SRI LANKA STANDARD 695: 2007
UDC 621.315.2/.5

SPECIFICATION FOR

CONDUCTORS IN INSULATED CABLES AND CORDS
(SECOND REVISION)

SRI LANKA STANDARDS INSTITUTION

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(SECOND REVISION)

SLS 695 : 2007

(Corrigendum 01 incorporated)

Gr. 12

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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.

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FOREWORD

This standard was approved by the Sectoral Committee on Electric cables and conductors and was authorized for adoption and publication as a Sri Lanka Standard by the Council of the Sri Lanka Standards Institution on 2007-11-27.

This is the Second revision of **SLS 695**. In this revision conductor material "aluminium or aluminium alloy" is introduced in place of "plain aluminium".

Exact formulae for temperature correction factors are given in Appendix **A** and Appendix **B** prescribes, Guide to the dimensional limits of circular conductors and other subsidiary information. Appendix **A** is normative and Appendix **B** is informative.

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 result of a test or analysis, shall be rounded off in accordance with **CS 102**. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

In the preparation of this standard, the assistance derived from **BS 6360 : 1991**,incorporating Amd. No 1: 1991, Amd: No.2: 1993, Amd. No. 3:1995 and Amd No.4 : 2005 : Specification for conductors in insulated cables and cords, is gratefully acknowledged.

SRI LANKA STANDARD
SPECIFICATION FOR CONDUCTORS IN INSULATED CABLES AND CORDS
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1 SCOPE

This standard specifies the nominal cross-sectional areas and requirements, including numbers and sizes of wires and resistance values, for conductors in electric cables and cords of a wide range of types. These conductors include solid and stranded copper and aluminium conductors in cables for fixed installations and flexible copper conductors.

The applicability of this standard to a particular type of cable is as specified in the standard for the type of cable. It does not apply, for example, to conductors for telecommunication purposes, and for some cables, for example flexible cables having the cores twisted together with unusually short lays, where the requirements specified for the class of conductors apply only in part.

2 REFERENCES

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60228	:	Conductors of insulated cables
SLS 978	:	Tensile testing of metallic materials Part 1 : Methods of test at ambient temperature
SLS 1125	:	Specification for wrought aluminium for electrical purposes – Solid conductors for insulated cables
SLS 1127	:	Specification for wrought aluminium for electrical purposes – wire

3 DEFINITIONS

For the purposes of this standard the following definition shall apply.
3.1 metal-coated : Coated with a thin layer of metal, such as tin, tin alloy or lead alloy.

4 CLASSIFICATION

The conductors have been divided into four Classes Class 1, Class 2, Class 5 and Class 6. Those in Class 1 and Class 2 are intended for use in cables for fixed installations, Class 1 being solid conductors and Class 2 stranded conductors. Class 5 and Class 6 are intended for use in flexible cables and cords, Class 6 being more flexible than Class 5.

5 MATERIALS

5.1 Introduction

The conductors shall consist of one of the following :

a) plain or metal-coated annealed copper;
b) plain or metal-coated hard-drawn copper;
c) aluminium or aluminium alloy;

as specified for the different type of conductors in **5.2, 5.3, 6** and **7**.

NOTE : *To avoid a proliferation of different resistance values for aluminium and aluminium alloy conductors, the same values are quoted for all types. To achieve this standardization of resistance, there may be a variation in wire sizes used for the same nominal cross-sectional areas according to the particular material used.*

5.2 Solid aluminium conductors

Circular and shaped solid aluminium conductors of nominal cross-sectional area 50 mm^2 and above, and all sectoral circular aluminium conductors, shall be made from aluminium of material as specified in **SLS 1125**.

Circular and shaped solid aluminium conductors of nominal cross-sectional area 35 mm^2 and below shall be made from aluminium of material as specified in **SLS 1125** or, at the option of the manufacturer, from material as specified in **SLS 1127,** the tensile strength of which shall not exceed the maximum specified for materials in the conditions as follows:

a) Up to and including 16 mm^2, H6; and
b) 25 mm^2 and 35 mm^2, H4

5.3 Stranded aluminium conductors in annealed condition

Stranded aluminium conductors shall be made from aluminium material as specified in **SLS 1127.** For nominal cross-sectional area 16 mm^2 and above the material shall be in the H68 condition; for nominal cross-sectional areas 10 mm^2 and below, the tensile strength shall not exceed the maximum specified for material in the H68 condition.

5.3.1 Stranded aluminium conductors in hard drawn condition

These conductors are of cross sectional area 10 mm^2 and above and the conductors shall be in the H9 condition as specified in **SLS 1127.**

6 CONDUCTORS FOR FIXED INSTALLATIONS

6.1 Solid conductors (Class 1)

6.1.1 Solid conductors (Class 1) shall consist of one of the following:

a) plain or metal-coated annealed copper;
b) plain or metal-coated hard-drawn copper;
c) aluminium or aluminium alloy.

