SRI LANKA STANDARD 1147 : 1997

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SPECIFICATION FOR RUBBER INSULATION AND SHEATH OF ELECTRIC CABLES

SRI LANKA STANDARDS INSTITUTION

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SLS 1147 : 1997

Gr. 13

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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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Sri Lanka Standard
SPECIFICATION FOR RUBBER INSULATION AND SHEATH OF ELECTRIC CABLES

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 Sri Lanka Standards Institution on 1997-05-08.

This standard specifies the physical and electrical requirement for the types of rubber insulation and sheath of electric cables. The relevant test methods for verification of compliance are given either in **IEC 811** or in the Methods of Test .

All the values given in this specification are in SI units.

For the purposes 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 an analysis, shall be rounded off in accordance with **CS 102**. The number of significant places retained in the rounded off value shall be the same as that of the specified value in this standard.

In the preparation of this standard the assistance obtained from the **BS 6899 : 1991**, including Amendment No. **1**, published by the British Standards Institution is gratefully acknowledged.

1 SCOPE

This standard specifies the physical and electrical requirements for the types of rubber insulation and sheath of electric cables given in Table **1**. XPLE compound (designated as Type GP 8) has been included.

2 REFERENCES

ISO 48 Methods of testing vulcanized rubber
IEC 50 International Electrotechnical Vocabulary
IEC 502 Extruded solid electric insulated power cables for rated voltages from 1 kV up to 30 kV.
IEC 811 Common test methods for insulating and sheathing materials of electric cables
- Part 1 : Methods for general application
  - Section 2 : Thermal ageing methods
  - Section 3 : Methods for determining the density - Water absorption tests - Shrinkage test
  - Section 4 : Tests at low temperature
- Part 2 : Methods specific to elastomeric compounds
  - Section 1 : Ozone resistance test - Hot set test Mineral Oil immersion test

Part 3 : Methods specific to PVC compounds
Section 1 : Pressure test at high temperature - Tests for resistance to crancking

SLS 616 Glossary of terms for plastics.
SLS 968 Glossary of terms used in rubber industry.
SLS 1024 Methods of test for insulation and sheath of electric cables
Part 1 : General applications.

3 DEFINITIONS

For the purposes of this Standard the following definition shall apply, together with those given in **SLS 616 : 1983, SLS 968 : 1992** and **IEC 50**.

3.1 Median value : When serveral test results have been obtained and ordered in an increasing or decreasing succession, the median value is the middle value if the number of available values is odd, and is the mean of the two middle values if the number is even.

3.2 Variation : The difference between the median value after ageing and the median value without ageing, expressed as a percentage of the latter.

4. TYPES

TABLE 1 - Types of compounds, designation, maximum operating temperature and general application.

Compound type	Operating temperature max. ^0C	General application		Clause references	Table number
		Insulation	Sheath		
(1)	(2)	(3)	(4)	(5)	(6)
EI 1	60	Ordinary duty		5.1	2
EM 1	60		Ordinary duty	5.2	3
EM 2	60		Ordinary duty oil- resisting and flame retardant		
RS 1	60		Heavy duty		
RS 2	60		Heavy duty oil-resisting and flame retardant		
GP 1 *	85	Ordinary duty		5.3	4
GP2 *	85	Ordinary duty			
FR 1 *	85	Flame retardant composite			
FR 2 *	85	Flame retardant composite			
OR 1	85	Oil-resisting and flame retardant			
RS 3 **	85		Ordinary duty oil-resisting and flame retardant	5.4	5
RS 4 **	85		Heavy duty oil-resisting and flame retardant		
RS 5	90	Ordinary duty	Ordinary duty	5.5	6
GP 4 *	90	Ordinary duty			
GP 5 *	90	Ordinary duty			
GP 6 *	90				
GP 7 *	90	Ordinary duty ***			
GP8	90	Ordinary duty XLPE		5.5	6
EI 3	110	Ordinary duty EVA rubber or equivalent	Ordinary duty EVA rubber or equivalent	5.6	7
EI 2 #	150	Ordinary duty silicone rubber	Ordinary duty silicone rubber	5.7	8
EM 5 ##	--	--	--	5.8	9

* *The voltage designation of the cable may have a bearing on the type of compound selected for a particular application.*

** *RS3 and **RS4** sheaths are suitable for use over cables operating at a maximum conductor temperature of* 90 ^0C.

*** ***GP7**, complying with EPR requirements in* **IEC 502 : 1994**.

 # The operating temperature may be increased to 180 ^0C if there are no limits imposed by environmental conditions.

Covering meterial for welding cables in accordance with **5.8.2.**

5 REQUIREMENTS

5.1 60 ^{0}C insulation

5.1.1 *60 ^{0}C insulation, Type* EI 1

The insulation shall consist of a vulcanized rubber compound in which the characteristic constituent is a natural or synthetic rubber, or a mixture of the two, formulated and vulcanized so as to comply with the performance requirements of this standard.

