PTFE INSULATED WIRES AND CABLES, LOW FREQUENCY, 600V, -100 TO +200°C

ESCC Detail Specification No. 3901/013

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DCR No.	CHANGE DESCRIPTION
750	Specification upissued to incorporate editorial changes per DCR.

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1 GENERAL

1.1 SCOPE

This specification details the ratings, physical and electrical characteristics, test and inspection data for PTFE Insulated Wires and Cables, Low Frequency, 600V, -100 to +200 °C. It shall be read in conjunction with ESCC Generic Specification No. 3901, the requirements of which are supplemented herein.

NOTES:

1. Only simple elements (finished wires and unshielded, jacketed multicore cables) can be used in the presence of hydrazine or nitrogen tetroxide.

1.2 TYPE VARIANTS

Variants of the basic types of wires and cables specified herein, which are also covered by this specification, are listed in Table 1(a).

1.3 MAXIMUM RATINGS

The maximum ratings, applicable to the finished wires and cables specified herein, which shall not be exceeded at any time during use or storage in controlled space environment, are scheduled in Table 1(b).

1.4 PARAMETER DERATING INFORMATION

The derating information applicable to the finished wires and cables specified herein is as follows:

– The maximum current for each wire used in a bundle shall be:

$$I_{Bmax}=I_{max}\times\frac{29-n}{28}\ \text{(for } 1<n<15\text{)}$$

$$I_{Bmax}=\frac{I_{max}}{2}\ \text{(for } n>15\text{)}$$

where n = number of wires in the bundle.

– The temperature derating information is shown in Figure 1 with maximum current I_{max} for a single wire.

– The derating factors contained herein indicate maximum stress values and do not preclude further derating.

1.5 PHYSICAL CHARACTERISTICS

The physical characteristics of the finished wires and cables specified herein are shown in Figures 2(a), 2(b) and 2(c) and their dimensions in Table 1(a).

1.6 FUNCTIONAL DIAGRAM

Not applicable.

TABLE 1(a) – TYPE VARIANTS

Variant No.	Shielded	Un-Shielded		No. of Cores	Wire Size AWG	Stranding No. of Strands × Diameter (mm)	Conductor Characteristics			Shield Strand Ø (mm)	Core Max Ø (mm)	Finished Wire Or Cable Characteristics	
		Jacketed	Un-Jacketed				Max Ø (mm)	Nom Section (mm^2)	Max Ohmic Resistance (Ω/km)			Max Ø (mm)	Max Weight (kg/km)
01			X	1	28	7×0.127 (1)	0.42	0.089	215	-	-	0.82	1.8
02			X	1	26	7×0.16 (1)	0.5	0.14	146	-	-	0.89	2.3
03			X	1	24	7×0.2	0.62	0.22	87.2	-	-	1.04	3.34
04			X	1	22	7×0.25	0.77	0.34	55.8	-	-	1.19	4.84
05			X	1	20	19×0.2	1.03	0.6	32.2	-	-	1.44	7.4
06			X	2	28	7×0.127 (1)	0.42	0.089	225	-	0.82	1.64	3.8
07			X	2	26	7×0.16 (1)	0.5	0.14	153	-	0.89	1.78	4.84
08			X	2	24	7×0.2	0.62	0.22	91.6	-	1.04	2.08	6.9
09			X	2	22	7×0.25	0.77	0.34	57.7	-	1.19	2.38	10
10			X	2	20	19×0.2	1.03	0.6	33.8	-	1.44	2.88	15.3
11			X	3	28	7×0.127 (1)	0.42	0.089	225	-	0.82	1.76	5.7
12			X	3	26	7×0.16 (1)	0.5	0.14	153	-	0.89	1.92	7.28
13			X	3	24	7×0.2	0.62	0.22	91.6	-	1.04	2.24	10.35
14			X	3	22	7×0.25	0.77	0.34	58.7	-	1.19	2.56	15
15			X	3	20	19×0.2	1.03	0.6	33.8	-	1.44	3.12	23
16			X	4	28	7×0.127 (1)	0.42	0.089	225	-	0.82	1.97	7.55
17			X	4	26	7×0.16 (1)	0.5	0.14	153	-	0.89	2.14	9.71
18			X	4	24	7×0.2	0.62	0.22	91.6	-	1.04	2.5	14
19			X	4	22	7×0.25	0.77	0.34	58.7	-	1.19	2.86	20.3
20			X	4	20	19×0.2	1.03	0.6	33.8	-	1.44	3.46	31.1
21		X		2	28	7×0.127 (1)	0.42	0.089	225	-	0.82	1.92	4.32
22		X		2	26	7×0.16 (1)	0.5	0.14	153	-	0.89	2.06	5.28
23		X		2	24	7×0.2	0.62	0.22	91.6	-	1.04	2.36	7.54