6.1.2 Solid copper conductors shall be of circular cross section.

NOTE: *The solid copper conductors having nominal cross-sectional areas of 25 mm^2 and above are examples of conductors for particular types of cable and not for general purposes.*

6.1.3 Solid aluminium conductors of sizes up to and including 16 mm^2 shall be of circular cross section. Sizes from 25 mm^2 up to 300 mm^2 shall be of circular cross section for single –core cables and shall be of either circular or shaped cross section for multicore cables.

Sizes above 300 mm^2 for single- core cables shall be circular sectoral comprising four solid sectors, each of the shape appropriate for a four- core cable, laid up together and suitably bound.

NOTE: *These conductors are known as sectoral conductors and are available in the conductor sizes of 380 mm^2 and above shown in Table* **1.**

Compliance with the requirements of **6.1.1** to **6.1.3** shall be checked by inspection and measurement where practicable.

6.1.4 The resistance of each conductor at 20 ^{o}C, when determined in accordance with Appendix **A**, shall not exceed the appropriate maximum value given in Table **1**.

6.2 Stranded circular non-compacted conductors (Class 2)

6.2.1 Stranded circular non-compacted conductors (Class 2) shall consist of one of the following:

a) plain or metal-coated annealed copper;
b) plain or metal-coated hard-drawn copper;
c) aluminium or aluminium alloy.

Stranded aluminium conductors shall normally have a cross-sectional area not less than 10 mm^2 but 4 mm^2 and 6 mm^2 may be used subject to the special consideration of the suitability of the conductor for the type of cable and its applications.

6.2.2 The wires in each conductors shall all have the same nominal diameter.

6.2.3 The number of wires in each conductor shall be not less than the appropriate minimum number given in Table **2**. The minimum numbers of wires are not specified for cross-sectional areas, from 1200 mm^2 to 2 000 mm^2.

Compliance with the requirements of **6.2.1** to **6.2.3** shall be checked by inspection and measurement where practicable.

6.2.4 The resistance of each conductor at 20 ^{o}C, when determined in accordance with Appendix **A**, shall not exceed the appropriate maximum value given in Table **2**.

TABLE 1 – Class 1 solid conductors for single-core and multicore cables

Nominal Cross-sectional area mm^2	**Maximum resistance of conductor at 20 ^oC**		
	Circular, annealed copper conductors*		**Aluminium conductors, circular or shaped Ω/km**
	Plain Ω/km	**Metal-coated Ω/km**	
(1)	**(2)**	**(3)**	**(4)**
0.5	36.0	36.7	-
0.75	24.5	24.8	-
1	18.1	18.2	-
1.5	12.1	12.2	18.1**
2.5	7.41	7.56	12.1**
4	4.61	4.70	7.41**
6	3.08	3.11	4.61**
10	1.83	1.84	3.08**
16	1.15	1.16	1.91**
25	0.727***	-	1.20
35	0.524***	-	0.868
50	0.387***	-	0.641
70	0.268***	-	0.443
95	0.193***	-	0.320
120	0.153***	-	0.253
150	0.124***	-	0.206
185	0.101***	-	0.164
240	0.0775***	-	0.125
300	0.0620***	-	0.100
380 (4 x 95)	-	-	0.0800
400	0.0465***	-	0.0778
480 (4 x 120)	-	-	0.0633
500	-	-	0.0605
600 (4 x 150)	-	-	0.0515
630	-	-	0.0469
740 (4 x 185)	-	-	0.0410
800	-	-	0.0367
960 (4 x 240)	-	-	0.313
1000	-	-	0.0291
1200 (4 x 300)	-	-	0.250

* To obtain the maximum resistance of hard-drawn conductors the values in Column **2** and Column **3** should be divided by 0.97.