5.1.2 Test requirements for physical and electrical properties

5.1.2.1 Tensile properties before and after ageing

(a) General

When tested as described in the methods given in **6.1** the properties of the insulation shall comply with **5.1.2.1.(b)w 5.1.2.1 (c)** and, as appropriate **5.1.2.1 (d)** and **5.1.2.1 (e).**

(b) Tensile properties of unaged material

The tensile strength and elongation at break shall be not less than the values given in Table **2.**

TABLE 2 - Test requirements for 60^0 C insulation

Test	Requirement					
	Tensile strength		Elongation at break		Elongation, max.	Permanent elongation, max.
	Min. N/mm^2	Variation max. %	Min. %	Variation, max. %	%	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Tensile properties of unaged test pieces	5.0	---	250	--	--	--
Tensile properties after accelerated ageing in air oven 10 days at 70 ± 1 ^{0}C	4.2	see Clause **5.1**	250	see Clause **5.1**	-- --	-- --
Tensile properties after accelerated ageing in oxygen bomb 4 days at 70 ± 1^{0}C	4.2	see Clause **5.1**	250 250	see Clause **5.1**	-- --	-- --
Tensile properties after accelerated ageing in oxygen bomb 7 days at 70 ± 1 ^{0}C	4.2	25	250	35	--	--
Hot set test at 200 ± 2 ^{0}C	--	--	--	--	100	25

NOTE.

A dash (-) denotes tests not applicable.

(c) Tensile properties after 10 days in air at 70 ± 1 ^{0}C.

(i) The tensile strength and elongation at break shall be not less than the values given in Table **2.**

(ii) If the median value of the tensile strength after this ageing test is equal to or greater than 5.0 N/mm^2 (e_1 in Figure **1**), the median values of the tensile strength and elongation at break shall not differ from the median values obtained without ageing by more than 40 per cent of the median values without ageing, and in addition the material shall comply with **5.1.2.1 (d).**

(iii) If the median value of the tensile strength after this ageing test is lower than 5.0 N/mm^2, but not less than 4.2 N/mm^2 (e_2 in Figure **1**), the material shall in addition comply with **5.1.2.1 (e).**

(d) Tensile properties after 4 days in oxygen at 70 ± 1 ^{0}C.

(i) The tensile strength and elongation at break shall be not less than the values given in Table **2.**

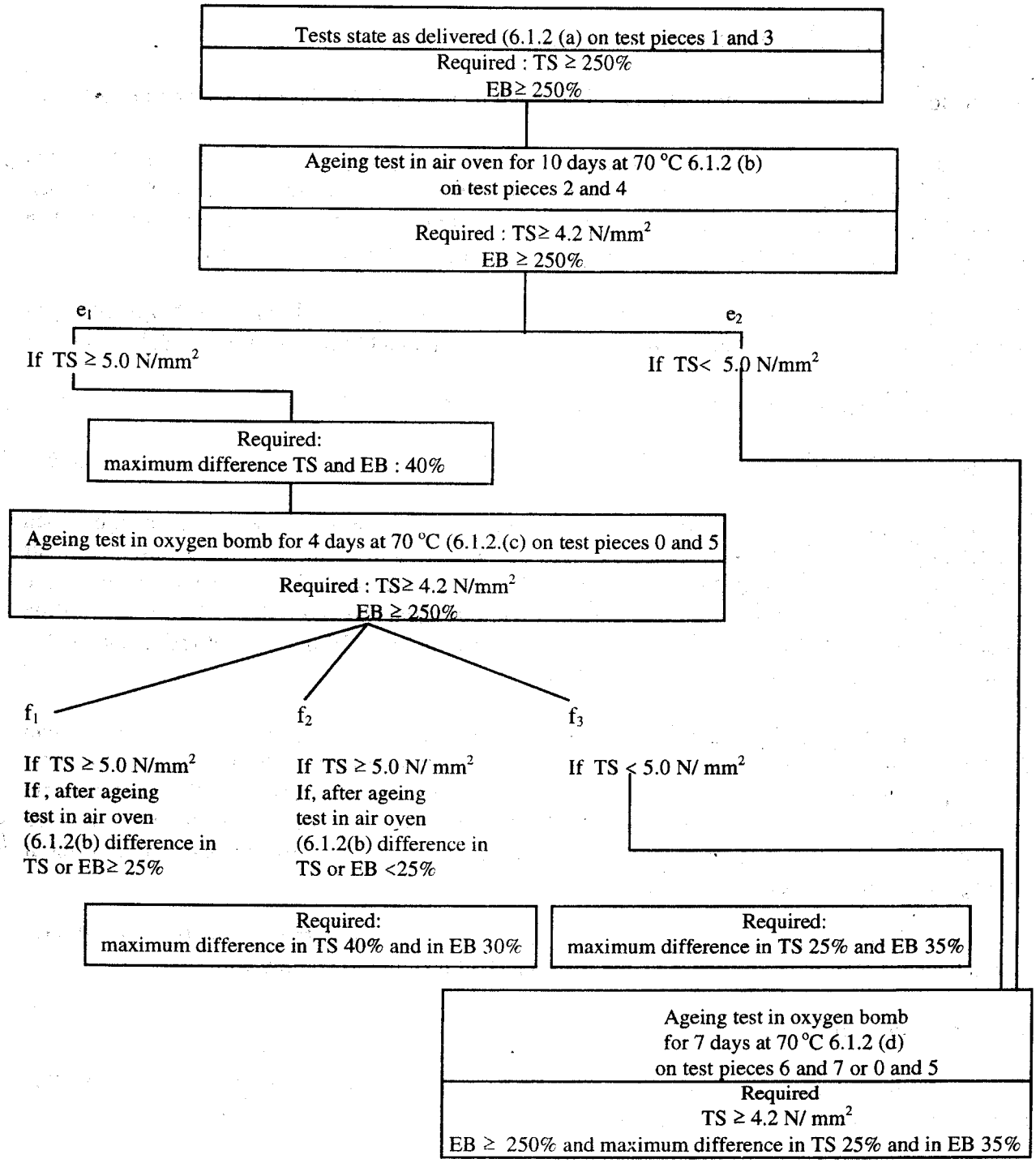
(ii) If the median value of the tensile strength after this ageing test is equal to or higher than 5.0 N/mm^2 and if the change in tensile strength or elongation at break after the ageing test in air **5.1.2.1 (c)** does not exceed 25 per cent (f_1 in Figure **1**), the median value after ageing in the oxygen bomb shall not differ from that obtained without ageing by more than, 40 per cent of the median value without ageing, in the case of tensile strength, and 30 per cent of the median value without ageing, in the case of elongation at break.