Variant No.	Shielded	Un-Shielded		No. of Cores	Wire Size AWG	Stranding No. of Strands × Diameter (mm)	Conductor Characteristics			Shield Strand Ø (mm)	Core Max Ø (mm)	Finished Wire Or Cable Characteristics	
		Jacketed	Un-Jacketed				Max Ø (mm)	Nom Section (mm^2)	Max Ohmic Resistance (Ω/km)			Max Ø (mm)	Max Weight (kg/km)
24		X		2	22	7×0.25	0.77	0.34	58.7	-	1.19	2.66	10.7
25		X		2	20	19×0.2	1.03	0.6	33.8	-	1.44	3.16	16.2
26		X		3	28	7×0.127 (1)	0.42	0.089	225	-	0.82	2.04	6.26
27		X		3	26	7×0.16 (1)	0.5	0.14	153	-	0.89	2.2	7.8
28		X		3	24	7×0.2	0.62	0.22	91.6	-	1.04	2.52	11
29		X		3	22	7×0.25	0.77	0.34	58.7	-	1.19	2.84	15.8
30		X		3	20	19×0.2	1.03	0.6	33.8	-	1.44	3.4	24
31		X		4	28	7×0.127 (1)	0.42	0.089	225	-	0.82	2.25	8.17
32		X		4	26	7×0.16 (1)	0.5	0.14	153	-	0.89	2.42	10.3
33		X		4	24	7×0.2	0.62	0.22	91.6	-	1.04	2.78	14.8
34		X		4	22	7×0.25	0.77	0.34	58.7	-	1.19	3.14	21.2
35		X		4	20	19×0.2	1.03	0.6	33.8	-	1.44	3.74	32.2
36	X			1	28	7×0.127 (1)	0.42	0.089	215	0.055	0.82	1.22	3.77
37	X			1	26	7×0.16 (1)	0.5	0.14	146	0.055	0.89	1.29	4.63
38	X			1	24	7×0.2	0.62	0.22	87.2	0.07	1.04	1.52	6.38
39	X			1	22	7×0.25	0.77	0.34	55.8	0.07	1.19	1.67	8.26
40	X			1	20	19×0.2	1.03	0.6	32.2	0.07	1.44	1.92	11.4
41	X			2	28	7×0.127 (1)	0.42	0.089	225	0.07	0.82	2.12	7.62
42	X			2	26	7×0.16 (1)	0.5	0.14	153	0.07	0.89	2.26	9.24
43	X			2	24	7×0.2	0.62	0.22	91.6	0.07	1.04	2.56	11.7
44	X			2	22	7×0.25	0.77	0.34	58.7	0.07	1.19	2.86	15.5
45	X			2	20	19×0.2	1.03	0.6	33.8	0.07	1.44	3.36	21.7
46	X			3	28	7×0.127 (1)	0.42	0.089	225	0.07	0.82	2.24	10.7
47	X			3	26	7×0.16 (1)	0.5	0.14	153	0.07	0.89	2.39	12.5