** Aluminium conductors 1.5 mm^2 to 16 mm^2 circular only (see **6.1.3**)

*** See **6.1.2**

TABLE 2 – Class 2 stranded conductors for single core and multicore cables

Nominal cross-sectional area	Minimum number of wires in the conductor						Maximum resistance of conductor at 20 °C		
	Circular conductor		Circular compacted conductor		Shaped conductor		Annealed copper conductor*		Aluminium conductor
	Cu	Al	Cu	Al	Cu	Al	Plain wires	Metal coated wires	
mm²							Ω/km	Ω/km	Ω/km
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0.5	7	-	-	-	-	-	36.0	36.7	-
0.75	7	-	-	-	-	-	24.5	24.8	-
1	7	-	-	-	-	-	18.1	18.2	-
1.5	7	-	6	-	-	-	12.1	12.2	-
2.5	7	-	6	-	-	-	7.41	7.56	-
4	7	7**	6	-	-	-	4.61	4.70	7.41
6	7	7**	6	-	-	-	3.08	3.11	4.61
10	7	7	6	-	-	-	1.83	1.84	3.08
16	7	7	6	6	-	-	1.15	1.16	1.91
25	7	7	6	6	6	6	0.727	0.734	1.20
35	7	7	6	6	6	6	0.524	0.529	0.868
50	19	19	6	6	6	6	0.387	0.391	0.641
70	19	19	12	12	12	12	0.268	0.270	0.443
95	19	19	15	15	15	15	0.193	0.195	0.320
120	37	37	18	15	18	15	0.153	0.154	0.253
150	37	37	18	15	18	15	0.124	0.126	0.206
185	37	37	30	30	30	30	0.0991	0.100	0164
240	61	61	34	30	34	30	0.0754	0.0762	0.125
300	61	61	34	30	34	30	0.0601	0.0607	0.100
400	61	61	53	53	53	53	0.0470	0.0475	0.0778
500	61	61	53	53	53	53	0.0366	0.0369	0.0605
630	91	91	53	53	53	53	0.0283	0.0286	0.0469
800	91	91	53	53	-	-	0.0221	0.0224	0.0367
960(4x240)	Number of wires not specified						0.0189		0.0313
1000	91	91	53	53	-	-	0.0176	0.0177	0.0291
1200	Number of wires not specified				-	-	0.0151		0.0247
1400					-	-	0.0129		0.0212
1600					-	-	0.0113		0.0186
1800					-	-	0.0101		0.0165
2000					-	-	0.0090		0.0149
2500					-	-	0.0072		0.0127

* To obtain the maximum resistance of hard-drawn conductors the values in Column 8 and Column 9 should be divided by 0.97.

** See 6.2.1

6.3 Stranded compacted circular conductors and stranded shaped conductors (Class 2)

6.3.1 Stranded compacted circular conductors and stranded shaped conductors (Class 2) shall consists of :

a) plain or metal-coated annealed copper, or
b) plain aluminium

Stranded-compacted circular aluminium conductors shall have a nominal cross-sectional area not less than 16 mm^2. Stranded shaped copper or aluminium conductors shall have a nominal cross - sectional area not less than 25 mm^2.

6.3.2 The ratio of the diameters of two different wires in the same conductor shall not exceed 2.

6.3.3 The number of wires in each conductor, for nominal cross-sectional areas up to and including 1000 mm^2, shall be not less than the appropriate minimum given in Table **2**.

NOTE: *This requirement applies to conductors made with wires of circular cross section before compaction and not to conductors of non-harmonized cables made with preshaped wires.*

6.3.4 The 960 mm^2 conductor shall be either of Milliken construction or comprise four stranded sector shaped sections laid up together; sizes 1200 mm^2 and above shall be of Milliken construction or comprise a number of stranded shaped sections laid up together or be of concentric stranded construction.

Milliken conductors shall consist of a number of stranded shaped sections, with adjacent sections lightly insulated from one another, laid -up to give a substantially circular profile.

Compliance with the requirements of **6.3.1** to **6.3.4** shall be checked by inspection and measurement where practicable.

6.3.5 The resistance of each conductor at 20 ^{o}C when determined in accordance with Appendix **A,** shall not exceed the appropriate maximum value given in Table **2**.

7 FLEXIBLE CONDUCTORS (Class 5 and Class 6)

7.1 Flexible conductors (Class **5** and Class **6**) shall consist of plain or metal-coated annealed copper.
7.2 The wires in each conductor shall all have the same nominal diameter.

7.3 The diameter of the wires in each conductor shall not exceed the appropriate maximum value given in Table **3** or Table **4**.
Compliance with the requirements of **7.1** to **7.3** shall be checked by inspection and measurement where practicable.

7.4 The resistance of each conductor at 20 ^{o}C when determined in accordance with Appendix **A**, shall not exceed the appropriate maximum value, given in Table **3** or Table **4.**

TABLE 3 – Class 5 flexible copper conductors for single- core and multicore cables

Nominal cross-sectional area mm^2	Maximum diameter of wires in conductor mm	Maximum resistance of conductor at 20 ^oC	
		Plain wires Ω/km	Metal-coated wires Ω/km
(1)	(2)	(3)	(4)
0.22	0.21	92.0	92.4
0.5	0.21	39.0	40.1
0.75	0.21	26.0	26.7
1	0.21	19.5	20.0
1.25	0.21	15.6	16.1
1.35	0.31	14.6	15.0
1.5	0.26	13.3	13.7
2.5	0.26	7.98	8.21
4	0.31	4.95	5.09
6	0.31	3.30	3.39
10	0.41	1.91	1.95
16	0.41	1.21	1.24
25	0.41	0.780	0.795
35	0.41	0.554	0.565
50	0.41	0.386	0.393
70	0.51	0.272	0.277
95	0.51	0.206	0.210
120	0.51	0.161	0.164
150	0.51	0.129	0.132
185	0.51	0.106	0.108
240	0.51	0.0801	0.0187
300	0.51	0.0641	0.0654
400	0.51	0.0486	0.0495
500	0.61	0.0384	0.0391
630	0.61	0.0287	0.0292

