanical properties of the conductor and the insulation of the cable shall be determined by tensile tests on samples of the solid copper conductors and samples of the insulation as delivered and after accelerated ageing. (see 6.4.1).

The stripping properties of the insulation shall also be checked.

6.3.1 *Selection, marking and preparation of samples for tensile tests*

6.3.1.1 Conductors

Conductors shall be subjected to the tensile tests. Samples of convenient length shall be taken at the ends of the cable in the packing or from a percentage of cable, as may be required by the purchaser. For any one size of cable a number of test samples not exceeding 5 per cent of the total number of test samples, shall be cut from pieces of cable at positions other than at their ends. Where this has been done the parts of any piece which have been separated by the removal of a sample shall be bound up into a separate coil. These pieces shall be accepted as good delivery if the cable satisfies all the requirements of this standard.

6.3.1.2 Insulation

Samples of cable shall be taken at both ends 'a' and 'b' of the cable. Three test specimens, approximately 100 mm in length, shall be taken from each lot of samples and marked in the following order :

a_1 a_2 a_3

b_4 b_5 b_6

The conductor shall be withdrawn from test specimens marked with an odd number, care being taken not to damage the insulation. For the other test specimens this procedure shall take place after accelerated ageing.

The cross-sectional area of the insulation shall be determined (see 6.3.2.1) and a length of 20 mm then marked centrally on the specimen by two reference lines.

Test specimens marked with an odd number shall be subjected to the tensile tests as delivered.

Those marked with an even number shall be subjected to the tensile tests after accelerated ageing.

6.3.2 *Measurement of cross-sectional area for tensile test*

The cross-sectional area A of the insulation shall be determined in square millimetres using the formula :

$$A = (D - a)\, a$$

where,

a = mean thickness of the insulation, in millimetres, measured as in 6.2.2.3;
D = diameter of the cable in millimtres, measured as in 6.2.2.2; and
= 3.14.

In the case of samples to be subjected to accelerated ageing, the dimensions used for the calculation of the cross-sectional area shall be measured after ageing.

6.3.3 Tensile test

The tensile test shall be carried out after the test specimens have been conditioned at a temperature of 23 ± 2 °C for at least 3 hours; the test shall be started within 5 minutes after removing from conditioning atmosphere.

The test specimens shall be placed in a tensile machine in such a way that the free length between the jaws is approximately 100 mm for the conductor and approximately 50 mm for the insulation.

The speed of separation of grips of the tensile machine shall be about 100 ± 20 mm/min for conductors, and between 250 ± 50 mm/min for insulation.

The elongation at break shall be determined by measuring the distance separating the two marking lines at the moment of rupture, and then calculating the percentage elongation in relation to the distance measured before the test.

The minimum breaking load of the conductor shall be not less than the relevant value given in Table 1

The samples of insulation taken as in 6.2.1.1 shall be subjected to the tensile test before and after ageing (see 6.4). The elongation at break and tensile strength of insulation shall be not less than the relevant values specified in Table 2.

TABLE 2 - Elongation at break and tensile strength of insulation

Test	Requirement for insulation
Tensile strength and elongation at break	
Minimum tensile strength	12.5 N/mm²
Minimum elongation at break	125 per cent
Accelerated ageing followed by tensile strength and elongation at break	
Minimum tensile strength	12.5 N/mm²
Maximum variation from unaged value	25 per cent
Elongation at break	125 per cent
Maximum variation from unaged value	25 per cent

6.4 Thermal stability and climatic tests

6.4.1 *Accelerated ageing*

The object of accelerated ageing is to condition the samples of insulation so that they are brought rapidly to a state normally reached after a long time.

The accelerated ageing test shall be carried out in an atmosphere having the composition and pressure of the ambient air.

The selected and marked test specimens of insulation (with conductor) shall be suspended freely in a hot-air oven with natural circulation of air. They shall be kept for 10 days at a temperature of 135 ± 2 °C. Immediately afterwards they shall be removed and allowed to recover for at least 16 hours at the temperature and the pressure of the ambient air, avoiding direct light. Then the tensile test as prescribed in 6.3.3 shall be carried out and the values measured shall comply with the requirement in Table 2.