(iii) If the median value of the tensile strength after this ageing test is equal to or greater than 5.0 N/mm^2 and if the change in tensile strength or elongation at break after the ageing test in air **5.1.2.1 (c)** exceeds 25 per cent (f_2 in Figure **1**), the median value after ageing in the oxygen bomb shall not differ from that obtained without ageing by more than, 25 per cent of the median value without ageing, in the case of tensile strength, and 35 per cent of the median value without ageing, in the case of elongation at break.

(iv) If the median value of the tensile strength after the ageing test in the oxygen bomb for 4 days is less than 5.0 N/mm^2 (f_3 in Figure **1**), the material shall in addition comply with **(e).**

(e) Tensile properties after 7 days in oxygen at 70 ± 1 ^{0}C

The tensile strength and elongation at break shall be not less than the values given in Table **2.** The maximum variation shall be as given in Table **2.**



TS denotes tensile strength
EB denotes elongation at break

FIGURE 1- Synopsis of tests for the mechanical properties of insulation consisting of compound Type EI 1.

5.1.2.2 Retests of tensile properties before ageing

If the tensile tests carried out in accordance with **5.1.2.1** were not conducted at an ambient temperature of 20 ± 5 ^{0}C and any maximum variation specified in **5.1.2.1** between tensile properties before and after ageing is exceeded, a single retest shall be carried out using the procedure described in **6.1.2(a)** at exactly the same temperature as that at which the tensile test after ageing was carried out.

5.1.2.3 Hot set test requirements

When samples of the insulation or sheath are taken, prepared and tested as described in Clause 9 of **IEC 811-2-1 : 1986,** the conditions of temperature and stress being those given in Table **2** the tensile properties of the samples shall be as given in Table **2.**

5.2 60 ^{0}C sheath

5.2.1 *Types of sheath*

5.2.1.1 Ordinary duty sheath Type **EM1**, and heavy duty sheath Type **RS1**

The sheath shall consist of a vulcanized compound in which the characteristic constituent is a natural or synthetic rubber or a mixture of the two, foumulated and vulcanized so as to comply with the performance requirements of this standard.

NOTES

*1. Sheaths of the types specified in **5.2.1.2** do not normally support combustion, but this property is affected by other components of the cable.*

*2. A cable employing sheath complying with the ageing in oil test requirement in **5.2.2** is not necessarily suitable for continuous use in oil.*

5.2.2 *Test requirements for physical and electrical properties*

When tested as described in **6.2** the properties of the sheath shall be in accordance with the requirements given in Table **3** for the particular type of material.

TABLE 3 - Test requirements for 60^0 C sheath

Tests	Requirements			
	Ordinary Duty		Heavy Duty	
	EM 1	EM 2	RS 1	RS 2
(1)	(2)	(3)	(4)	(5)
Tensile properties of unaged test pieces				
Minimum tensile strength, N/mm^2	7.0	10.0	12.0	11.0
Minimum elongation at break, %	300	300	300	250
Tensile properties after accelerated ageing in air oven for 10 days at 70 ± 1 ^{0}C				
Maximum variation in tensile strength, %	20	15*	20	15*
Elongation at break:				
median value, minimum, %	250	250	250	200
maximum variation, %	20	25*	20	25*
Tensile properties after ageing in oil for 24 h *at* 100 ± 2 ^{0}C				
Maximum variation in tensile strength from unaged value, %	--	40	--	40
Maximum vairation in elongation at break from unaged value %	--	40	--	40
Tear resistance				
Minimum value, N/mm	--	--	--	5
Hot set test at 200 ± 2 ^{0}C *stress on test piece* 0.2 N/mm^2				
Maximum elongation, %	100	100	100	100
Maximum permanent elongation, %	25	25	25	25
Bending test at low temperature				
Test temperature (^{0}C)	--	-35	--	--
Requirement	--	No cracks	--	--
Elongation test at low temperature				
Test temperature (^{0}C)	--	-35	--	--
Minimum elongation without break, (%)	--	30	--	--

* There is no limit on the increase in value after ageing

NOTE

A dash (-) denotes test not applicable

5.3 85 ^{0}C insulation

5.3.1 *Types of insulation*

5.3.1.1 Ordinary duty, Type **GP1** and Type **GP2**

The insulation shall consist of a compound based on a synthetic rubber, formulated and vulcanized so as to comply with the performance requirements of this standard.