Variant No.	Shielded	Un-Shielded		No. of Cores	Wire Size AWG	Stranding No. of Strands × Diameter (mm)	Conductor Characteristics			Shield Strand Ø (mm)	Core Max Ø (mm)	Finished Wire Or Cable Characteristics	
		Jacketed	Un-Jacketed				Max Ø (mm)	Nom Section (mm^2)	Max Ohmic Resistance (Ω/km)			Max Ø (mm)	Max Weight (kg/km)
48	X			3	24	7×0.2	0.62	0.22	91.6	0.07	1.04	2.72	16
49	X			3	22	7×0.25	0.77	0.34	58.7	0.07	1.19	3.04	21.2
50	X			3	20	19×0.2	1.03	0.6	33.8	0.1	1.44	3.73	33.7
51	X			4	28	7×0.127 (1)	0.42	0.089	225	0.07	0.82	2.45	12.8
52	X			4	26	7×0.16 (1)	0.5	9.14	153	0.07	0.89	2.62	15.6
53	X			4	24	7×0.2	0.62	0.22	91.6	0.07	1.04	2.98	20.5
54	X			4	22	7×0.25	0.77	0.34	58.7	0.1	1.19	3.49	30.5
55	X			4	20	19×0.2	1.03	0.6	33.8	0.1	1.44	4.09	43.2
56			X	1	18	19×0.25	1.29	0.93	20.6	-	-	1.85	12
57			X	1	16	19×0.285	1.44	1.23	16.5	-	-	2.23	17
58			X	2	18	19×0.25	1.29	0.93	21.6	-	1.85	3.7	24.9
59			X	2	16	19×0.285	1.44	1.23	17.3	-	2.23	4.46	34.6
60			X	3	18	19×0.25	1.29	0.93	21.6	-	1.85	3.98	37.3
61			X	3	16	19×0.285	1.44	1.23	17.3	-	2.23	4.8	51.8
62			X	4	18	19×0.25	1.29	0.93	21.6	-	1.85	4.46	49.7
63			X	4	16	19×0.285	1.44	1.23	17.3	-	2.23	5.37	69.1
64		X		2	18	19×0.25	1.29	0.93	21.6	-	1.85	3.83	26
65		X		2	16	19×0.285	1.44	1.23	117.3	-	2.23	4.63	35.8
66		X		3	18	19×0.25	1.29	0.93	21.6	-	1.85	4.13	38.6
67		X		3	16	19×0.285	1.44	1.23	17.3	-	2.23	4.93	59.3
68		X		4	18	19×0.25	1.29	0.93	21.6	-	1.85	4.59	51.2
69		X		4	16	19×0.285	1.44	1.23	17.3	-	2.23	5.5	70.9
70	X			1	18	19×0.25	1.29	0.93	20.6	0.07	1.85	2.26	17
71	X			1	16	19×0.285	1.44	1.23	16.5	0.07	2.23	2.6	22.9

Variant No.	Shielded	Un-Shielded		No. of Cores	Wire Size AWG	Stranding No. of Strands × Diameter (mm)	Conductor Characteristics			Shield Strand Ø (mm)	Core Max Ø (mm)	Finished Wire Or Cable Characteristics	
		Jacketed	Un-Jacketed				Max Ø (mm)	Nom Section (mm^2)	Max Ohmic Resistance (Ω/km)			Max Ø (mm)	Max Weight (kg/km)
72	X			2	18	19×0.25	1.29	0.93	21.6	0.1	1.85	4.23	35.5
73	X			2	16	19×0.285	1.44	1.23	17.3	0.1	2.23	4.98	47.8
74	X			3	18	19×0.25	1.29	0.93	21.6	0.1	1.85	4.6	51
75	X			3	16	19×0.285	1.44	1.23	17.3	0.1	2.23	5.41	67.9
76	X			4	18	19×0.25	1.29	0.93	21.6	0.1	1.85	5.07	65.9
77	X			4	16	19×0.285	1.44	1.23	17.3	0.1	2.23	5.97	91.5
78			X	1	30	7×0.1 (1)	0.32	0.055	375	-	-	0.71	1.2

