SRI LANKA STANDARD 821 : 1988

UDC 621 . 315 . 21 : 678 . 743

SPECIFICATION FOR

LOW - FREQUENCY CABLES AND WIRES WITH PVC INSULATION AND PVC SHEATH FOR TELECOMMUNICATION

PART 1 – GENERAL REQUIREMENTS AND TESTS

SRI LANKA STANDARDS INSTITUTION

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PART 1 : GENERAL REQUIREMENTS AND TESTS

SLS 821 : 1988

Gr.14

SRI LANKA STANDARDS INSTITUTION
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Sri Lanka.

Sri Lanka Standards are subject to periodical revision in order to accommodate the progress made by industry. Suggestions for improvement will be recorded and brought to the notice of the Committees to which the revisions are entrusted.

This standard does not purport to include all the necessary provisions of a contract.

SRI LANKA STANDARD

SPECIFICATION FOR LOW-FREQUENCY CABLES AND WIRES WITH PVC INSULATION AND PVC SHEATH FOR TELECOMMUNICATION

PART 1 : GENERAL REQUIREMENTS AND TESTS

FOREWORD

This Sri Lanka Standard was authorized for adoption and publication by the Council of the Sri Lanka Standards Institution on 88.06.30, after the draft, finalized by the Drafting Committee on Low-Frequency Cables, had been approved by the Electrical Engineering Divisional Committee.

This standard comes in several parts. Part 1 specifies general requirements and test methods and, is in line with the publication 189 - 1 of International Electro-technical Commission and the British Standards Specification 4808 Part 1. The subsequent parts cover specific requirements.

This standard is presented in 5 parts. Namely

Part 1 General requirements and tests.
Part 2 Equipment wires with solid or standard & conductors, unscreened, single.
Part 3 Cables and equipment wires, with solid or stranded conductors, Screened, single.
Part 4 Equipment wires with solid or stranded conductors, unscreened, in pairs, triples, quads and quintuples.
Part 5 Cables with solid or stranded conductors, screened and sheathed, one pair.

All values in this specification are in SI units.

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

The assistance derived from the publications of the International Electroctechnical Commission and the British Standards Institution, in the preparation of this specification is gratefully acknowledge.

1 SCOPE

This specification covers the general requirements and tests for low-frequency cables and wires having insulation and sheath made of polyvinylchloride and designed for telecommunication and other electronic devices.

2 REFERENCES

IEC 28 International standard of resistance for copper.
IEC 304 Standard colours for insulation for low-frequency cables and wires
BS 6746 PVC insulation and sheath of electric cables.
SLS 102 Presentation of numerical values.
SLS 428 Random sampling methods.
SLS 580 Basic environmental testing procedures for electronic components and equipment, Part 1.

3 DEFINITIONS

For the purpose of this specification the following definitions shall apply.

3.1 conductor : Part of the cable or wire intended to carry electric current. The conductor may be :

a) single - consists of a single insulated conductor;
b) multiple - consists of several insulated conductors, the shall not exceed five

NOTE *:The following designations are used :*

pair - for multiple wire with two conductors;
triple - for multiple wire with three conductors;
quad - for multiple wire with four conductors; and
quintuple - for multiple wire with five conductors.

3.2 Low-frequency cables

3.2.1 *sheathed cable :* Assembly of insulated conductors enclosed in a common continuous protective covering, having a certain degree of flexibility.

3.2.2 *unsheathed cable :* Assembly of more than five insulated conductors held together.

3.3 **type test** : The type test of a product is the complete series of tests to be carried out on a number of specimens representative of the type, with the object of determining whether a particular manufacturer can be considered to be able to produce products meeting the specification.

3.4 **acceptance tests** : Tests carried out on samples for the purpose of the acceptance of a lot.

3.5 **lot** : All low-frequency cables of the same type, category and rating manufactured from the same materials under essentially similar conditions of production shall constitute a lot.

4 DESIGNATION

A solid conductor is designated by its nominal diameter. A stranded conductor is designated by its nominal cross sectional area and its make-up is indicated by the number and diameter of wires.

5 REQUIREMENTS

5.1 Conductor

5.1.1 *Material construction and finish*

All conductor wires shall be circular in cross section and shall consist of annealed copper, smoothly drawn, uniform quality, free from defects.

The conductors may be either plain or uniformly coated with pure tin. The properties of the copper used for wires shall be in accordance with **IEC 28.**

Normally the conductor shall be drawn in one piece. In cases of necessity, joints in the conductor are permitted provided that the tensile strength of a joint shall be not less than 85 per cent of the tensile strength of the unjointed conductor.

