



**LIGHTWEIGHT, EXTRA THIN, FLUOROPOLYMER
INSULATED WIRES AND CABLES, LOW
FREQUENCY, 600V, -200 TO +200 °C
BASED ON TYPE LEW**

ESCC Detail Specification No. 3901/026

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1 GENERAL

1.1 SCOPE

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

1.2 TYPE VARIANTS

Variants of the basic types of wires and cables 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 a 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 the finished wire used in a bundle shall be:

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

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

where n = number of wires in a 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 DIMENSIONS AND CHARACTERISTICS

The physical characteristics of the 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		No. of Cores	Wire Size ISO / (AWG)	Stranding No. of Strands x Diameter (mm)	Conductor Characteristics			Shield Strand Dia (mm)	Core Max Dia (mm)	Finished Wire or Cable Characteristics	
	Yes	No				Max Dia (mm)	Nom Sect. (mm ²)	Max Ohmic Resistance (Ω/km)			Max Dia (mm)	Max Weight (kg/km)
01		x	1	-/(28)	7x0.127	0.39	0.09	253	-	-	0.62	1.14
02		x	1	001/(26)	19x0.1 (1)	0.47	0.15	157	-	-	0.71	1.63
03		x	1	002/(24)	19x0.12 (1)	0.58	0.25	111	-	-	0.83	2.25
04		x	1	004/(22)	19x0.15 (1)	0.76	0.4	58	-	-	1.1	3.74
05		x	1	006/(20)	19x0.2 (1)	0.99	0.6	32	-	-	1.25	6.2
06		x	1	012/(16)	19x0.3 (1)	1.49	1.2	14	-	-	1.8	13.5
07		x	2	001/(26)	19x0.1 (1)	0.47	0.15	170	-	0.75	1.45	3.4
08		x	2	002/(24)	19x0.12 (1)	0.58	0.25	120	-	0.85	1.8	4.9
09		x	2	004/(22)	19x0.15 (1)	0.76	0.4	63	-	1.1	2.2	7.6
10		x	2	006/(20)	19x0.2 (1)	0.99	0.6	35	-	1.26	2.5	12.7
11	x		2	-/(28)	7x0.127	0.39	0.09	258	0.079	0.7	1.75	5.9
12	x		2	001/(26)	19x0.1 (1)	0.47	0.15	170	0.079	0.75	1.95	7.1
13	x		2	002/(24)	19x0.12 (1)	0.58	0.25	120	0.079	0.85	2.2	9
14	x		2	004/(22)	19x0.15 (1)	0.76	0.4	63	0.079	1.1	2.45	12.6
15	x		2	006/(20)	19x0.2 (1)	0.99	0.6	35	0.079	1.26	3	19
16	x		3	-/(28)	7x0.127	0.39	0.09	259	0.079	0.7	1.85	7.9
17	x		3	001/(26)	19x0.1 (1)	0.47	0.15	171	0.079	0.75	2.05	9
18	x		3	002/(24)	19x0.12 (1)	0.58	0.25	121	0.079	0.85	2.3	11.3
19	x		4	-/(28)	7x0.127	0.39	0.09	260	0.079	0.7	2	9.1
20	x		4	001/(26)	19x0.1 (1)	0.47	0.15	171	0.079	0.75	2.2	11
21	x		4	002/(24)	19x0.12 (1)	0.58	0.25	122	0.079	0.85	2.4	14.3

NOTES:

1. In accordance with ISO 2635. AWG sizes are given for reference.

TABLE 1(b) – MAXIMUM RATINGS

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

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

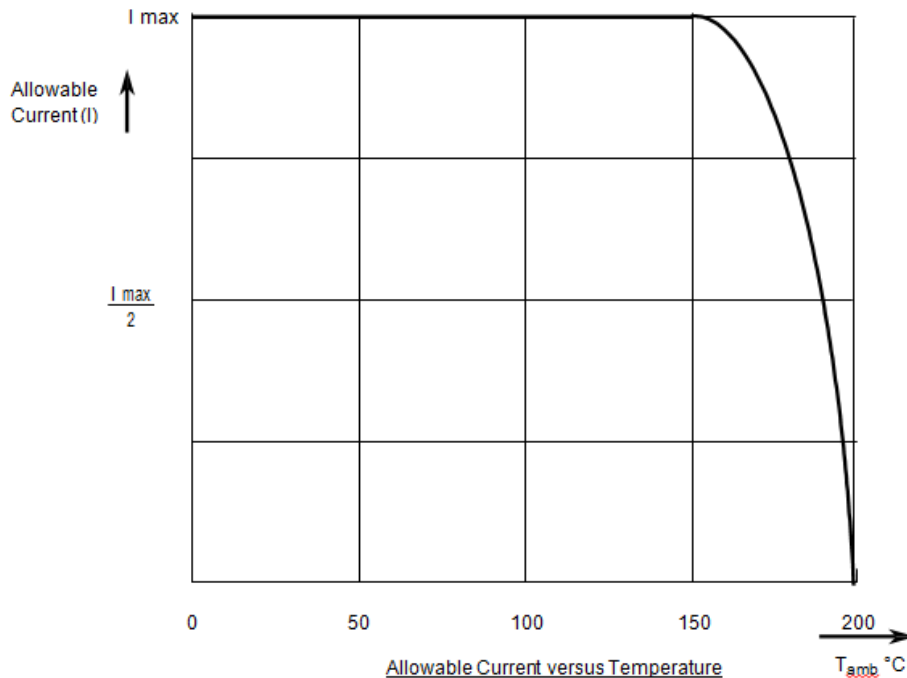


FIGURE 2 – PHYSICAL DIMENSIONS

Dimensions are given in Table 1(a)

FIGURE 2(a) – FINISHED WIRES

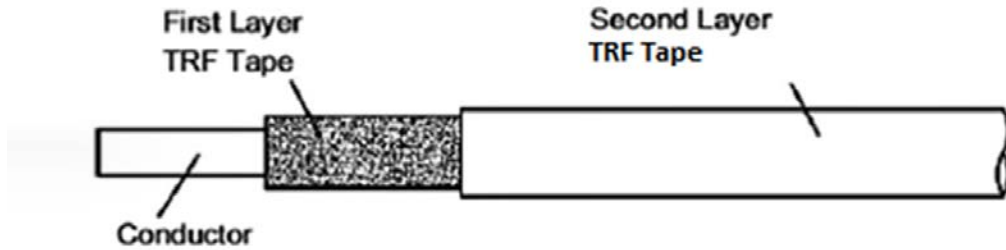
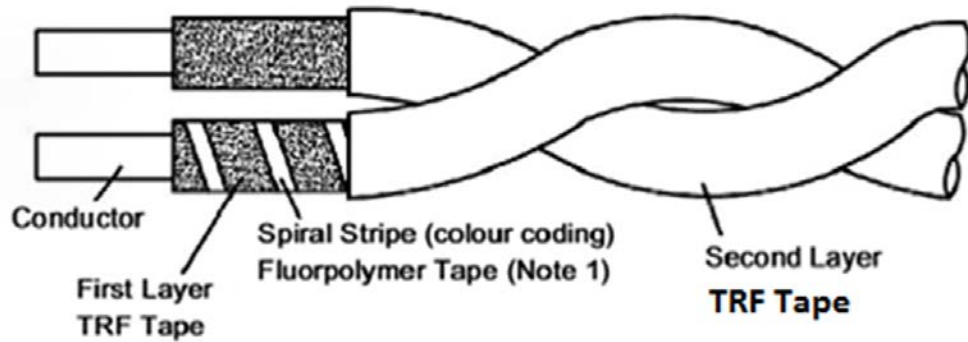


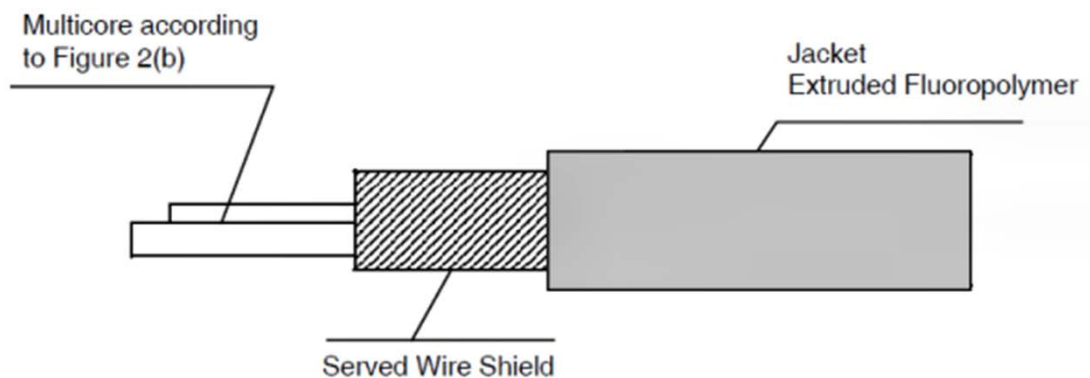
FIGURE 2(b) – MULTICORE CABLE



NOTES:

1. The colour coding is defined in Para. 4.4.6.2.

FIGURE 2(c) - SHIELDED AND JACKETED CABLES



2 APPLICABLE DOCUMENTS

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

- ESCC Generic Specification No. 3901, Wires and Cables, Electrical, 600V, Low Frequency.
- MIL-STD-104, Limits for Electrical Insulation Colours.
- ISO 2635, Aircraft - Conductors for General Purpose Aircraft.