NOTES:

1. Copper alloy.

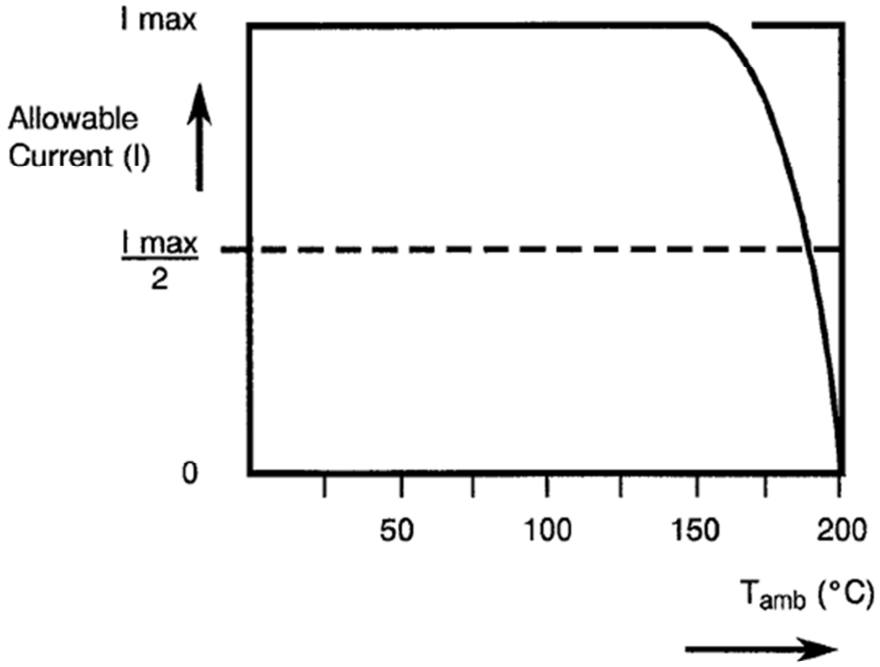
TABLE 1(b) – MAXIMUM RATINGS

No.	Characteristics	Symbol	Maximum Rating	Unit	Remarks
1	Voltage	V_P	600	V_{rms}	
2	Maximum Current (Note 1)	I_{max}		A	For AWG:
			0.8		30
			1.5		28
			2.5		26
			3.5		24
			5		22
			7.5		20
			10		18
			13		16
3	Operating Temperature Range	T_{amb}	-100 to +200	^oC	
4	Storage Temperature Range	T_{stg}	-100 to +200	^oC	

NOTES:

1. The above specified current will generate a temperature rise of approximately 50°C above ambient temperature in a vacuum environment. Precautions shall be taken to prevent the total temperature of the wire (ambient plus rise) exceeding the continuous operating temperature of the wire.

FIGURE 1 – PARAMETER DERATING INFORMATION



Allowable Current versus Temperature

FIGURE 2 – PHYSICAL CHARACTERISTICS

Dimensions are given in Table 1(a)