5.1.2 *Dimensions*

The conductor dimensions shall conform to the requirements of the relevant part of this standard.

5.2 Insulation

5.2.1 *Material and application*

The insulation shall consist of Polyvinyl Chloride (PVC) complying with the requirements of **BS 6746.** 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, to the conductor or to the tinning if any. The stripping properties of insulation shall be cheked by means of a normal stripping pliers.

In particular cases, however, for example where wires are to be used employing wire wrapping techniques, or 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.

5.2.2 *Thickness*

The insulation shall be perfectly continuous having a thickness as uniform as possible and not less than the value specified in the relevant part of the standard, when measured in accordance with 7.3.2.1.

5.2.3 *Colour*

The insulated conductors shall be coloured by one colour or by two different colours. Colours shall correspond reasonably with the standard colours shown in **IEC 304**.

Colour fastness to daylight, checked according to **ISO 105** , shall be rated at not less than standard 4, prolonging the exposure until the contrast is equivalent to grade 4 on the grey scale.

When two colours are used, the following conditions shall be fulfilled.

a) markings shall be rings or helices; if helices, single helices are preferred, double helices however are allowed, it may be made by helical bicolour extrusion.

b) markings printed or painted on the insulation shall adhere satisfactorily;

c) markings shall be easily identifiable within any 15 mm length of the insulated conductor;

d) the distance of re petition of the markings shall be not less than 4 mm measured from centre to centre parallel to the axis; and

e) the width of the rings or helices and the width of their spacing measured parallel to the axis, shall be approximately constant and shall be not less than 1.5 mm, the width of the rings or helices need not be the same as that of the spacing.

5.3 Equipment wires and cabling elements

Equipment wires and cabling elements shall be one of the following:

a) a single insulated conductor;

b) two insulated conductors uniformly twisted together to form a pair;

c) three insulated conductors uniformly twisted together to form a triple;

d) four insulated conductors uniformly twisted together to form a quad; and

e) five insulated conductors uniformly twisted together to form a quintuple.

The maximum length of lay in the completed wire or cable shall be :

100 mm for pairs and triples
120 mm for quads and quintuple.

5.4 Lay-up of cabling elements

5.4.1 The cabling elements shall be laid up to form a compact and circular cable.

5.4.1.1 The colours of the wires in the various sizes of cable shall be as specified in the relevant part of this standard.

5.4.1.2 The sequence of stranding shall be as specified in the relevant part of the series of this specification, the first element being in the centre.

5.5 Fillers and binders

5.5.1 Fillers made of non-hygroscopic material may be provided at the discretion of the manufacturer unless otherwise specified in the relevant part of the series of this specification.

5.5.2 Binders shall be provided as specified in the relevant part of the series of this specification and shall be applied by one of the following methods:

a) a single lapping tape having an overlap of not less than 20 per cent;

b) two tapes breaking joint (see Note);

c) one tape applied longitudinally with an overlap of not less than 10 mm or 30 per cent of the tape width, whichever is the smaller; or

d) a single whipping of non-hygroscopic material.

NOTE - This means two layers of tape having the same direction of lay, applied helically so that the outer tape is approximately central over the gap of inner tape.

5.6 Screens

5.6.1 Screens shall be of braided, lapped or taped construction as specified in the relevant part of the series of this specification and shall conform to the requirement in 5.6.1.1.

The braided screens and lapped screens shall be formed of tinned annealed copper as required. The nominal diameter of the individual screen wires shall be as specified in the relevant part of the series of this specification.

5.6.1.1 Braided screens

The braided screen shall be close fitting but wherever the cable or wire is cut it shall be possible to slide back the screen by hand distance of 100 mm on a 600 mm length of cable or wire, the other end of which shall be clamped during the test.

Where a break in a screen wire occurs, or renewal of a bobbin is necessary, the loose ends of screen wire shall be soldered or tucked out of the braid. There shall be not more than one such break or renewal in any 25 mm length of braid.

The complete screen shall not be joined.

Braid construction shall be as follows :

ends per spindle (minimum)	3
filling factor (minimum) :	
for individual screens	0.5
for collective screens	0.7

limiting factor (maximum), when specified 0.09

where the following definitions apply:

Filling factor (K_f) is defined as : $$\frac{mnd}{2\pi D}\left[1+\frac{\pi^2 D^2}{L^2}\right]^{1/2}$$

$$\text{Limiting factor} = K_f - \frac{mnd}{2\pi D}$$

D = mean diameter of braid in millimetres;
d = nominal diameter of braid wire in millimetres;
L = lay of braid wire in millimetres;
m = total number of spindless;
n = total number of ends per spindle.
π = 3.14

5.6.1.2 Lapped screens

The lapped screen shall consist of a close lapping of at least sixteen wires laid beside. The filling factor defined as:

$$\frac{N\ d}{\pi\ D} \times \left[1 + \frac{\pi^2\ D^2}{L^2} \right]^{1/2}$$

shall be not less than 0.9 where N = the total number of wires.

