JULY, 1941.

EMERGENCY STANDARD
No. (E)D.1502–1941

STANDARDS ASSOCIATION OF AUSTRALIA.
Headquarters :
Science House, Gloucester and Essex Streets, Sydney.

AUSTRALIAN STANDARD SPECIFICATION FOR AIRCRAFT MATERIAL

(Emergency Series)

VARNISHED CAMBRIC INSULATED CABLES

For Power and Lighting for Aircraft.

This standard forms one of a series prepared by the Standards Association of Australia at the request of Departments of the Commonwealth Government for use in relation to the supply of materials required for defence purposes. In appropriate cases these specifications will be reviewed for inclusion in the normal series of Australian standards.

SCOPE.

1. Scope. This specification shall apply to varnished cambric insulated cables, single- and multi-core, both shielded and unshielded, for use in power and lighting circuits of aircraft, operating on voltages not exceeding 50 volts D.C.

STANDARD SIZES.

2. Standard Sizes.

(*a*) *Conductor Sizes.* The nominal cross-sectional areas of conductors given in Table I shall be considered standard for aircraft power and lighting cables.

(*b*) *Cable Sizes.* The maximum diameters of the finished cables given in Table I shall be considered standard for varnished cambric insulated cables for aircraft power and lighting.

MATERIALS.

3. General. When materials are used which are not specifically designated they shall be entirely suitable for the purpose.

4. Conductors. All wires used in the manufacture of cable to this specification shall be of annealed copper drawn from wire bars complying with British Standard No. 198, "Electrolytic Copper Wire Bars, Cakes, Slabs and Billets."

The wires shall be uniformly coated with a smooth continuous layer of tin, free from all impurities, the quality of the tinning being such that the tinned wires shall comply with the tinning test described in Clause 22 (a). All wires shall be free from lumps, burrs, kinks, abrasions, scraped or corroded surfaces and skin imperfections.

The resistance of the finished conductors shall not exceed the values given in Table I.

5. Varnished Cambric. The varnished cambric insulation shall consist of a high grade of varnished cloth substantially free from blisters or other imperfections, and shall in the finished cable be capable of complying with the tests described in Clause 22 of this specification.

6. Cotton Braid. Adjacent threads of the cotton braid shall touch each other.

The thickness of the braid shall be not less than that given in Table I.

7. Braid Impregnating or Coating Compound. The impregnating or coating compound shall withstand temperatures up to 70° C. and shall be flexible, non-cracking, flame-resisting and waterproof. It shall not deteriorate seriously when exposed to sunlight, oil, petrol, kerosene or salt water, and shall be capable of complying with the tests described in Clause 22 of this specification.

8. Shielding. The shielding shall comprise closely woven braid of tinned copper wire.

The diameter of the braiding wire shall be not less than 0·005 in. nor greater than 0·008 in.

The metallic braid shall be applied in such a manner as to cover not less than 70% of the underlying impregnated cotton braid in the case of single-core cables and not less than 70% of the minimum area enclosing the braided and compounded conductors of multi-core cable. The coverage shall be calculated by the methods described in Appendix A.

CONSTRUCTION.

9. General. The cable shall be manufactured in a thoroughly workmanlike manner, consistent with high grade commercial practice for this class of work.

10. Conductors. The conductors shall be composed of tinned copper wires in accordance with Table I with a bunched, concentric or rope-lay stranding. The finished conductor and the individual wires shall be uniformly circular in cross section and shall be free from nicks, kinks and flats.

The cross-sectional area of the conductor shall be deemed to be the sum of the areas of the component wires and shall be within plus 5% and minus 1½% of the nominal area specified in Table I.

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11. Insulation. The conductor shall be covered with not less than two layers of varnished cambric strip of the width specified in Table I, wound helically in opposite directions. Each layer shall be wound tightly, evenly and substantially free from wrinkles, and shall form a continuous sheath by overlapping not less than 33% of the width of the strip measured normal to the edge of the strip.

12. Braiding. Cotton braid conforming to Clause 6 shall be applied over the cambric and shall be thoroughly treated with compound complying with Clause 7.

13. Diameter of Finished Cable. The diameter of the finished single-core unshielded cable shall not exceed that given in Table I.

14. Multi-core Cables. Multi-core cables shall consist of the requisite number of single conductors, each manufactured in accordance with the provisions of Clauses 9 to 13, cabled with a suitable lay and then braided overall with cotton braid complying with Clause 6. The braid shall be thoroughly treated with compound complying with Clause 7.

15. Shielded Cable.

(*a*) *Single-core shielded cable* shall consist of a single conductor manufactured in accordance with the provisions of Clauses 9 to 13 enclosed in a braided metal shield complying with Clause 8. A further layer of cotton braid shall then be applied over the metal shield, and shall be thoroughly treated with compound complying with Clause 7.