FIGURE 2(a) – FINISHED WIRES

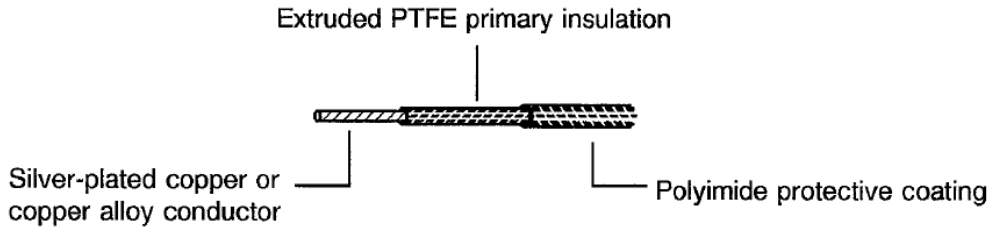


FIGURE 2(b) – UNSHIELDED MULTICORE CABLES

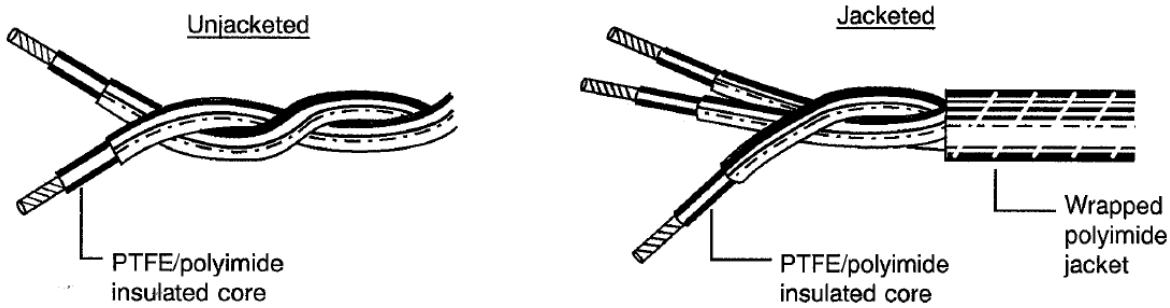


FIGURE 2(c) – SHIELDED AND JACKETED CABLES

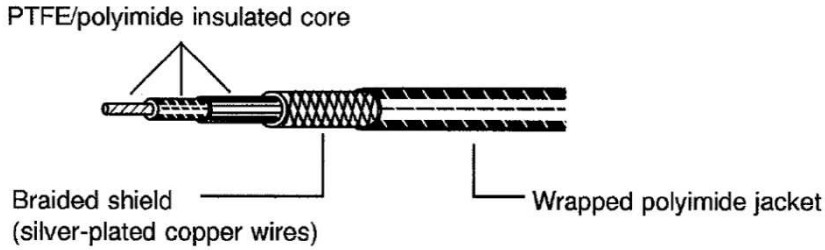
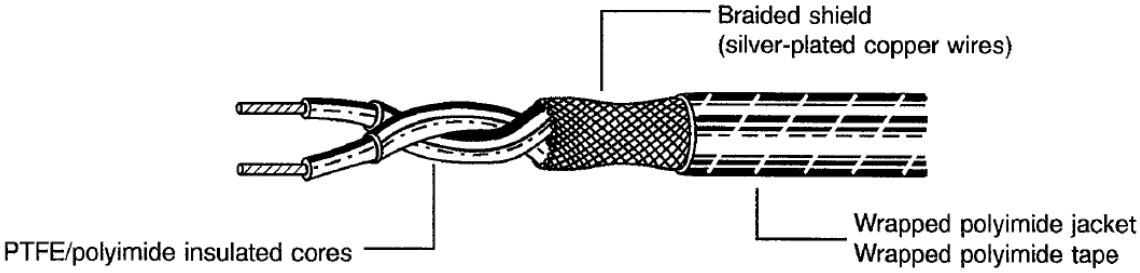


FIGURE 2(d) – SHIELDED AND JACKETED CABLES



2 APPLICABLE DOCUMENTS

The following documents form part of this specification and shall be read in conjunction with it:

(a) ESCC Generic Specification No. 3901, Wires and Cables, Electrical, 600V, Low Frequency.
(b) MIL-W-81381, Wires, Electrical, Polyimide Insulated, Copper or Copper Alloy.

3 TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS

For the purpose of this specification, the terms, definitions, abbreviations, symbols and units specified in ESCC Basic Specification No. 21300 and ESCC Generic Specification No. 3901 shall apply.