5.3.1.2 Flame retardant composite, Type **FR1** and Type **FR2**

The insulation shall consist of an inner layer of Type **GP1** or **GP2** and a closely adherent outer layer complying with the physical requirements of Type **OR1,** (see **5.3.1.3**) formulated and vulcanized so as to comply with the performance requirements of this standard.

5.3.1.3 Oil-resisting and flame retardant, Type **OR1**

The insulation shall consist of a compound based on chlorosulphonated polyethylene or equivalent, formulated and vulcanized so as to comply with the performance requirements of this standard.

NOTES

*1. Insulation of the types specified in **5.3.1.2** and **5.3.1.3** do not normally support combustion, but this property is affected by other components of the cable.*

2. A cable employing insulation complying with the ageing in oil test requirements in **5.3.2** *is not necessarily suitable for continuous use in oil.*

5.3.2.2 When tested as described in the methods given in **6.2**, the properties of the insulation shall be in accordance with the reqirements given in Table **4** for the particular type of material. For **FR1** and **FR2** compounds having insulation thickness greater than 2.5 mm, in the inner layer shall after separation comply with the requirements for Type **GP1** and Type **GP2,** for the tensile properties of unaged test pieces and for test pieces aged in an air bomb, and the outer layer with the requirements for Type **OR1** for the tensile properties of unaged test pieces and for test pieces aged in an air bomb and in oil.

TABLE 4 - Test requirements for 85 ^{0}C insulation

Test (1)	Requirements for insulation Type				
	GP1 (2)	**GP2** (3)	**FR1** (4)	**FR2** (5)	**OR1** (6)
Tensile properties of unaged test pieces					
Minimum tensile strength, N/mm^2	4.2	4.2	5.5*	5.5*	7.0
Minimum elongation at break, %	200	200	200*	200*	200
Tensile properties after accelerated ageing in air bomb, 42 h at 127 ± 1 ^{0}C					
Tensile strength : minimum percentage of value for unaged samples %	60	60	50*	50*	50
Elongation at break : minimum percentage of value for unaged samples %	60	60	50*	50*	50
*Tensile properties after prolonged ageing (Type test)***	As specified in **5.3.2.3**				
Ozone resistance test at ozone concentration 0.025% to 0.030 %					
Test duration, h	--	3	--	3	--
Power factor and permittivity test					
Maximum power factor at 20 ^{0}C	--	0.035	--	0.035	--
Maximum permittivity at 20 ^{0}C	--	4.5	--	5.5	--
Water absorption **					
Maximum increase in capacitance :					
1 to 14 days, %	10	6	15	10	15 ***
7 to 14 days, %	3	2.5	5	3	5 ***
Insulation resistance constant test **					
Maximum *K* value at 20 ^{0}C, MΩ.km	2400	4800	1900	3700	10
Tensile properties after ageing in oil, 24 h at 100 ± 2 ^{0}C					
Tensile strength: minimum percentage of for unaged samples, %	--	--	--	--	60
Elongation at break: minimum percentage of value for unaged samples, %	--	--	--	--	60

* These requirements are applicable only to **FR1** and **FR2** compounds having insulation thickness up to and including 2.5 mm. (see **5.3.2.2** and **6.2.2)**

** These tests are carried out only when requested by the purchaser. It is essential therefore for the purchaser to state at the time of enquiry or order he wishes this testing to be done.

*** These are additional requirements for Type **OR1** which apply only if the purchaser specifies at the time of ordering that the cable is to be used in a wet location.

NOTE.

A dash (-) denotes test not applicable.

5.3.2.3 When the insulation is tested as described in **6.2,** the tensile properties after prolonged ageing in an air oven shall be in accordance with the following.

(a) After ageing for 28 days the median value of elongation at break shall be not less than 120 per cent.
(b) After ageing for 28 days the median value of the tensile strength shall be not less than 50 per cent of the tensile strength without ageing.
(c) The difference in the elongation at break after ageing for 14 days and 28 days respectively shall be not more than 20 per cent of the elongation at break without ageing.

5.4 85 ^{0}C sheath

5.4.1 *Type of sheath*

The sheath shall be one of the following types:

(a) ordinary duty oil-resisting and flame retardant Type **RS3**; or
(b) heavy duty oil-resisting and flame retardant, Type **RS4**.

For each type, the sheath shall consist of a compound based on a synthetic rubber, formulated and vulcanized so as to comply with the performance requirements of this standard. The colour of the compounds shall be black unless otherwise specified for the particular cable.