5.6.1.3 Taped screens

The taped screen shall be formed of aluminium or copper tape an approved laminated tape as required. The tape shall be as specified in the relevant part of the series of this specification.

The thickness of tape shall be at least 0.04 mm unless otherwise specified in the relevant part of the series of this specification.

A continuity conductor consisting of tinned annealed copper of suitable diameter shall be provided unless specifically excluded in the relevant part of the series of this specification. This conductor shall be laid longitudinally in contact with the screening tape.

5.7 Rip cords

A rip cord shall be laid under the sheath when specified in the relevant part of the series of this specification. The rip cord shall be non-metallic and may incorporate the manufacturer's identification colours.

5.8 Sheath

5.8.1 *Material and application*

The sheath shall consist of PVC compound complying with the requirements of **BS 6746**. The type, thickness and overall diameter shall conform to the relevant part of the series of this specification; it shall also meet the requirements of resistance to flame propagation when tested as in 7.5.3. The thickness and overall diameter shall be determined as described in 7.3.2.1.

The sheath shall be perfectly continuous, annular and of a thickness as uniform as possible. It shall be applied to fit closely over the cable or screened wire without adhesion.

5.8.2 The colour of the sheath shall be grey or cream as specified by the purchaser.

6 PACKING AND MARKING

6.1 The wires or cables shall be either wound on reels or drums or coiled, and packed and labelled.

6.2 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 dimensions of the conductor of wire or cable;

c) Type of wire or cable contained in the coil, reel or drum;

d) Number of cores;

e) Length of wire or cable contained in the coil, reel or drum;

f) Country of manufacture; and

g) Any other information as agreed between the purchaser and the manufacturer.

6.3 The means of identifying the manufacturer shall be provided on the cable when required by the relevant part of the series of this specification. This may be done by name tapes.

NOTE - The continuous length of wire or cable shall be 100 m or as agreed between the purchaser and the manufacturer.

7 TESTS

7.1 Standard conditions for testing

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

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

7.2 Classification of tests

7.2.1 *Type tests*

Schedule of type tests is given in the Appendix A.

7.2.2 *Acceptance tests*

Tests on samples shall be carried out when specified by the purchaser at the time of ordering. The sampling procedure shall be agreed between the purchaser and the manufacturer, or as given in Appendix B.

7.3 Dimensions

7.3.1 *Selection and preparation of samples*

7.3.1.1 Insulation

Samples of insulated conductors, approximately 100 mm in length, shall be taken at both ends of the cable or wire. One sample shall be taken at each end. Any covering(s) shall be removed from the insulation and the conductor withdrawn, care being taken not to damage the insulation. The insulation shall be cleanly cut at right angles to its longitudinal axis.

7.3.1.2 Sheath

Samples, approximately 100 mm in length, shall be taken from the finished cable at both ends. One sample shall be taken at each end. The insulated conductors, binding tapes and screening, if any, shall then be removed from the sheath, and the sample shall be cleanly cut at right angles to the axis of the cable.

NOTE *- If there is any marking on the sheath, the samples selected shall bear this marking.*

7.3.1.3 Finished cable or wire

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

7.3.2 *Measurement of dimensions*

7.3.2.1 Minimum thickness of insulation or sheath

Both samples shall be measured. The prepared sample shall be placed under a measuring microscope with the plane of the cut at right angles to the optical axis.

A micrometer applying a pressure of between 50 kPa and 80 kPa can also be used for measurement of samples of the sheath.

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.*

7.3.2.2 Diameter of finished cable or wire

Both samples shall be measured. For cables or wires with a diameter of 10 mm or more, the external circumference of the samples shall be measured by means of thin measuring tape. The tape may be graduated in millimetres of diameter or in millimetres of circumference, the value of being taken as 3.14. The tape shall be wound round the sample for one complete turn. In case of dispute on the measured diameter,the force exerted on the tape shall be as close as possible to 2.5 N.

For cables and wires with a diameter up to 10 mm, 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 or the wire is a sliding fit between the anvils.