4 REQUIREMENTS

4.1 GENERAL

The complete requirements for procurement of the finished wires and cables specified herein are stated in this specification and ESCC Generic Specification No. 3901. Deviations from the Generic Specification, applicable to this specification only, are listed in Para. 4.2.

Deviations from the applicable Generic Specification and this Detail Specification, formally agreed with specific Manufacturers on the basis that the alternative requirements are equivalent to the ESCC requirements and do not affect the components' reliability, are listed in the Appendices attached to this specification.

4.2 DEVIATIONS FROM GENERIC SPECIFICATION

4.2.1 Deviations from Special In-process Controls

None.

4.2.2 Deviations from Final Production Tests (Chart II)

None.

4.2.3 Deviations from Burn-in and Electrical Measurements (Chart III)

Not applicable.

4.2.4 Deviations from Qualification Tests (Chart IV)

(a) Para. 9.21, Resistance to Fluids: To be modified as stated in Para. 4.8.11 of this specification.

4.2.5 Deviations from Lot Acceptance Tests (Chart V)

None.

4.3 MECHANICAL REQUIREMENTS

4.3.1 Dimension Check

The dimensions of the finished wires and cables specified herein shall be checked. They shall conform to those shown in Table 1(a), Figure 2 and Para 4.4 of this specification (see below for the list of parameters to be checked).

LIST OF PARAMETERS TO BE CHECKED

Parameter	Table 1(a)	Figure 2	Para. 4.4
COMPOSITION			
Number of conductors	X		
Gauge	X		
Shielding	X		
Jacket		X	
CONDUCTOR			
Nature			X
Outer diameter	X		
Number of strands	X		
Strand diameter	X		
Length of lay			X
Silver thickness			X
INSULATION			
Composition		X	X
Protective coating		X	X
Thickness			X
Outer diameter	X		
Concentricity			X
SHIELDING			
Number of strands	X		
Type of shielding			X
Strand diameter	X		
Nature		X	X
Silver thickness			X
Shielding lay			X
Braid angle			X
Shield coverage			X
JACKET			
Composition		X	X
Protective coating		X	X
Thickness			X
Overlapping			X
Outer diameter	X		

4.3.2 Weight

The maximum weight of the finished wires and cables specified herein shall be as specified in Table 1(a).

4.4 MATERIALS AND FINISHES

The materials and finishes shall be as specified herein. Where a definite material is not specified, a material which will enable the wires and cables specified herein to meet the performance requirements of this specification shall be used. Acceptance or approval of any constituent material does not guarantee acceptance of the finished product.

4.4.1 Conductor

4.4.1.1 Material Characteristics

All strands used in the manufacture of the conductors shall be silver-coated, soft or annealed, oxygen-free high conductivity copper from AWG 16 to 24 inclusive and silver-coated, high strength copper alloy for AWG 26 to 30. On silver-coated strands, the thickness of silver shall be 2 microns minimum.

On all copper conductors, any strand shall show a 10% minimum elongation. On all high-strength copper alloy conductors, any strand shall show a 6% minimum elongation at break and a 350N/mm^2 minimum tensile strength.

The resistance of the conductors shall be determined at +20°C in accordance with Para 9.5 of ESCC Generic Specification No. 3901, where the α coefficient for copper alloy is 0.0035.

4.4.1.2 Stranding

The conductors shall be constructed of concentrically laid strands to produce a smooth and uniform conductor of circular cross-section and free from any high strands or other surface irregularities.

The length of the left-hand lay of the external layer shall not be less than 8, nor more than 16, times the maximum conductor diameter specified in Table 1(a).

4.4.2 Insulation

4.4.2.1 Material

Any insulating material shall be virgin polytetrafluoroethylene and polyimide with only those additives that are necessary for processing and pigmentation.

4.4.2.2 Construction

The insulation shall have a uniform cross-section throughout the length of the cable and the conductor shall be evenly centred in the insulation.