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 THE GENERIC SPECIFICATION

4.2.1 Deviations from Special In-process Controls

None.

4.2.2 Deviations from Final Production Tests (Chart II)

- Paragraph 9.6.1, Spark Test: To be modified in accordance with Table 2 herein.
- Paragraph 9.7(b), Voltage Testing: To be modified in accordance with Para. 4.8.4 of this specification.

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

Chart III is not applicable.

4.2.4 Deviations from Qualification Tests (Chart IV)

None.

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 table below for the list of parameters to be checked).

LIST OF PARAMETERS TO BE CHECKED

Parameter	Table 1(a)	Figure 2	Para. 4.4
<u>COMPOSITION</u>			
Number of conductors	X		
Gauge	X		
Shielding	X		
Jacket		X	
<u>INNER CONDUCTOR</u>			
Nature			X
Outer diameter	X		
Number of strands	X		
Strand diameter	X		
Length of lay			X
Silver thickness			X
<u>INSULATION</u>			
Composition		X	X
Concentricity			X
Outer diameter	X		
Core Identification			X
<u>SHIELDING</u>			
Type of shielding			X
Strand diameter	X		
Nature		X	X
Silver thickness			X
Shielding lay			X
Shield coverage			X
<u>JACKET</u>			
Composition		X	X
Thickness			X
Protective sheath		X	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 for ISO 004, 006, 012, and silver-coated high strength copper alloy for ISO 001 and 002 and AWG 28 inclusive.

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.

For high-strength copper alloy conductors, the tensile characteristics shall be not less than 6% in elongation and 35kg/mm² in tensile strength.

For determination of the conductor resistance at +20°C, as mentioned in Para. 9.5 of ESCC Generic Specification No. [3901](#), the α coefficient for copper alloy is 0.0035 and for copper 0.0039.

4.4.1.2 *Stranding*

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

The length of 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*

The insulating material shall be Thin Resistant Fluoropolymer (TRF), or Fluoropolymer 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.

The insulation shall consist of wrapped layers of TRF tapes, a spiral stripe of Fluoropolymer tape as specified in Figure 2(a) and Figure 2(b).

4.4.3 Shield

4.4.3.1 *Material*

Shield strands shall be silver-coated, annealed copper as specified in Para. 4.4.1.1 of this specification, but the thickness of silver shall be 2.5 microns minimum.

4.4.3.2 Construction

Shields shall be closely and helically wound around the twisted bundle of insulated wires (core) and provide not less than 90% coverage as calculated by the following formula:

$$K = \frac{n \times d_w \sqrt{(\pi D)^2 + P^2}}{P \pi D} \times 100(\%)$$

- K = coverage (%)
- n = number of serving wires
- d_w = shield strand diameter (mm)
- D = diameter of core (mm)
- P = serving pitch (mm)

4.4.4 Jacket

All shielded cables shall be provided with jackets of extruded Fluoropolymer (wall thickness 0.15mm nominal) as specified in Figure 2(c).

4.4.5 Construction of Cables

Cables shall be constructed by twisting the required number and size of finished wires to form a uniform cable without high strands, bends or other irregularities. Finished wires of only one size shall be used for one cable.

The cabling shall be with a left-hand lay and the lay length shall not be less than 12 times and not be more than 16 times the outside diameter of the unshielded, unjacketed cable. The construction of shielded and jacketed cables is shown in Figure 2(c).

4.4.6 Colour Coding

4.4.6.1 Finished Wire Colour Coding

The colour of finished wires shall be natural.

4.4.6.2 Multicore Cable Colour Coding

All individual cores in multicore cables shall be coloured according to the following scheme:

No. of Cores in Cable	Colour of Respective Cores and Colour Coding Tape (Note 1)			
2	natural	natural with black colour coding tape		
3	natural	natural with black colour coding tape	natural with red colour coding tape	
4	natural	natural with black colour coding tape	natural with red colour coding tape	natural with green colour coding tape

NOTES:

1. The colour coding tape shall be spiral wrapped Fluoropolymer.

4.4.6.3 Jacket Colour

The colour of jacket shall indicate the wire size ISO / (AWG) of the individual insulated wires within the cable as defined in the table below:

Wire Size ISO / (AWG)	Jacket Colour
- / (28)	Red
001 / (26)	Green
002 / (24)	Blue
004 / (22)	Black
006 / (20)	Yellow

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: 390102614B

- Detail Specification Number: 3901026
- Type Variant (see Table 1(a)): 14
- 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 shall be marked as follows:

Example: 150m

- Length in metres (see Note): 150
- 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 Manufacturer's Quality Control Inspector's stamp.