6.4.2 *Resistance to flame propagation*

The object of this test is to determine the extent to which the cable is capable of supporting or spreading combustion.

The test shall be carried out on three samples approximately 300 mm in length of the finished cable.

The test shall be made in still air with a Bunsen burner, having a nozzle with an internal diameter of 9 mm and supplied with Liquefied Petroleum gas.
With the burner in the vertical position, the flame shall be adjusted to an overall length of 100 mm and a core length of 50 mm.

The burner shall then be supported with its axis at an angle of 45^0 to the vertical. The sample shall be held at an angle of 45^0 to the vertical, with its axis in a vertical plane at right angles to the vertical plane containing the axis of the burner.

Its position shall be such that it passes through the centre of the flame, 100 mm from its lower end, the distance between the sample and the nozzle of the burner being 35 mm.
The sample shall remain in the flame for 60 seconds.

The flame shall extinguish itself within 30 seconds after removal from the burner. There shall be no violent or explosive burning and no detachment or emission of burning particles or droplets.

6.4.3 *Cold bend test*

The object of this test is to determine the extent to which the cable may be used after exposure to low temperature.

Two samples of cable of adequate length shall be subjected to the following test:

The samples, shall be placed for 2 hours in a chamber cooled to -10 ± 2^0C. Without removing them from the chamber, they shall then be wound helically for three complete contiguous turns round a mandrel having the same temperature.

The mandrel diameter shall have the value, rounded off to the nearest whole millimetre, of three times the mean overall diameter of the cable. The mean overall diameter of the cable may be calculated from the nominal diameter of the conductor plus twice the mean thickness of the insulation, measured as described in 6.2.2.1.

The samples shall then be examined with the naked eye.

The insulation shall remain adequately pliable at -10^0C and shall show no cracks.

6.4.4 *Heat shock test*

The object of this test is to determine the extent to which the insulation withstands variations in temperature without suffering damage.

Two samples of cable of adequate length shall be subjected to the following test:
The samples shall be wound helically for three complete contiguous turns round a mandrel of diameter as specified, in 6.4.3.

Each sample on its mandrel shall be placed in an oven, the atmosphere of which has the composition and pressure of ambient air, and maintained at a temperature of 150 ± 3°C for 1 hour.

After this period, the sample shall be examined with the naked eye while still on the mandrel.

The insulation shall withstand variations in temperature without damage. No cracks shall be visible to the naked eye.

6.4.5 *Measurement of insulation shrinkage after over heating of conductor*

The object of this test is to check the extent to which the insulation shrinks after overheating of the conductor.

Two samples of cable approximately 150 mm in length, shall be subjected to the following test :

Each sample shall be made as straight as possible. A length of 100 ± 5 mm shall be marked on the insulation by two lines; the insulation shall be removed beyond these lines.

The samples shall then be placed in an oven, the atmosphere of which has the composition and pressure of ambient air, and maintained at a temperature of 150 ± 2°C for 900 seconds. After this period, the samples shall be removed from the oven and cooled down to ambient temperature within 1 hour. The length of the insulation shall then be measured, and the percentage of shrinkage calculated. This value shall not exceed 3 per cent.

6.5 Electrical tests

6.5.1 *Electrical resistance of conductors*

The electrical resistance shall be measured on the finished cable by means of a device capable of measuring accurately to within 0.5 per cent of the value to be determined.
The measured value corrected proportionately to the length, and expresses in ohms/kilometre, shall be referred to the standard temperature of 20 °C.

For copper conductors the resistance shall be corrected to the standard temperature by multiplying the measured value by the factor K , where :

$$K = \frac{1}{1 + 0.00393\ (t - 20)}$$

Where, t is the temperature in Celsius degrees at which the measurement is made.