The value of the diameter measured with the tape, or the mean of the two values measured with the micrometer, shall be rounded off to the nearest tenth of a millimetre.

7.3.2.3 Mean thickness of insulation or sheath

The prepared 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 or of the sheath 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 or of the sheath.

NOTE *- This measurement enables one of the factors occurring in the calculation of the cross-sectional area of the insulation or of the sheath to be determined. It shall be made on samples selected, marked and prepared for the tensile tests. (see 7.4.2.1)*

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

7.4 Mechanical tests

The mechanical qualities of the various parts of the cable or wire are determined by tensile tests on samples of the solid copper conductors and samples of the insulation and sheath as delivered and after accelerated ageing. (see 7.5.1)

The stripping properties of the insulation shall also be checked.

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

7.4.1.1 Conductors

Solid conductors only shall be subjected to the tensile tests. amples of convenient length shall be taken at the ends of the cable or wire.

7.4.1.2 Insulation

Samples of insulated conductors shall be taken at both ends 'a' and 'b' of the cable or wire. 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

Any covering(s) shall be removed from the insulation.

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 7.4.2.1) 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.

7.4.1.3 Sheath

One sample shall be taken from the cable as delivered at both ends a and b of the cable.

Three test specimens, approximately 100 mm in length, shall be taken from each sample and marked in the following order:

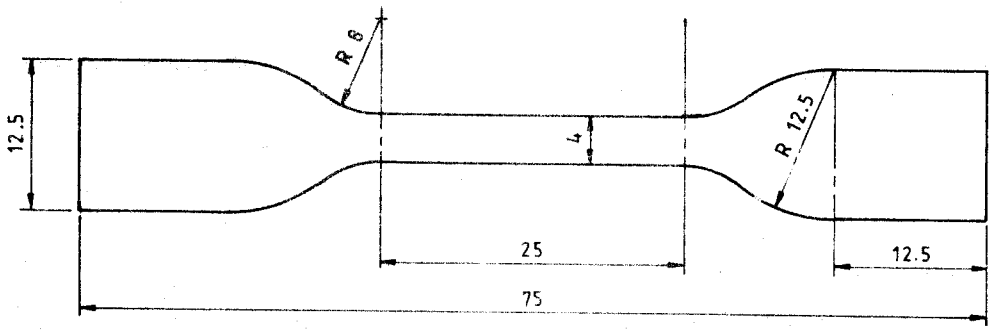
a_1 a_2 a_3

b_4 b_5 b_6

If necessary, the sheath shall be cut open in the direction of the ridges caused by the core, if there are such ridges. The insulated conductors, binding tapes, screening, if any, etc. shall be removed from the sheath.

The sheath shall be ground, if necessary, to obtain two flat and parallel surfaces, care being taken to avoid under heating.

If the mean diameter over the sheath is more than 12 mm, a test strip according to Figure 1, shall be punched from each specimen.



Dimensions in millimetres

Figure 1 - Test strip

The cross-sectional area of the test specimens shall be determined (see 7.4.2.2) and a length of 20 mm then marked centrally on the specimens 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.

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

The cross-sectional area of the samples shall be determined by one or other of the methods described below.

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

7.4.2.1 Insulation

a) Method A

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

$$S = \pi (d + i) i$$

where,

i = mean thickness of the insulation in millimetres, measured as described under 7.3.2.3

d = nominal diameter of the conductor in millimetres, given in the relevant part of the series of this specification; and

π = 3.14

b) Method B

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

$$S = \pi (D - i) i$$

where,

i = mean thickness of the insulation, in millimetres, as described under 7.3.2.3;

D = diameter of the insulated conductor in millimetres, measured as described under 7.3.2.2 for wires with a diameter up to 10 mm, the mean of the two values measured with the micrometer being rounded off to the nearest one hundredth millimetre; and

π = 3.14.

7.4.2.2 Sheath

a) Method A

If the mean diameter over the sheath does not exceed 12 mm, the cross-sectional are S of the sheath shall be determined in square millimetres on the test specimen using the formula:

$$S = \frac{V}{I}$$

where,

V = volume of the test specimen in cubic millimetres, ascertained by immersion in alcohol of 96 per cent purity contained in a measuring glass calibrated at 27°C; and,

I = length of the test specimen in millimetres.

b) Method B

If the mean diameter over the sheath does not exceed 12 mm, the cross-sectional area S of the sheath shall be determined in square millimetres on the test specimens using the formula:

$$S = \pi (D - i)\, i$$

where,

i = mean thickness of the sheath in millimetres, measured as described under 7.3.2.3.