TABLE 4 – Class 6 flexible copper conductors for single-core and multicore cables

Nominal cross-sectional area mm^2	Maximum diameter of wires in conductors mm	Maximum resistance of conductor at 20 ^oC	
		Plain wires Ω/km	Metal-coated wires Ω/km
(1)	(2)	(3)	(4)
0.5	0.16	39.0	40.1
0.75	0.16	26.0	26.7
1	0.16	19.5	20.0
1. 5	0.16	13.3	13.7
2.5	0.16	7.98	8.21
4	0.16	4.95	5.09
6	0.21	3.30	3.39
10	0.21	1.91	1.95
16	0.21	1.21	1.24
25	0.21	0.780	0.795
35	0.21	0.554	0.565
50	0.31	0.386	0.393
70	0.31	0.272	0.277
95	0.31	0.206	0.210
120	0.31	0.161	0.164
150	0.31	0.129	0.132
185	0.41	0.106	0.108
240	0.41	0.0801	0.0817
300	0.41	0.0641	0.0654

TABLE 5 - Temperature correction factors

Temperature of conductor at time of measurement, t ^{o}C	Correction factor, k_t* All conductors
(1)	(2)
5	1.064
6	1.059
7	1.055
8	1.050
9	1.046
10	1.042
11	1.037
12	1.033
13	1.029
14	1.025
15	1.020
16	1.016
17	1.012
18	1.008
19	1.004
20	1.000
21	0.996
22	0.992
23	0.988
24	0.984
25	0.980
26	0.977
27	0.973
28	0.969
29	0.965
30	0.962
31	0.958
32	0.954
33	0.951
34	0.947
35	0.943
36	0.940
37	0.936
38	0.933
39	0.929
40	0.926

NOTE: *The values of correction factors k_t are based on a resistance-temperature coefficient of 0.004 per ^{o}C at 20 ^{o}C. The values of temperature correction factors specified in column 2 are approximate but give practical values well within the accuracies that can normally be achieved in the measurements of conductor temperature and length of cables or flexible cords.*

For more accurate values for the temperature correction factors for copper and aluminium, reference should be made to Appendix A. However, these should not be treated as a requirement for testing in compliance with this standard in the assessment of resistances

* Temperature correction factors k_t for conductor resistance to correct the measured resistance at t ^{o}C to 20 ^{o}C

TABLE 6 – Permissible mass of copper dissolved in tinning

Diameter of wire		Maximum mass of copper dissolved
Above mm	Up to and including mm	g/m^2
(1)	(2)	(3)
0.149	0.51	5
0. 51	3.2	3

TABLE 7 – Elongation of annealed copper wires

Diameter of wire		Minimum elongation
Above mm	Up to and including mm	%
(1)	(2)	(3)
-	0.14	5.5
0.14	0.21	9
0. 21	0.51	14
0. 51	1.36	18
1. 36	-	22.5

8 METHODS OF TEST

8.1 Tinning test

When wires taken from circular tinned annealed or hard-drawn copper conductors are tested by the method specified in Clause **8.1.1** to **8.1.5.** The mass of copper dissolved shall not exceed the appropriate value specified in Table **6**.

8.1.1 ***Selection of test samples and preparation of test specimens***

Cut a test sample of the length given in Column **4** of Table **8** from each core of the finished cable and remove the insulation by any method that does not cause injury to the tin coating, e.g the insulation may be loosened from the conductor by drawing solvent and/or oil up the interstitial spaces of the conductor.

TABLE 8 – Test specimen for tinning test

Test sample				Test specimens		
Diameter and number of wires in conductor			Length	Number	Length between marks	
Diameter		Number			For each specimen	Total for each group
Above mm	Up to and including mm		mm		mm	mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0.149	0.3	7 or more	1080	5	1000	5 000
0.3	0.67	7 or more	747	3	667	2 000
0.67	3.2	7 or more	413	3	333	1 000
0.67	3.2	1	1080	1	1000	1 000

Take two groups of specimens each comprising the number of single wires given in Column **5** of Table **8** from the test samples and mark these 40 mm from each end by means of a grease pencil or in some other manner that does not cause damage to the tin coating.

Select the wires for these groups at random from the various cores of multicore cables. In the event of insulation adhering to the test specimen, clean the wire if necessary, before winding the helix, by rubbing with a pad of clean cotton wool soaked in a suitable solvent, for example 1,1,1 - trichlorethane or toluene. In refractory cases carry out a preliminary treatment with hot solvent to facilitate the removal of the adherent insulation. Wind each group of test specimens into one helix upon a smooth mandrel in such a manner as to ensure that no twisting movement is imparted to the wires. The diameter of the mandrel shall be as given in Table **9**. The 40 mm end portions shall not be wrapped round the mandrel but so arranged as to project above the surface of the testing solution in which the helix is immersed. The radius of any necessary bends shall not be less than half the diameter of the mandrel used to produce the helix. The helix shall not be wrapped so tightly as to inhibit the entry of the solution.