NOTES

*1. Sheaths of the types given in **5.4.1** do not normally support combustion, but this property is affected by other components of the cable.*

*2. A cable employing sheath complying with the ageing in oil test requirement in **5.4.2** is not necessarily suitable for continuous use in oil.*

5.4.2 Test requirements for physical and electrical properties.

When tested as described in the methods given in **6.2** the properties of the sheath shall be in accordance with the requirements given in Table **5** for the particular type of material.

TABLE 5 - Test requirements for 85 ^{0}C sheath

Test (1)	Requirements for sheath type	
	RS3 (2)	RS4 (3)
Tensile properties of unaged test pieces		
Minimum tensile strength, N/mm^2	8.0	11.0
Minimum elongation at break, %	250	250
Tensile properties after ageing in air bomb, 42 h at 127 ± 1 ^{0}C		
Tensile strength: minimum percentage of value for unaged sample	50	50
Elongation at break: minimum percentage of value for unaged sample	50	50
Prolonged ageing test * (type test)	As **5.3.2.3**	As **5.3.2.3**
Tensile properties after ageing in oil, 24 h *at* 100 ± 2 ^{0}C		
Tensile strength: minimum percentage of value for unaged sample %	60	60
Elongation at break: minimum percentage of value for unaged sample %	60	60
Tear resistance		
Minimum value, N/mm	--	5.0
Hot set test at 200 ± 2 ^{0}C *stress on test piece* 0.2 N/mm^2		
Maximum elongation %	175	175
Maximum permanent elongation, %	25	25

* This test is carried out only when requested by the purchaser. It is essential therefore for the purchaser to state at the time of enquiry or order he wishes this testing to be done.

NOTE

A dash (-) denotes test not applicable.

5.5 90 ^{0}C insulation and sheath

5.5.1 *Types of compound*

5.5.1.1 Ordinary duty, Type **GP4**, Type **GP6** and Type **GP7**

The insulation shall be based on ethylene propylene rubber which when vulcanized complies with the performance requirements of this standard.

5.5.1.2 Ordinary duty, Type **GP8**

The insulation shall be a thermoset material formed by the cross-linking of thermoplastic polyethylene compound either by chemical or by irradiation methods, so as to comply with the performance requirements of this standard.

5.5.1.3 Ordinary duty, Type **RS5**

The sheath shall be based on ethylene propylene rubber which when vulcanized complies with the performance requirements of this stnadard.

NOTE

The colour of the material should be grey.

5.5.2 Test reqirements for physical and electrical properties

When tested as described in the methods given in **6.2** the properties of the insulation or sheath shall be in accordance with the requirements given in Table **6** for the particular type of material.

TABLE 6 - Test requirments for 90 ^{0}C rubber insulation and sheath

Test (1)	Requirements for insulation or sheath Type					
	GP4 (2)	GP5 (3)	GP6 (4)	GP7 (5)	GP8 (6)	RS5 (7)
Tensile properties of unaged test pieces						
Minimum tensile strength, N/mm^2	6.5	6.5	8.5	4.2	12.5	6.0
Minimum elongation at break, %	200	200	200	200	200	200
Tensile properties after accelerated ageing in air oven for 7 days at 135 ± 3 ^{0}C						
Tensile strength: maximum variation from unaged value, %	30	30	30	30	25	30
Elongation at break: maximum variation from unaged value, %	30	30	30	30	25	30
Tensile properties after ageing in air bomb for 40 h at 127 ± 1 ^{0}C						
Tensile strength: maximum variation from unaged value, %	30	30	30	30	--	30
Elongation at break: maximum variation from unaged value, %	30	30	30	30	--	30
Ozone resistance at ozone concentration 0.025 % to 0.030 %						
Test duration, h	--	3	30	30	--	--
Hot set test, stress on test piece 0.2 N/mm^2 *at temperature,* ^{0}C	200 ± 2	200 ± 2	250 ± 3	250 ± 3	200 ± 2	200 ± 2
Maximum elongation, %	100	100	100	100	175	100
Maximum permanent elongation, %	25	25	25	25	15	25
Determination of hardness						
Minimum hardness, IRHD	--	--	80	--	--	--
Water absorption						
maximum increase in capacitance:						
1 to 14 days, %	10	6	--	--	--	--
7 to 14 days, %	3	2.5	--	--	--	--
Water absorption (gravimetric) 14 days at 85 ± 2 ^{0}C						
Maximum variation in mass, mg/cm^2	--	--	5	5	1	--
Insulation resistance constant						
Minimum K value at 20 ^{0}C, MΩ.km	2400	4800	--	--	--	--
Minimum K value at 90 ^{0}C, MΩ.km	--	--	3.67	3.67	3.67	--
Shrinkage test, 1 h at 130 ± 3 ^{0}C						
Maximum shrinkage, %	--	--	--	--	4	--
Power factor and permittivity test						
Maximum power factor at 20 ^{0}C	--	0.035	--	*	*	--
Maximum permittivity at 20 ^{0}C	--	4.5	--	*	*	--

* Tests on cables should be carried out in accordance with the appropriate cable standards.

NOTE

A dash (-) denotes test not applicable

5.6 110 ^{0}C insulation or sheath

5.6.1 *110 ^{0}C insulation or sheath, Type* EI 3

The insulation or sheath shall consist of a vulcanized compound in which the characteristic constituent is ethylene vinyl acetate or equivalent, formulated so as to comply with the performance requirements of this standard.