D = diameter of cable over the sheath in millimetres, measured as described under 7.3.2.2 ; and

π = 3.14

c) Method C

If the mean diameter over the sheath is more than 12 mm, the thickness of the test strip (Figure 1) shall be measured by means of a micrometer or the like, applying a pressure between 50 KPa and 80 kPa.

The cross-sectional area of the test strip shall be determined in square millimetres from the smallest width and the measured thickness.

7.4.3 *Tensile test*

The tensile test shall be carried out after the test specimens have been conditioned at a temperature of 27 ± 1°C for at least 10 hours; the test shall be started within 5 minutes after removing from the 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 and the sheath.

The speed of the tensile machine shall be about 100 mm/min for conductors and between 250 mm/min 350 mm/min for insulation and sheath.

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.

7.5 **Thermal stability and climatic tests**

7.5.1 *Accelerated ageing*

The object of accelerated ageing is to condition the samples of insulation and sheath 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 and sheath (with conductor in the case of insulation) shall be suspended freely in a hot-air oven with natural circulation of air. They shall be kept for 7 x 24 hours at a temperature of 80 ± 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.

7.5.2 *Pressure test*

The object of this test is to determine the extent to which the cable sheath can withstand deformation when the cable is subjected to moderately high temperatures under mechanical pressure.

A piece of finished cable, approximately 100 mm in length, shall be taken at each end of the cable.

A strip shall be cut from the sheath; if the sheath shows ridges caused by the core, the strip shall be cut in the direction of the ridges so that it contains at least one groove throughout its length. The width of the strip shall correspond to approximately one third of the circumference of the sheath.

The strip shall be placed on a horizontal cylindrical metal pin having approximately the diameter of the cable under the sheath.

The strip on the pin shall be placed in an oven and kept for 16 hours at a temperature of 80 ± 2°C.

A load in accordance with the Table 1 shall then be applied by means of the test apparatus illustrated in Figure 2. The blade in contact with the strip shall be placed perpendicularly to the axis of the pin.

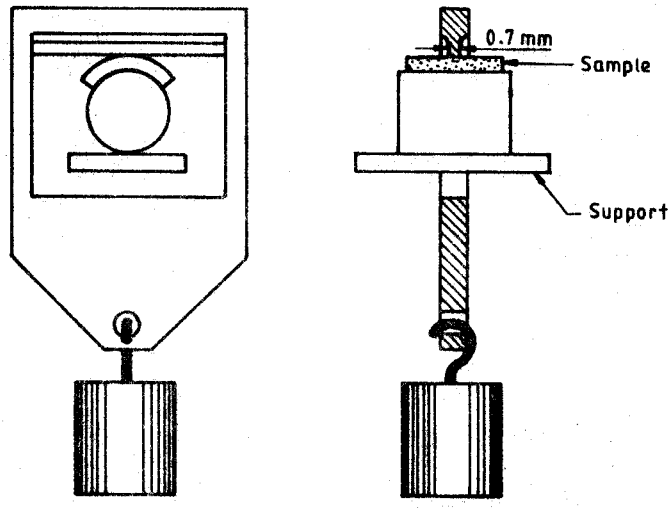


FIGURE 2 - Apparatus for pressure test at high temperature

TABLE 1 - Cable diameters with corresponding loads for pressure test

Mean diameter of cable over sheath mm (See 7.3.2.2)			Load N
Up to and including		6	2.5
Over 6 up to and including		8	3.0
Over 8 "	"	10	3.5
Over 10 "	"	12	4.0
Over 12 "	"	15	4.5
Over 15 "	"	19	5.0
Over 19 "	"	23	5.5
Over 23 "	"	28	6.0
Over 28 "	"	35	6.5
Over 35			7.0

The apparatus, with the strip in position, shall be maintained in this condition in the oven for 4 hours.

The strip shall then be removed from the oven and apparatus, and cooled within 10 seconds by immersion in cold water.

The thickness of the sheath shall be measured at the point of impression, and at points about 10 mm away on both sides of the impression, by means of a measuring microscope. The mean value of these last two measurements shall be calculated and compared with the thickness at the point of impression to determine the percentage deformation.

7.5.3 *Resistance to flame propagation*

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

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

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 Liquified Petroleum gas.

With the burner in the vertical position, the flame shall be adjusted to an overall length of 100 mm and a cone length of 50 mm.

The burner shall then be supported with its axis at an angle of 45° to the vertical. The sample shall be held at an angle of 45° 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 1 minute.

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.