TABLE 9 – Mandrel diameter for tinning test

Diameter of wire		Diameter of mandrel
Above mm	Up to and including mm	mm
(1)	(2)	(3)
0.149	0.41	20
0.41	0.67	25
0.67	0.85	30
0.85	1.13	35
1.13	1.53	45
1.53	1.78	55
1.78	2.25	65
2.25	2.52	75
2.52	2.85	85
2.85	3.20	95

Remove the helix from the mandrel by slipping it off endwise without further distortion of the wire.

Immerse the test helix for a period of 10 s in a suitable solvent for example 1,1,1-trichloroethane or toluene contained in one vessel, followed by a similar period of immersion in solvent contained in a second vessel, the helix being agitated during each immersion and allowed to dry before immersion in the test solution. Should colouration of the solvent due to dissolved material become discernible, renew the solution taking care to ensure that the vessel containing the cleaner liquid is used for the second (and final) wash.

8.1.2 *Preparation of testing solution*
Prepare the testing solutions as follows:

8.1.2.1 Persulphate solution
Dissolve 10 g of fresh crystalline ammonium persulphate in distilled water, add 20 ml of ammonia solution ($\rho = 0.880$ g/ml at 20 ^{o}C) and make up to 1 litre with distilled water.

8.1.2.2 Standard Colour reagent
Dissolve 3.927 g of pure copper sulphate ($CuSo_4.5H_2O$) in distilled water with 50 ml of ammonia solution ($\rho = 0.880$ g/ml at 20 ^{o}C) and make up to 1 litre with distilled water, 1 ml of this solution is equivalent to 0.001 g of copper.

8.1.3 ***Immersion for test***
Carry out the test at normal room temperature but immediately before the immersion of the helix bring the test solution to a temperature of 20 ^{o}C ± 2 ^{o}C.

After cleaning immerse the helix for 10 min. in a vessel containing the persulphate solution specified in **8.1.2.1**, in such a manner that the surface of the wire between the marks (see Column **6** of Table **8**) is exposed to the testing solution and the 40 mm ends project above the surface.

The volume of the solution for wires:

a) up to and including 1.78 mm diameter shall be 75 ml, and
b) above 1.78 mm diameter shall be 200 ml.

8.1.4 ***Determination of mass of copper dissolved***
Determine the mass of copper dissolved from the wire by the persulphate solution colorimetrically by comparison with the standard colour reagent specified in **8.1.2.2** Express the mass as grams of copper per square metre surface area of wire immersed.

8.1.5 Assessment of results

If the result of one group of specimens exceeds the specified maximum value, repeat the test on a fresh group of specimens cut from the wires from which the defective group was taken to ensure that the failure was not due purely to “end effect.” If this additional group fails to pass the test, the conductor represented by this sample shall be deemed not to comply with the requirements.

8.2 Tests for mechanical properties

8.2.1 *Elongation test*

A wire taken from a solid or non-compacted circular annealed copper conductor shall have an elongation at break not less than the appropriate value specified in Table **7**. Apply the load gradually and uniformly to a straightened length of wire having an original gauge length of 200 mm alternatively 250 mm. Measure the elongation on the gauge length after the fractured ends have been fitted together.

Express the elongation after break as a percentage of the original gauge length.

The determination shall be valid, whatever the position of fracture, if the specified value is reached. If the specified value is not reached, the determination shall be valid only if the fracture occurs between the gauge marks and not closer than 22 mm to either mark. If a valid result is not obtained the test shall be repeated.

8.2.2 *Tensile strength*

When tested by the method specified in **SLS 978** with the load applied gradually and uniformly, a wire from a solid or non compacted circular plain or tinned hard-drawn copper conductor shall have a breaking load corresponding to a tensile strength of not less than 370 N/mm^2.

8.2.3 *Wrapping test*

When tested by the following method, a wire taken from a solid or circular non-compacted plain or tinned hard-drawn copper conductor shall not break during the test. Wrap the wire round a wire of it own diameter to form a close helix of eight turns. Unwrap six turns and again wrap in the same direction as before.

APPENDIX A
(Normative)

MEASUREMENT OF RESISTANCE
EXACT FORMULAE FOR THE TEMPERATURE CORRECTION FACTORS

a) Annealed copper conductors : plain

$$k_{t,Cu} = \frac{254.5}{234.5 + t} = \frac{1}{1 + 0.00393(t - 20)}$$

b) Aluminium conductors : plain

$$k_{t,Al} = \frac{248}{228 + t} = \frac{1}{1 + 0.00403(t - 20)}$$

NOTE : *For aluminium alloys, reference should be made to the manufacturer*

c) Hard-drawn copper conductors: plain or metal-coated

$$k_{t,\ HCu} = \frac{262.5}{242.5 + t} = \frac{1}{1 + 0.00381(t - 20)}$$

In all the above cases, t refers to the temperature of the conductor at the time of measurement in degrees Celsius.