5.6.2 Test requirements for physical and electrical properties

When tested as described in the methods given in **6.2** the properties of the insulation or sheath shall be in accordance with the requirements given in Table **7**.

TABLE 7 - Test requirements for 110 ^{0}C insulation or sheath Type **EI 3**

Test (1)	**Requirement** (2)
Tensile properties of unaged test pieces	
Minimum tensile strength, N/mm^2	6.5
Minimum elongation at break, %	200
Tensile properties after accelerated ageing in air oven for 10 days *at* 150 ± 2 ^{0}C	
Tensile strength: maximum variation from unaged value, %	30
Elongation at break: maximum variation from unaged value, %	30
Tensile properties after accelerated ageing in air oven for 10 days *at* 150 ± 2 ^{0}C	
Tensile strength: maximum variation from unaged value %	6.0
Elongation at break: maximum variation from unaged value, %	-30
Hot set test at 200 ± 2 ^{0}C, *stress on test piece* 0.2 N/mm^2	
Maximum elongation, %	100
Maximum permanent elongation, %	25
Hot pressure test: 0.5 h *at* 150 ± 2 ^{0}C	
K value	1.0
Maximum penetration, %	50

5.7 150 ^{0}C insulation or sheath

5.7.1 150 ^{0}C *insulation or sheath, Type* EI 2

The insulation or sheath shall consist of a vulcanized compound in which the characteristic onstituent is a silicone rubber, formulated so as to comply with the performance requrements of this standard.

5.7.2 Test requirements for physical and electrical properties

When tested as described in the methods given in **6.2** the properties of the insulation or sheath shall be in accordance with the requirements given in Table **8**.

TABLE 8 - Test requirements for 150 ^{0}C insulation or sheath, Type **EI 2**

Test	Requirements
Tensile properties of unaged test pieces	
Minimum tensile strength, N/mm^2	5.0
Minimum elongation at break, %	150
Tensile properties after accelerated ageing in air for 10 days *at* 200 ± 2 ^{0}C	
Minimum tensile strength, N/mm^2	4.0
Minimum elongation at break, %	120
Hot set test at 250 ± 3 ^{0}C, *stress on test piece* 0.2 N/mm^2	
Maximum elongation, %	100
Maximum permanent elongation, %	25

5.8 Covering material for welding cables

5.8.1 *Type of covering material*

The covering material, as specified in **5.8.2** shall be Type **EM5** and shall be a rubber compound in which the characteristic constituent is a synthetic chlorinated rubber, e.g. polychloroprene (PCP), chlorosulphonated polyethylene (CSP) or chlorinated polyethylene (CPE). When vulcanized it shall comply with the performance requirements of this standard.

5.8.2 The covering shall consist of one of the following:

a) a layer of ordinary duty 85 ^{0}C **HOFR** * Sheath complying with the requirements of **5.4** the preferred colour being orange;
b) as a) but in including on inner layer of 85 ^{0}C rubber insulation, the preferred colour of the outer layer being orange;
c) a layer of ordinary duty 85 ^{0}C rubber sheath comlying with the requirements of **5.4** for Type **GP3**, the preferred colour being grey.

5.8.3 *Test requirements for physical properties*

When test as described in the methods given in **6.2** the properties of the covering material shall be in accordance with the requirements given in Table **9.**

* HOFR is the abbreviation for heat resisting, oil resisting and flame retardant (*maximum continuous operating temperature 85 ^{0}C*).

TABLE 9 - Test requirements of covering material for welding cables*

Test	Requirments for covering Type EM 5
Tensile properties of unaged test pieces	
Minimum tensile strength, N/mm^2	10.0
Minimum elongation at break, %	300
Tensile properties after accelerated ageing in air oven for 14 days *at* 100 ± 2 ^0C	
Maximum vatiation in tensile strength from unaged value, %	-30**
Maximum variation in elongation at break from unaged value, %	-40**
Tensile properties after ageing in oil, 24 *h at* 100 ± 2 ^0C	
Tensile strength, minimum percentage of value for unaged sample	60
Elongation at break, minimum percentage of value for unaged sample	60
Hot set test at 200 ± 2 ^0C, *stress on test piece* 0.2 N/mm^2	
Maximum elongation, %	100
Maximum permanent elongation, %	25

* As specified in **5.8.2**
** An increase in value after ageing is permitted without limit.

6 METHODS OF TEST

6.1 Test methods for 60 ^0C insulation Type **EI 1**

6.1.1 *Sampling and numbering of test pieces*

Take samples from each core if the cable has one, two or three cores and from three cores (or different colours, if any) if the cable has more than three cores.

Take three samples from each of the requisite number of cores, each sample not less than 1 m from the other two, and of sufficient size to provide six or eight (see note) test pieces as described in Clause **5.1.3** of **SLS 1024 Part 1 : 1994**. Reject any samples that show signs of mechanical damage. Number the test pieces obtained from each sample consecutively 0 to 5 (or 0 to 7).