The resistance shall not exceed the relevant value in Table 1.

6.5.2 *Voltage test (Dielectric strength)*

This test shall be carried out before the measurement of insulation resistance described in 6.5.3.

The test shall be made at room temperature with an alternating voltage of approximately sine - wave form having a frequency in the range 50 Hz to 60 Hz. The applied voltage shall be increased gradually and maintained at the full r.m.s value of 2.5 kV for 5 minutes without breakdown of the insulation. Then the insulation resistance shall be measured as in 6.5.3.

6.5.3 *Insulation resistance*

Immediately after completion of the voltage test specified in 6.5.2, the insulation resistance between the conductor and the water in which the cable is immersed should be measured after electrification for one minute with d.c. voltage of 300 V to 500 V. The electrification shall proceed in a regular manner, during the period of electrification.

NOTE

The insulation resistance of the length of cable shall not be less than that resulting from calculation using the following expression:

$$R_{1000} = k \log_{10} D/d \text{ M ohm.km.}$$

Where
k is the insulation resistance constant at 27°C=19 M ohm km,
D is the diameter over insulation in mm,
d is the diameter over conductor in mm, and
R_{1000} is the insulation resistance of cable in M ohm.km.

The temperature of the water in which the core is immersed should be at or near to 27°C.

APPENDIX A

COMPLIANCE OF A LOT

The sampling scheme given in this Appendix should be applied where compliance of a lot to the requirements of this standard is to be assessed based on statistical sampling and inspection.

Where compliance with this standard is to be assured based on manufacturer's control systems coupled with type testing and check tests or any other procedure, appropriate schemes of sampling and inspection should be adopted.

A.1 Lot : In any consignment all reels, drums or coils of cables of the same dimension belonging to one batch of supply or manufacture shall constitute a lot.

A.2 Scale of sampling

A.2.1 Samples shall be tested from each lot for ascertaining conformity to the requirements of this specification.

A.2.2 The number of reels, drums or coils of cables to be selected from a lot shall be in accordance with Table 3

TABLE 3 - Scale of sampling

No. of reels, drums or coils in the lot (1)	No. of reels, drums or coils to be selected (2)	Sub-sample size (3)
0 - 25	3	3
26 - 50	4	3
51 - 90	5	4
91 - 150	8	5
151 and above	13	6

A.2.3 The reels, drums or coils shall be selected at random. In order to ensure randomness of selection random numbers as given in SLS 428 shall be used .

A.2 Number of tests

A.2.1 Each reel, drum or coil selected as in A.1.2.2 shall be inspected for packaging and marking requirements, finish and colour of insulation.

A.2.2 Each reel, drum or coil selected as in A.1.2.2 shall be tested for requirements given in 4.1.2 , 4.2.2 and 4.3.

A.2.3 Each reel, drum or coil in the sub-sample selected as in Column 3 of the Table 3 shall be tested for mechanical properties.

A.2.4 Each sample tested as in A.2.3 shall be tested or insulation requirements given as in 4.2.

A.2.5 Each reel, drum or coil in the sub-sample selected as in Column 3 of the Table 3 shall be tested for electrical properties.

A.3 CRITERIA FOR CONFORMITY

A lot shall be declared as conformity to the requirements of this specification if the following conditions are satisfied.

A.3.1 Each reel, drum or coil inspected as in A.2.1 satisfies the relevant requirements.

A.3.2 The values of the expressions $x + S$ and $x - S$ calculated using the test results on each dimension, thickness and overall diameter lie between the specified values of each requirement.

Where,

x = mean of the test results; and

S = standard deviation of the test results

$$S = \frac{(\quad x)^2 - (\quad x)^2/n}{n - 1}$$

A.3.3 The values of the expression $x - S$ calculated using the test results on tensile test is not less than the specified value.

A.3.4 Each sample tested as in A.2.4 satisfies the insulation requirements.

A.3.5 The value of the expression $x + S$ calculated using the test results on electrical resistance on conductors is not greater than the specified value.

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