APPENDIX B
(Informative)

GUIDE TO THE DIMENSIONAL LIMITS OF CIRCULAR CONDUCTORS AND OTHER SUBSIDIARY INFORMATION

B.1 INTRODUCTION
This Appendix provides additional information on dimensional limits of circular conductors and conceptual constructions, nominal diameters of circular conductors and weight. Information given on dimensional limits are based on IEC 228 A.

NOTE : Shaped conductors
*a) In **SLS 695** there is already a cross-reference to **SLS 1125**, which gives dimensional data for the shaped solid aluminium conductors used in cables of the types for which such conductors are specified in current Sri Lanka Standards. The data in **SLS 1125** relates to the conductors for use in making the cables and not directly to the dimensions of the conductors in the manufactured cables. However, as the dimensions of the maximum envelopes of the conductors specified in **SLS 1125** are unlikely to increase as a result of the cablemaking process, there are a good guide for the designers and users of connectors intended to fit the conductors in the cables.*

b) As shaped stranded copper and aluminium conductors are normally making circular before connection, it is considered unnecessary to standardize dimensional limits for these conductors.

B.2 DIMENSIONAL LIMITS OF CIRCULAR CONDUCTORS

B.2.1 Object

This Appendix is intended as a guide to manufacturers of cables and cable connectors to assist in ensuring that connectors and cable conductors fit together. It gives guidance on dimensional limits for the following types for conductors included in this Standard:

a) circular solid conductors, Class 1, of copper and aluminium;
b) circular and compacted circular stranded conductors, Class 2, of copper and aluminium;
c) flexible conductors, Class 5 of copper; and
d) flexible conductors, Class 6 of copper.

B.2.2 Dimensional limits for circular copper conductors

The diameters of circular copper conductors should not exceed the values given in Table **10**.

For circular copper conductors, maximum diameters only are given and for the stranded (Class 2) conductors these are based on uncompacted conductors. The reason for this is that connectors will cope with a wider range of diameters with copper than with aluminium and, therefore, with copper it is generally only necessary to recommend the maximum diameters to be accommodated. Moreover, circular stranded copper conductors are more frequently used in the uncompacted from than are aluminium conductors.

If minimum diameters for circular copper conductors Class 1 and Class 2 are needed, reference can be made the minimum diameters for solid and stranded compacted circular aluminium conductors indicated in Table **11.**

NOTE : *The values given for flexible conductors are intended to allow for both Class 5 and Class 6 conductors*.

For Class 5 conductors only, the diameters of the 2.5 mm^2 and 4 mm^2 sizes will generally be smaller and not exceed the following:

2.5 mm^2 : 2.3 mm
4 mm^2 : 2.9 mm

B.2.3 Dimensional limits for circular aluminium conductors.

The diameters of solid aluminium conductors and compacted circular stranded aluminium conductors should not exceed the maximum values and should be not less than the minimum values given in Table **11**.

In the exceptional case of uncompacted circular stranded aluminium conductors the maximum diameters should not exceed the corresponding values for copper conductors given in Column 3 of Table **10**.

The dimensional limits of aluminium conductors, with cross-sectional areas smaller than 16 mm^2 are not given because of the variations of dimensions that exist depending on the wide range of materials and combinations of materials used.
The dimensional limits of aluminium conductors with cross-sectional areas above 630 mm^2 are not given as the compaction technology is not generally established.

TABLE 10 – Maximum diameters of circular copper conductors

Cross-sectional area	**Conductors in cables for fixed installations**		
	Solid (Class 1)	**Stranded (Class 2)**	**Flexible conductors (Class 5 and 6)**
mm^2	**mm**	**mm**	**mm**
(1)	(2)	(3)	(4)
0.5	0.9	1.1	1.1
0.75	1.0	1.2	1.3
1	1.2	1.4	1.5
1.5	1.5	1.7	1.8
2.5	1.9	2.2	2.6
4	2.4	2.7	3.2
6	2.9	3.3	3.9
10	3.7	4.2	5.1
16	4.6	5.3	6.3
25	5.7	6.6	7.8
35	6.7	7.9	9.2
50	7.8	9.1	11.0
70	9.4	11.0	13.1
95	11.0	12.9	15.1
120	12.4	14.5	17.0
150	13.8	16.2	19.0
185	15.4	18.0	21.0
240	17.6	20.6	24.0
300	19.8	23.1	27.0
400	22.2	26.1	31.0
500	-	29.2	35.0
630	-	33.2	39.0
800	-	37.6	-
1000	-	42.2	-