NOTE

Two additional test pieces are required where ageing in oxygen for 7 days proves necessary.

6.1.2 *Test procedures*

Determine the cross-sectional area of each of the test pieces in accordance with **IEC 811** and **SLS 1024 : Part 1 : 1994** and then proceed as follows.

a) Subject test pieces 1 and 3 to the conditioning and to the tensile test in accordance with Clause **5** of **SLS 1024 : Part 1 : 1994** and Clause **8** of **IEC 811-1-2 : 1985** in the state as delivered. Obtain the median values of tensile strength and elongation at break.

b) Subject test pieces 2 and 4 to ageing in an air oven for 10 days at 70 ± 1 ^{0}C and subsequently to the conditioning and to the tensile test in accordance with Clause **9** of **IEC 811-1-1 : 1993** and Clause **8** of **IEC 811-1-2 : 1985**. Obtain the median values of tensile strength and elongation at break.

If the median value of the tensile strength obtained in **6.1.2 (b)** is equal to or greater than 5.0 N/mm^2 and the variation in the values of tensile strength and elongation at break between **6.1.2 a)** and **6.1.2 b)** is not more than 40 per cent, proceed with **6.1.2 c)** with an ageing period of 4 days.

If the median value of the tensile strength obtained in **6.1.2 b)** is less than 5.0 N/mm^2 but not less than 4.2 N/mm^2, proceed with **6.1.2 c)** with an ageing period of 7 days.

(c) Subject test pieces 0 to 5 to ageing in an oxygen bomb for 4 days or 7 days at 70 ± 1 ^{0}C in accordance with Clause **8** of **IEC 811-1-2 : 1985** and subsequently to the conditioning and to the tensile test in accordance with Clause **9** of **IEC 811-1-1 : 1993**. Obtain the median values of tensile strength and elongation at break.

If the median value of the tensile strength obtained in **6.1.2 c)** after 4 days ageing at 70 ^{0}C is less than 5.0 N/mm^2 but not less than 4.2 N/mm^2, proceed with **6.1.2 d).**

(d) Subject test peices 6 and 7 to ageing in an oxygen bomb for 7 days at 70 ± 1 ^{0}C in accordance with Clause **8** of **IEC 811-1-2 : 1985** and subsequently to the conditioning and to the tensile test in accordance with Clause **5** of **SLS 1024 : Part 1 : 1994.** Obtain the median values of tensile strength and elongation at break.

NOTE

A synopsis of the test for the mechanical properties of Type **EI 1** *insulation is given in Figure* **1.**

6.2 Test methods for compounds other than Type **EI 1.**

6.2.1 *Sampling*

Take insulation and sheath samples as described in **SLS 1024 : Part 1.**

6.2.2 *Test procedures*

6.2.2.1 General

Carry out in accordance with the methods given in Table **9** the applicable tests given in italic type in Table **3** to Table **8**, as appropriate, under the conditions of temperature, test duration, etc. given in those tables.

TABLE 10 - Test procedures for compounds other than Type **EI1**

Test	Method
Tensile properties: tensile strength and elongation at break	Clause **5** of **SLS 1024 : - 1 : 1994**
Accelerated ageing	Clause **8** of **IEC 811-1-2 : 1985**
Shrinkage test	Clause **10** of **IEC 811-1-3 : 1993**
Gravimetric water absorption test	Clause **9.2** of **IEC 811-1-3 : 1993**
Ageing of insulation and sheath in oil	Clause **10** of **IEC 811-2-1 : 1986**
Ozone resistance of insulation	Clause **8** of **IEC 811-2-1 : 1986**
Hot set test	Clause **9** of **IEC 811-2-1 : 1986**
Tear resistance of sheath	Clause **6.2.2.2**
Water absorption of insulation	Clause **6.2.2.3**
Insulation resistance constant (K value)	Clause **6.2.2.4**
Determination of hardness	Method **CM** of **ISO 48 : 1994**
Power factor and permittivity	Clause **6.2.2.5**
Prolonged ageing test	Clause **6.2.2.6**
Hot pressure tests	Clause **8** of IEC **811-3-1 : 1985**
Low temperature tests	Clause **8** of IEC **811-1-4 : 1985**

NOTE

For thickness of **FR1** *and* **FR 2** *compound greater than* 2.5 mm, *the layers of insulation require separating, e.g. by grinding, and testing individually for compliance with* **5.3.2.2**

6.2.2.2 Method for tear resistance

a) General

This test method is to determine the tear resistance of sheathing materials.

b) Preparation of test pieces

Prepare six test pieces having dimensions as shown in Figure 2, with a thickness not greater than 4.0 mm and not less than 1.0 mm. Cut these, preferably along the direction of the cable axis, by means of a sharp knife or die from portions of the sheath from which all irregularities or corrugations, if present, have been removed by grinding or cutting. Make a central longitudinal cut, perpendicular to the width of the test piece, with a sharp razor to a point 3.8 mm from the wider end.