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 $T_{amb} = +22 \pm 3$ °C.

4.6.2 Electrical Measurements at High and Low Temperatures

Not applicable.

4.6.3 Circuits for Electrical Measurements (Figure 4)

Not applicable.

4.7 BURN-IN TESTS

Not applicable.

4.8 ENVIRONMENTAL AND ENDURANCE TESTS (CHARTS IV AND V OF ESCC GENERIC SPECIFICATION NO. [3901](#))

4.8.1 Mechanical Properties of Conductor

The mechanical properties are detailed in Para. 4.4.1.1 of this Specification.

4.8.2 Accelerated Ageing

Ageing Temperature: $+230 \pm 5$ °C.

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 wrap testing of shielded and jacketed cables are given in Table B.

TABLE A – MANDREL DIAMETERS AND LOADS FOR FINISHED WIRES

Wire Size ISO / (AWG)	Mandrel Diameter (mm)	Applied Weight (kg)
- / (28)	6	0.25
001 / (26)	8	0.25
002 / (24)	8	0.25
004 / (22)	10	0.3
006 / (20)	10	0.4
012 / (16)	15	0.5

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

Wire Size ISO /(AWG)	Number of Cores	Mandrel Diameter (mm)	Applied Weight (kg)
- / (28)	2	10	0.5
001 / (26)	2	15	0.5
002 / (24)	2	20	0.5
004 / (22)	2	25	0.7
006 / (20)	2	25	0.8
- / (28)	3	12	0.5
001 / (26)	3	15	0.75
002 / (24)	3	20	0.75
- / (28)	4	12	0.8
001 / (26)	4	15	1
002 / (24)	4	20	1

4.8.4 Voltage Test

No particular conditions are applicable with regard to the voltage test performed on a sample.

The following conditions shall apply to the voltage test performed on the Whole Length:

- For cables, with or without a jacket, between conductors, at 3.5kV DC
- For shielded and jacketed cables, successively:
 - Between each conductor and all other conductors connected to the shield, at 3.5kV DC
 - Between shield and joined conductors, at 3.5kV DC

4.8.5 Shrinkage

The shrinkage temperature shall be +200±5 °C.

4.8.6 Blocking

The blocking temperature shall be +230±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 ISO / (AWG)	Mandrel Diameter (mm)	Applied Weight (kg)
- / (28)	6	0.25
001 / (26)	6	0.25
002 / (24)	6	0.25
004 / (22)	8	0.3
006 / (20)	8	0.4
012 / (16)	10	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 ISO / (AWG)	- / (28)	001 / (26)	002 / (24)	004 / (22)	006 / (20)	012 / (16)
Cut-through Load (N)	14	23	25	45	46	46

4.8.9 Notch Resistance

The depth of notch shall be 0.04mm minimum.

4.8.10 Flammability Resistance

No particular conditions are applicable.

4.8.11 Resistance to Fluids

No particular conditions are applicable.

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 ISO / (AWG)	- / (28)	001 / (26)	002 / (24)	004 / (22)	006 / (20)	012 / (16)
Weight Applied to Abrading Needle (g)	270	330	340	380	440	450

4.8.14 Soldering Shrinkage

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 Outgassing in Vacuum

No particular conditions are applicable.

4.8.19 Long-term Ageing Test

The long-term ageing temperature shall be +200 °C.

4.8.20 Anthony and Brown Test

No particular conditions are applicable.

TABLE 2 – ELECTRICAL MEASUREMENTS AT ROOM TEMPERATURE

No.	Characteristics	Spec. and/or Test Method	Test Conditions	Limits	Units
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: 2.5 Jacket: 1.5	kVrms
3	Voltage Test: Sample Whole Length	ESCC No. 3901, Section 9 Para. 4.2.2 of this Specification	Para. 9.7(a) Para. 4.8.4 of this Spec.	Para. 9.7(a) Para. 4.8.4 of this Spec.	kVrms kV DC
4	Insulation Resistance	ESCC No. 3901, Section 9	Para. 9.8	Insulation: ≥ 750 Jacket: ≥ 30	MΩ.km
5	Surface Resistance	ESCC No. 3901, Section 9	Para. 9.22	≥ 125	MΩ.mm