TABLE 11 – Minimum and maximum diameters of circular aluminium conductors

Cross-sectional area	Solid conductors (Class 1)		Stranded compacted conductors (Class 2)	
	Minimum diameter mm	Maximum diameter mm	Minimum diameter mm	Maximum Diameter mm
mm^2				
(1)	(2)	(3)	(4)	(5)
10	3.4	3.7	3.6	4.0
16	4.1	4.6	4.6	5.2
25	5.2	5.7	5.6	6.5
35	6.1	6.7	6.6	7.5
50	7.2	7.8	7.7	8.6
70	8.7	9.4	9.3	10.2
95	10.3	11.0	11.0	12.0
120	11.6	12.4	12.3	13.5
150	12.9	13.8	13.7	15.0
185	14.5	15.4	15.3	16.8
240	16.7	17.6	17.6	19.2
300	18.8	19.8	19.7	21.6
400	21.2	22.2	22.3	24.6
500	24.0	25.1	25.3	27.6
630	27.3	28.4	28.7	32.5

B.3 CONCEPTUAL CONSTRUCTIONS, NOMINAL DIAMETERS OF CIRCULAR CONDUCTORS AND WEIGHTS

Additional data for annealed copper conductors and aluminium or aluminium alloy conductors of cables for fixed installations are given in Table **12** and Table **13** respectively. Additional data for flexible copper conductors are given in Table **14.**

NOTE : *The term 'conceptual construction' is used for the conductor construction from which the specified maximum resistance values were originally calculated. The conceptual constructions are theoretically feasible constructions for uncompacted circular conductors, not necessarily used in practice*

TABLE 12 – Additional data for annealed copper conductors of cables for fixed installations

Nominal cross-sectional area	Conceptual construction no. / diameter of wires	Nominal diameter of equivalent solid (Class 1) conductors	Equivalent stranded (Class 2) conductor no. / diameter of wires	Nominal diameter of stranded (Class 2) conductor	Nominal mass per km of conductor	
					Solid	Stranded
mm^2	-/mm	mm	-/mm	mm	kg	kg
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0.5	1/ 0.80	-	7/ 0.31	0.93	4.5	4.8
0.75	1/ 0.97	-	7/ 0.37	1.11	6.6	6.9
1	1/ 1.13	-	7/ 0.44	1.32	9.0	9.7
1. 5	1/ 1.38	-	7/ 0.53	1.59	13.3	14.0
2. 5	7 /0.67	1.77	-	2.01	21.9	22.4
4	7 /0.85	2.24	-	2.55	35.0	36.1
6	7/ 1.04	2.74	-	3.12	52.4	54.0
10	7/ 1.35	3.56	-	4.05	88.5	90.8
16	7/ 1.70	4.48	-	5.10	140	145
25	7/ 2.14	5.64	-	6.42	222	229
35	7/ 2.52	6.64	-	7.56	308	317
50	19 /1.78	7.72	-	8.90	416	429
70	19/ 2.14	9.28	-	10.70	601	620
95	19/ 2.52	10.93	-	12.60	834	860
120	37/ 2.03	12.29	-	14.21	1055	1086
150	37/ 2.25	13.62	-	15.75	1295	1334
185	37/ 2.52	-	-	17.64	-	1673
240	61/ 2.25	-	-	20.25	-	2199
300	61/ 2.52	-	-	22.68	-	2759
400	61/ 2.85	-	-	25.65	-	3528
500	61/ 3.20	-	-	28.80	-	4448
630	127/ 2.52	-	-	32.76	-	5744
800	127/ 2.85	-	-	37.05	-	7346
1000	127/ 3.20	-	-	41.60	-	9260

TABLE 13 – Additional data for aluminium or aluminium alloy conductors of cables for fixed installations

Nominal cross-sectional area	Conceptual construction no./ diameter of wires	Nominal diameter of equivalent solid (Class 1) conductor	Nominal diameter of stranded (Class 2) conductor	Nominal mass per km of conductor	
				Solid	Stranded
mm^2	mm	mm	mm	kg	kg
(1)	(2)	(3)	(4)	(5)	(6)
16	7/ 1.70	4.46	5.10	42.2	43.9
25	7/ 2.14	5.58	6.42	66.2	69.5
35	7/ 2.52	6.58	7.56	91.8	96.4
50	19/1.78	7.65	8.90	124	131
70	19/2.14	9.20	10.70	180	189
95	19/2.52	10.83	12.60	249	262
120	37/2.03	12.18	14.21	315	331
150	37/ 2.25	13.50	15.75	387	406
185	37/ 2.52	15.12	17.64	485	509
240	61/ 2.25	17.33	20.25	638	669
300	61/2.52	19.41	22.68	800	839
400	61/2.85	-	25.65	-	1073
500	61/3.20	-	28.80	-	1353
630	127/2.52	-	32.76	-	1746
800	127/2.85	-	37.05	-	2233
1000	127/3.20	-	41.60	-	2816
	Sectoral circular conductors				
	No./ cross section of sectors	Nominal diameter of laid-up conductor			
	-/mm^2	mm			
380	4/ 95	22.16	-	1016	-
480	4/120	24.86	-	1285	-
600	4/150	27.58	-	1579	-
740	4/185	30.86	-	1979	-
960	4/240	35.38	-	2603	-
1200	4/300	39.58	-	3264	-