c) Conditioning of test pieces

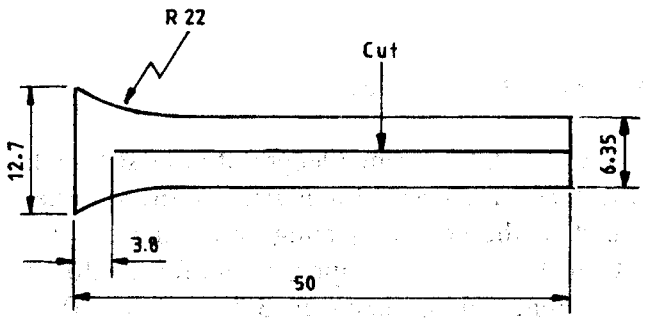
Before the start of the test, keep the test pieces for at least 3 h at the ambient temperature at which the test is to be carried out, which shall be 20 ± 5 ^{0}C, and commence testing within 5 min of removal from the conditioning chamber.

d) Procedure

Test each test piece in the following way. Place the halves of the split end in the jaws of a tensile testing machine and separate the jaws at a a rate between 350 mm/min and 500 mm/min.

e) Evaluation of results

Determine the tear resistance by dividing the maximum load (N) required to tear the section, by the thickness of the test piece (in mm). Classify the results in order of increasing value and take the average of the two middle values as the tear resistance.



Dimensions in millimetres

FIGURE 2 – Test piece for tear resistance test

6.2.2.3 Method for water absorption of insulation

a) Preparation of test specimen
Take a smaple of the core about 4.5 m long, after vulcanization but before the application of any covering except tape applied before vulcanization. Wherever possible remove any tape before the test. Prepare the test specimen from the sample not less than 48 h after vulcanization, by drying for 24 h in air at 75 ± 5 ^{0}C before immersion in the water.

b) Immersion of specimen
Place the test specimen in a water tank so that its middle portion for a length of 3 m is immersed, whilst each end is above the water level for a length of 0.75 m. Maintain the water at a emperature of 50 ± 1 ^{0}C for 14 days. Place a tightly fitting cover directly above the water surface with suitable watertight bushings for the ends of the test specimen and keep the water level constant.

c) Electrical measurements
Carry out the test with one of the following voltages:

i. an average stress at any frequency from 40 Hz to 62 Hz inclusive, of;
   1. 800 V/mm for Type **GP 1**, Type **FR 1**, Type **OR 1** and Type **GP 4**,
   2. 2500 V/mm for Type **FR 2**,
   3. 3200 V/mm for Type **GP 2** and Type **5**.

ii. a low voltage at any frequency from 800 Hz to 1000 Hz inclusive.

Measure the capacitance after continuous immersion for 1, 7 and 14 days checking that the water is at the same termperature for all measurements.

Express the increase in capacitance from 1 day to 14 days and from 7 days to 14 days as percentages of the 1- day and the 7-day values respectively.

6.2.2.4 Method for insulation resistance constant (*K* value)

Remove the sheath and any other covering or filling from a length of at least 5 m, taking care not to damage the insulation. Immerse the core for at least 12 h in water at the specified temperature, a length of about 250 mm at each end of the core projecting above the water. Maintain the temperature of the water at 20 ± 1 ^{0}C or 90 ± 2 ^{0}C, as appropriate, for the 30 min immediately preceding the test. Apply a direct current voltage between 300 V and 500 V between the conductor and the water. Measure the insulation resistance 1 min after the application of the voltage.

Calculate the insulation resistance constant (K value) from the equation:

$$K = \frac{l\,R}{1000 \log_{10}(D/d)} \quad \text{M}\,\Omega.\text{km}$$

where

D is the diameter over insulation (mm);

d is the diameter over conductor (mm);

l is the immersed length of core (m);

R is the insulation resistance of the length of core (MΩ) .

6.2.2.5 Method for power factor and permittivity

Take samples of core of length not less than 5 m, from the complete cable and immerse them in water for 24 h at room temperature with a length of about 250 mm at each end of the core projecting above the water. Measure the power factor and capacitance of the insulation between the conductor and the water with suitable equipment at any convenient frequency between 40 Hz and 62 Hz, at the rated voltage to earth U_0, of the cable and at a temperature of $20 \pm 1\ ^0$C.

Calculate the permittivity from the equation:

$$\varepsilon = \frac{41.4\,C \log_{10}(D/d)}{l}$$

where

ε is the permittivity of the insulation;

C is the measured capacitance of the sample (nF);

D is the diameter over insulation (mm);

d is the diameter over conductor (mm);

l is the immersed length of core (m).

6.2.2.6 Method for prolonged ageing*

Carry out the test by the method described in **IEC 811-1-2 : 1985** for accelerated ageing by the air oven method using ten test pieces. Place the test pieces in the dark in the air oven maintained at a temperature of $110 \pm 1\ ^{0}C$.

After a period of 14 days remove five of the test pieces from the oven, allow them to cool down and keep them at room temperature, avoiding direct sunlight, for at least 16 h. Subject these test pieces to the tensile tesing specified for insulation and sheath.

After a period of 28 days from the commencement of ageing remove the remaining test pieces from the oven and subject them to the same procedure as the first test pieces.

* This is a type test to be carried out by a manufacturer before he supplies cable on a general commercial basis. The test need not be repeated unless changes are made which might affect compliance with the test requirements.

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