7.5.4 *Cold bend test*

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

7.5.4.1 Insulation

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

The samples, stripped of their covering(s), if any,shall be placed for 2 hours in a chamber cooled to - 10 ± 1 °C. 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 insulated conductor. The mean overall diameter of the insulated conductor may be calculated from the nominal diameter of the conductur plus twice the mean thickness of the insulation, measured as described in 7.3.2.3.

The rate of winding shall be approximately one turn per second.

The samples shall than be examined with the naked eye.

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

7.5.4.2 Sheath

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

The samples shall be be placed for 16 hours in a chamber cooled to -10 ± 1 °C. Without removing them from the chamber, they shall be wound helically for three complete contiguous turns round a mandrel having the same temperature.

The diameter of mandrel is specified as a function of the diameter over the sheath of the cable in Table 2.

TABLE 2 - Cable diameters with corresponding mandrel diameters for cold bend test

Diameter of cable over sheath mm (See 7.3.2.2)	Mandrel diameter mm
Up to and including 10	20
Over 10 up to and including 12	40
Over 12 " " 15	65
Over 15 " " 19	100
Over 19 " " 23	140
Over 23 " " 28	180
Over 28 " " 35	300
Over 35	500

The rate of winding shall approximately be one turn per 5 seconds.

The samples shall then be examined with the naked eye.

The sheath shall remain adequately pliable at - 10 °C and show no cracks.

7.5.5 *Heat shock test*

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

7.5.5.1 Insulation

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

Thw samples, stripped of their covering(s), if any, shall be wound helically for three complete contiguous turns round a mandrel of diameter as specified, in 7.5.4.1.

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 ± 2 °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.

7.5.5.2 Sheath

From each of two samples, taken from the two ends of the cable, a test speciman, 4 mm wide and of convenient length, shall be cut from the sheath in the direction of the axis of the cable.

Each test specimen shall be wound helically for six complete contiguous turns round a mandrel of diameter as specified in Table 3.

TABLE 3 - Sheath thickness with corresponding mandrel diameter for heat shock test

Minimum thickness of the sheath mm	**Mandrel diameter mm**
Up to and including 1	5
More than 1	10

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 ± 2 °C for 1 hour.

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

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

7.5.6 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 insulated conductor, approximately 150 mm in length, shall be subjected to the following test :

Each sample shall be stripped of its covering(s) if any and made as straight as possible. A length of 100 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 15 minutes. 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.

7.5.7 *Solder test on tinned conductors*

The object of this test is to determine the extent to which the tin coatings of the conductors permits easy soldering.

Compliance shall be checked by the solder bath method as follows:

7.5.7.1 Description of solder bath

The solder bath shall be of sufficient volume to ensure that the temperature of the solder remains uniform when introducing the conductor. It shall be provided with means of maintaining the temperature of the solder at the temperature specified in 7.5.7.2.

Precautions shall be taken to ensure uniformity of temperature throughout the mass of the solder within the limits specified in 7.5.7.2.

The exposed area of the surface of the solder shall be reduced as far as possible by the use of a sheet of asbestos so that the conductor shall not be heated by direct radiation from the both.

7.5.7.2 Procedure

The temperature of the solder bath shall be 270 ± 10 °C. The surface of the bath shall be kept clean and bright and immediately before the immersion of the conductor a piece of solder shall be dropped into the middle of the bath. This solder, approximately 12 mm long and 1.6 mm diameter, shall be of 60/40 tin-lead alloy with a non-activated resin core. No other flux shall be used for this test.

NOTE - The term "non-activated" is intended to mean "pure wood resin, grade WW". Although widely known as "water white", it is actually a clear pale amber colour.

As soon as the added solder has melted, the stripped end of the conductor shall be immersed to a length of 10 mm in the direction of its longitudinal axis into the bath. The duration of the immersion shall be 2 ± 0.5 seconds.

The conductors shall then be examined for tinning.

Good tining shall be evident by free flowing of the solder with wetting of the conductor ends.

7.6 Electrical test

7.6.1 *Electrical resistance of conductors*

The electrical resistance shall be measured on the finished cable or wire 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 expressed in ohm/kilometre, shall be referred to the standard temperature of 27°C.

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

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

In this formula, t is the temperature in celsius degrees at which the measurement is made.

The resistahce shall not exceed the value specified in the relevant part of the series of this specification.

NOTE - To correct the value proportionately to the length, the measured resistance shall be multiplied by the factor i/L (L being the length of the cable in kilomtres).

7.6.2 *Dielectric strength*

This test shall be carried out before the measurement of insulation resistance described in 7.6.3.