At any cross-section along the length of the completed wire, the minimum thickness of the insulation shall not be less than 41% of the difference between measured diameter over insulation and measured diameter over conductor, nor less than 70% of the maximum thickness at that cross-section. Measurements to determine concentricity shall be made of the primary insulation only and shall not include the thickness of outer coverings.

Nominal overall wall thickness: 0.2mm.

PTFE: 0.18mm.

Coating: 0.02mm.

4.4.3 Shield

4.4.3.1 Material

Shield strands shall meet the requirements for silver-coated, annealed copper as outlined in Para. 4.4.1.1 of this specification.

4.4.3.2 Construction

The shield shall be made of closely woven round strands and provide not less than 90% coverage, 'K' being calculated by the following formula:

$K = (2F - F^2) \times 100$,

where:

– K = % coverage.
– $F = \frac{n.d.P}{\sin a}$

and where:

– n = number of strands per carrier.
– d = diameter of strands (mm).
– P = picks per mm.
– a = angle of braid with cable axis in degrees: $\tan a = \frac{2\pi(D+2d)P}{C}$

where:

– D = effective diameter of cable under shield (mm).
– D = (π+n) b/π, where:
  - n = number of basic wires
  - b = basic wire diameter.
  - C = number of carriers.

4.4.4 Jacket

Wrapped sealed polyimide tape, type 0.1/1/0.1 according to MIL-W-81381:

– 1 layer minimum for jacketed unshielded cables.
– 2 layers minimum for shielded and jacketed cables.

4.5 MARKING

4.5.1 General

The marking of all spools of finished wires and cables delivered to this specification shall be in accordance with the requirements of ESCC Basic Specification No. 21700. Each spool shall be marked in respect of:

(a) The ESCC Component Number.
(b) Characteristics.
(c) Traceability Information.
(d) Additional Marking.

4.5.2 The ESCC Component Number

Each spool shall bear the ESCC Component Number which shall be constituted and marked as follows:

Example: 390101302B

– Detail Specification Number: 3901013
– Type Variant (see Table 1(a)): 02
– Testing Level (B is mandatory): B

4.5.3 Characteristics

The characteristics shall show the length(s) of finished wire or cable wound on each spool and the length shall be marked as follows:

Example: 100m

– Length in metres (see Note): 100
– Symbol for metres: m

NOTES:

1. Whenever the length is less than 100 metres, insert a zero in the first block (example: 075m). If more than one length of finished wire or cable is wound on a spool, the characteristics of each length shall be marked as above.

4.5.4 Traceability Information

Each spool shall be marked in respect of traceability information in accordance with the requirements of ESCC Basic Specification No. 21700.

4.5.5 Additional Marking

Each spool shall bear the cable manufacturer's Quality Control Inspector's stamp or initials.

4.6 ELECTRICAL MEASUREMENTS

4.6.1 Electrical Measurements at Room Temperature

The parameters to be measured at room temperature are scheduled in Table 2. The measurements shall be performed at T_{amb} = +22±3 °C.

4.6.2 Electrical Measurements at High and Low Temperatures

Not applicable.

4.6.3 Circuits for Electrical Measurements

Not applicable.

4.7 BURN-IN TESTS
Not applicable.

4.8 ENVIRONMENTAL AND ENDURANCE TESTS

4.8.1 Mechanical Properties of Conductor
As detailed in Para. 4.4.1.1 of this Specification.

4.8.2 Accelerated Ageing
Ageing Temperature: +250±5 °C.

The mandrel diameter and appropriate weight used for accelerated age testing of the finished wires is given in Table A.