TABLE 14 – Additional data for flexible copper conductors

Nominal cross-sectional area mm^2	Conceptual construction of flexible conductors no./ diameter of wires -/mm	Approximate diameter of conductor	
		Bunched mm	Multiple stranded mm
(1)	(2)	(3)	(4)
0.22	7/ 0.20	0.60	-
0.5	16/ 0.20	0.93	-
0.75	24/ 0.20	1.14	-
1	32/ 0.20	1.32	-
1.25	40/ 0.20	1.48	-
1.35	19/ 0.30	1.50	-
1.5	30/ 0.25	1.6	-
2.5	50/ 0.25	2.0	-
4	56/ 0.30	2.6	-
6	84/ 0.30	3.3	3.6
10	80/0.40	4.2	4.6
16	126/0.40	5.3	5.7
25	196/0.40	6.6	7.1
35	276/0.40	7.8	8.5
50	396/0.40	9.4	10.3
70	360/0.50	11.2	12.4
95	475/0.50	13.0	14.5
120	608/0.50	14.5	16
150	756/0.50	-	18
185	925/0.50	-	20
240	1221/0.50	-	23
300	1525/0.50	-	26
400	2013/0.50	-	30
500	1769/0.60	-	33.5
630	2257/0.60	-	37

B.4 METHOD OF CALCULATION OF MAXIMUM RESISTANCE VALUES

The maximum resistance values given in Table **1**, Table **2**, Table **3** and Table **4** were calculated, using the conceptual constructions, from the formula:

$$R = \frac{4A}{n\pi d^2} K_1 K_2 K_3$$

where

R is the maximum resistance at 20 °C in Ω/km;
A is the volume resistivity at 20 °C of the conductor metal in Ωmm^2/km; ie,
17.241 for annealed copper;
28.264 for stranded aluminium conductors (based on material specified in SLS 1127 in the H4 or H68 condition);
n is the number of wires in the conductor;
d is the nominal diameter of the wires in the conductor in mm;
K_1 is a factor depending on the diameter of the wires and the metal, as given in Table **15**
K_2 is a factor depending on conductor formation as follows:

a) 1.00 for solid conductors
b) 1.02 for stranded Class 2 conductors if the nominal wire diameter exceeds 0.6 mm
c) 1.04 for stranded flexible conductors if the nominal wire diameter does not exceed 0.6 mm

K_3 is a factor depending upon whether the conductor has frequent use in multicore cables, making allowance for the lay of the cores, or is of a size generally used for single core cables

Values of K_3 are as follows:

a) 1.00 for conductors of cables for fixed installations of nominal cross-sectional areas, 500 mm^2 and above and for flexible conductors of 630 mm^2.

b) 1.02 for conductors of cables for fixed installation of nominal cross-sectional areas, up to and including 400 mm^2.

c) 1.05 for flexible conductors of nominal cross-sectional areas, up to and including 500 mm^2.

For circular sectoral aluminium conductors the maximum resistance is calculated from the maximum resistance specified for each of the four individual sector shaped conductors of which it consists. In effect, the value for one of the individual sector shaped conductors is divided by four in order to derive the maximum resistance value of the circular sectoral aluminium conductors.

NOTE: *The value of resistivity for aluminium of 28.264 Ω.mm²/km is the standard value for material in the H4 and H68 condition, as used for the wire sizes for standard conductors, which are the conceptual constructions for calculation of specified resistances. In practice the larger sizes of solid conductor are made from material in condition 0 for which the standard resistivity* *is 28.03 Ω mm²/km . However the specified resistances of the solid conductors are the same as for the equivalent standard conductors and the difference in resistivity is taken into account in the design dimensions of the solid conductors.*

As the specified resistance are now the same for single core and multicore cables, the factor K_3 is now related to the nominal cross-sectional area of the conductor and not directly to whether the cable is single core or multicore.

TABLE 15- Values of factor K_1

Maximum diameter of wires in conductor		**K_1**			
1	**2**	**3**	**4**	**5**	**6**
Above	**Up to and including**	**Solid conductor**		**Stranded conductor**	
		Plain copper	**Metal coated copper**	**Plain copper**	**Aluminium or aluminium alloy**
mm	**mm**				
0.05	0.10	-	-	1.07	1.12
0.10	0.31	-	-	1.04	1.07
0.31	0.91	1.03	1.05	1.02	1.04
0.91	3.60	1.03	1.04	1.02	1.03
3.60	4.50	1.03	1.04	-	-
4.50	-	1.03	1.03	-	-

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