The dielectric strength of the insulation shall be checked on the finished cable or on a sample of wire. The test voltage may be either d.c. or a.c. In the latter case, the waveform shall be approximately sinusoidal. The frequency shall be between 40 Hz, and 60 Hz and the voltage to be taken into consideration shall be expressed as an r.m.s. value.

The value of the test voltage and the duration of application shall be specified in the relevant part of the series of this specification.

A protective resistance of adequately high value shall be connected in the circuit supplying the test voltage to the sample under test.

7.6.2.1 Wires

a) Unscreened wires

A sample of the finished wire, approximately 10 m in lenght, shall be wound helically in contiguous turns round a metallic mandrel of 100 mm diameter. The force exerted on the wire during winding shall be not less than 5 N. The mandrel shall then be immersed in water.

The voltage shall be applied gradually and consecutively between each conductor and water in which the mandrel is immersed and all others connected to the mandrel.

The full voltage shall be maintained for the specified period.

b) Screened wires

A sample of the finished wire, approximately 10 m in length, shall be wound in a coil, the diameter of which is approximately the usual diameter of delivery coils.

The screen and the insulation shall then be removed for a length of at least 50 mm at each end of the sample. The ends of the screen shall be carefully pushed back from the ends of the conductors and be maintained in this position with tape.

The voltage shall be applied gradually and consecutively between each conductor and all others connected to the screen.

NOTE - If the insulated conductors are individually screened, the screens shall be connected together.

The full voltage shall be maintained in dry state for the specified period.

7.6.2.2 Cables

The test shall be carried out on complete lengths of the finished cable.

The voltage shall be applied gradually and consecutively :

a) between any conductor and all others plus the screen, if any, connected to earth, if the cabling element is a single wire;

b) between either group and the other group connected to earth if the cabling element is a pair (a group is all conductors a connected together, or all conductors b connected together);the screen if any, shall be connected in turn to the earthed group;

c) between any group and the other two groups connected to earth, if the cabling element is a triple (a group is considered to be all conductor a coonected together, or all conductors b connected together, or all conductors c connected together); the screen, if any, shall be connected to the two interconnected group;

d) between either group and the other group connected to earth, if the cabling element is a star quad (a group is all conductors a and b connected together, or all conductors c and d connected together); the screen, if any, shall be connected in turn to the earthed group ; and

e) between any group and the other groups connected to earth, if the cabling element is a quintuple ; the screen if any, shall be connected to the four interconnected groups.

The full voltage shall be maintained for the specified period.

The insulation resistance shall be not less than the value specified in the relevant part of the series of this specification.

7.6.3 *Insulation resistance*

This measurement shall be made after the dielectric strength test described in 7.6.2.

The insulation resistance shall be measured on the finished cable or on a sample of wire by means of a device capable of measuring accurately to within 10 per cent of the value to be determined.

The test voltage shall be between 200 V and 500 V d.c.

The measurement shall be carried out at a temperature of 27± 3°C; in case of dispute on the value of resistance, the measurement shall be repeated at 27 ± 1°C.

7.6.3.1 Wires

Unscreened wires

A sample of the finished wire, approximately 10 m in length, shall be wound helically in contiguous turns round a metallic mandrel of 100 mm diameter. The mandrel shall have been stored during the previous 24 hours at the same temperature as the wire. The force exerted on the wire during winding shall not less than 5 N. Then the mandrel shall be immersed in water for a period not less than one hour.

The insulation resistance shall be measured after one minute's application of the test voltage, consecutively between each conductor and all others connected to the mnandrel.

Screened wires

A sample of the finished wire, approximatelyy 10 m in length, shall be wound in a coil, the diameter of which is approximately the usual diameter of delivery coils.

The screen and the insulation shall then be removed for a length of at least 50 mm at each end of the sample. The ends of the screen shall be carefully pushed back from the ends of the conductors and maintained in this position with tape.

The insulation resistance shall be measured in dry state after one minute's application of the test voltage, consecutively between each conductor and all others connected to the screen.

NOTE *- If the insulated conductors are individually screened, the screens shall be connected together.*

7.6.3.2 Cables

Insulation resistance measurements on the completed cable shall be made with not less than 500 V d.c. After steady electrification for one minute the insulation shall be measured between each conductor in the cable and the remaining conductors connected together. The value of insulation resistance shall be not less than 50 M for 1000 m at 27 $\pm$ 3°C. The manufacturer may group the cores in any convenient manner for this test.

7.6.4 *Mutual capacitance*

The mutual capacitance shall be measured on the finished cable by means of a device capable of measuring accurately to within 1 per cent of the value to be determined.