TABLE A – MANDREL DIAMETERS AND LOADS FOR FINISHED WIRES

Wire Size (AWG)	Mandrel Diameter (mm)	Weight (kg)
30	3	0.2
28	3	0.2
26	3	0.2
24	3	0.2
22	6	0.35
20	6	0.35
18	6	0.5
16	10	0.5

4.8.3 Wrap Test at Ambient Temperature

The mandrel diameters and applied loads for wrap testing of finished wires are given in Table A. The mandrel diameters and applied loads for screened and jacketed cables are given in Table B.

TABLE B – MANDREL DIAMETERS AND LOADS FOR SHIELDED AND JACKETED CABLES

Cable Size (AWG)	Number of Cores	Mandrel Diameter (mm)	Load (kg)
28	1	6	0.2
26	1	6	0.2
24	1	6	0.2
22	1	6	0.35
20	1	6	0.35
18	1	10	0.5
16	1	12	0.5
28	2	12	0.4
26	2	12	0.4
24	2	12	0.4
22	2	12	0.7
20	2	12	0.7
18	2	15	1
16	2	15	1
28	3	12	0.6
26	3	12	0.6
24	3	12	0.6
22	3	12	1
20	3	12	1
18	3	15	1.5
16	3	15	1.5
28	4	12	0.8
26	4	12	0.8
24	4	12	0.8
22	4	12	1.5
20	4	12	1.5
18	4	20	2
16	4	20	2

4.8.4 Voltage Test

No particular conditions are applicable.

4.8.5 Shrinkage

The shrinkage temperature shall be +260±5 °C.

4.8.6 Blocking

The blocking temperature shall be +260±5 °C.

4.8.7 Cold Bend Test

The mandrel diameters and loads shall be as specified in Table C.

TABLE C – MANDREL DIAMETERS AND LOADS FOR FINISHED WIRES OR CORES

Wire Size (AWG)	Mandrel Diameter (mm)	Weight (kg)
30	6	0.2
28	6	0.2
26	6	0.2
24	6	0.2
22	10	0.35
20	10	0.35
18	10	0.5
16	13	0.5

4.8.8 Cut-through Resistance

The mean load measured during the required tests shall not be less than the relevant value specified below:

Wire Size (AWG)	30	28	26	24	22	20	18	16
Cut-through Load (kg)	2	2.5	2.7	3	3.6	4.2	4.75	5.4

4.8.9 Notch Resistance

The depth of notch shall be 0.08mm.

4.8.10 Flammability

No particular conditions are applicable.

4.8.11 Resistance to Fluids

Tests (e) and (f) shall be performed only on finished wires or cores.

4.8.12 Surface Resistance

No particular conditions are applicable.

4.8.13 Abrasion Resistance

The weight to be applied to the needle is specified below:

Wire Size (AWG)	30	28	26	24	22	20	18	16
Scrape Abrasion Load (kg)	450	500	550	650	750	850	925	1000

4.8.14 Soldering

No particular conditions are applicable.

4.8.15 Solderability

No particular conditions are applicable.

4.8.16 Radiation Resistance

No particular conditions are applicable.

4.8.17 Overload Resistance

No particular conditions are applicable.

4.8.18 Long-term Ageing Test
The long-term ageing temperature shall be +200°C.

4.8.19 Anthony and Brown Test
No particular conditions are applicable.

TABLE 2 – ELECTRICAL MEASUREMENTS AT ROOM TEMPERATURE

No.	Characteristics	Specification and Test Method	Test Condition	Limits	Unit
1	Conductor Resistance	ESCC No. 3901, Section 9	Para. 9.5	Table 1(a)	Ω/km
2	Spark Test	ESCC No. 3901, Section 9	Para. 9.6	Insulation: 3 Jacket: 1.5	kV
3	Voltage Test	ESCC No. 3901, Section 9	Para. 9.7	Para. 9.7	kV
4	Insulation Resistance	ESCC No. 3901, Section 9	Para. 9.8	Insulation: 5000 Jacket: 30	MΩ.km
5	Surface Resistance	ESCC No. 3901, Section 9	Para. 9.22	125	MΩ.mm