The measurement shall be carried out with alternating current at a frequency between 500 Hz and 2000 Hz.

No measurement shall be made on cables where the cabling element is a single wire.

For cables in pairs or triples, the mutual capacitance shall be measured on a certain number of elements between wire a and wire b and, all the remaining conductors being connected together and to the screen, if any.

For cables in quads or quintuples, the mutual capacitance shall be measured on a certain number of elements between wire a and wire b and, if required, between wire c and wire d all other conductors being connected together and to the screen, if any.

The measured capacitance shall be corrected proportionately to the length, and expressed in nanofarads per kilometre.

The capacitance shall be complied with the value specified in the relevant part of the series of this specification.

7.6.5 *Capacitance unbalance*

The capacitance unbalance shall be measured on the finished cable by means of a device capable of measuring accurately to within 5 pf ± 5 % of the value to be determined.

The measurement shall be carried out with alternating current at a frequency between 500 Hz and 2,000 Hz.

For cables in pairs or triples, the capacitance unbalance shall be measured between different pairs. For cables in quads or quintuples, the capacitance unbalance shall be measured between the pairs a b of different cabling elements and, if required, between the two pairs a b and c d of the same element. Adjacent cabling elements shall be selected for at least two thirds of the tests.

The capacitance unbalance shall be expressed in picofarads per 500 m length of cable.

If the tested cable has a length L other than 500 m, the measuured value shall be multiplied by a correction factor of 500/L.

Lengths of less than 100 m shall be considered as equal to 100 m.

The capacitance shall be complied with the value specified in the relevant part of the series of this specification.

APPENDIX A

SCHEDULE OF TYPE TESTS

Some or all of these tests may be repeacted from time to time on samples drawn from current production to confirm that the quality of the product still conforms to the requirements of this specification. Failure in the later tests may show defects in design not apparent in the original tests, or may merely indicate defects in production which need to be corrected.

Test	
A.1 Dimensions	
a) Minimum thickness of insulation or sheath	7.3.2.1
b) Diameter of finished cable or wire	7.3.2.2
A.2 Mechanical tests	
Tensils test	7.4.3
A.3 Thermal stability and climatic tests	
a) Accelerated ageing	7.5.1
b) Pressure test	7.5.2
c) Resistance to flame propagation	7.5.3
d) Cold bend test	7.5.4
e) Heat shock test	7.5.5
f) Measurement of insulation shrinkage after overheating of conductor	7.5.6
g) Solder test on tinned conductors	7.5.7
A.4 Electrical tests	
a) Electrical resistance of conductors	7.6.1
b) Dielectric strength	7.6.2
c) Insulation resistance	7.6.3
d) Mutual capacitance	7.6.4
e) Capacitance unbalance	7.6.5

APPENDIX B

SCALE OF SAMPLING AND CRITERIA FOR ACCEPTANCE OF A LOT

B.1 Scale for sampling

B.1.1 Samples shall be taken from each lot to ascertain its conformity to the requirments of this specification.

B.1.2 The number of reels, drums or coils to be selected from a lot shall be in accordance with column 1 and column 2 of Table 4.

TABLE 4 - Scale of sampling

Number of reels or drums or coils in the lot	Number of reels or drums or coils to be selected	Sub sample size (reels)	Acceptance number
1	2	3	4
Up to 50	5	3	0
51 to 100	8	5	0
101 to 150	13	5	1
151 and above	20	8	2

B.1.3 Reels, drums or coils shall be selected at random. In order to ensure randomness of selection, random umber Tables as given in SLS 428 shall be used.

B.2 Number of tests

B.2.1 Each reel or drum or coil selected as in B.1.2 shall be inspected for marking requirements.

B.2.2 Each reel or drum or coil selected as in B.1.2 shall be tested for dimensions (The required test pieces to carry out these tests shall be obtained in accordance with relevant test methods).

B.2.3 A sub sample of size as given in column 3 of Table 4 shall be taken from the sample selected as in B.1.2 and shall be subjected to Cold bend test, Heat shock test and electrical test.

B.3 Criteria for conformity

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

B.3.1 Each reel or drum or coil inspected as in B.2.1 satisfies the marking requirements.

B.3.2 The number of reels or drums or coils not conforming to any one or more requirements when tested as in B.2.2 is less than or equal to the corresponding acceptance number given in column 4 of Table 4.

B.3.3 The reels, or drums or coils tested for stability tests, elimatic test and electrical tests as in B.2.3 satisfy the relevant requirements.

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