(*b*) *Multi-core shielded cable* shall consist of the requisite number of single conductors, each manufactured in accordance with the provisions of Clauses 9 to 13 cabled with a suitable lay and then braided overall with a metal shield complying with Clause 8. A further layer of cotton braid shall then be applied over the metal shield, and shall be thoroughly treated with compound complying with Clause 7.

16. Finish. After braiding and compounding the cable shall have an even, smooth and waterproof finish. When the cable is wound on reels, adjacent layers shall not stick to one another at any temperature under 70° C.

17. Identification. Every cable manufactured to this specification shall have incorporated throughout its entire length, either in the insulation or in the cotton braid, a manufacturer's mark, by means of which the cable may be identified.

PACKING AND MARKING.

18. Length. Unless otherwise specified, the cable shall be supplied in continuous, unspliced lengths of not less than 100 yd.

19. Packing. Each length of cable shall be delivered on a suitable reel which shall be of strong construction and shall have flanges of sufficient diameter to protect the cable from injury in handling and rolling.

20. Marking. The following information shall be marked on each roll :

(i) The number of this specification.
(ii) The cable size number.
(iii) The length in yards.
(iv) The manufacturer's name or distinguishing mark.
(v) The purchaser's Stores Reference Number (if required in the purchaser's specification).
(vi) The inspector's stamp.

SAMPLING AND TESTING.

21. Sampling. A sample of suitable length shall be selected at random from each continuous length of unspliced cable and shall be tested in accordance with this specification not less than 14 days after the final application of the impregnating or coating compound.

All samples selected for test shall be in addition to the quantities specified in the order and shall be furnished free of charge.

22. Testing.

(*a*) *Physical Test of Copper Conductors.* Each strand of the finished conductor shall withstand an elongation of 15% of its length in 10 in. before breaking (10 in. elongated to 11·5 in.). The wire shall be pulled at a uniform rate of one inch per minute.

(*b*) *Tinning Test.* Test pieces of the tinned wire before being stranded or insulated, each approximately 6 in. long, shall be used. The wires shall be thoroughly cleaned by immersion for three minutes in one or more of the following solvents : benzol, re-distilled petroleum ether, alcohol or carbon tetrachloride, and shall be wiped dry with a clean soft cloth after each immersion. After cleaning, that part of the wire to be immersed in the test solutions shall not be handled.

Each test piece shall then be immersed in test solutions, as stated below, the solutions being maintained at a temperature of approximately 15·6° C. throughout the test. The cycle of operation shall be performed twice, each cycle consisting of :

First : immersion of the test piece for one minute in hydrochloric acid, as defined in Appendix B, the test piece then being washed in clean water and wiped dry.

Second : immersion of the test piece for 30 seconds in sodium polysulphide solution, as defined in Appendix B, the test piece then being washed in clean water and wiped dry.

The test piece shall then be examined to ascertain if copper exposed through openings in the tin coating has been blackened by the action of the sodium polysulphide. The test piece shall be considered to have failed if, by such blackening, exposed copper is revealed.

(*c*) *Flexibility Test.*

(i) Four suitable lengths of the finished cable at 20° C. ± 5° shall each be wound tightly round a smooth cylindrical rod of metal for ten complete turns with the coils touching, and shall be held in place by tying with string. The rod shall have a diameter equal to three times the diameter of the cable. Straight ends 7 in. long shall be brought away from the coil with a radius of curvature not less than that of the coil itself and shall project in the same direction at right angles to the axis of the coil.

The sample shall be considered to have failed if cracking of the compound or separation or breaking of the braid occurs in any one of the test pieces.

(ii) One of the coils prepared in accordance with paragraph (i) shall then be placed in an oven and maintained at a temperature of 70° C. ± 2° for 6 hours. At the expiration of this period, it shall be straightened and rewound without at any time showing signs of failure as defined in paragraph (i).

(*d*) *Test for Resistance to Lubricating Oil.* A second coil prepared for the flexibility test shall be immersed for 24 hours in mineral lubricating oil conforming to British Air Ministry Material Specification No. D.T.D.109, with 6 in. of the straight ends projecting vertically above the surface. Throughout the test the oil shall be maintained at a temperature of 70° C. ± 2°.

The oil adhering to the surface shall then be removed by lightly washing the coil in either aviation spirit or a mixture of 75 parts by volume of white spirit conforming to B.S. No. 245, and 25 parts by volume of benzol conforming to the latest issue of B.S. No. D.10. The impregnating or coating compound shall then show no signs of softening, absorption or other deterioration.

At the completion of the voltage and insulation resistance tests, the sample shall be dismantled and inspected for any penetration of oil into the cable.

(*e*) *Test for Resistance to Organic Solvents.* A third coil shall be immersed for 24 hours in a mixture of 75 parts by volume of white spirit conforming to B.S. No. 245, and 25 parts by volume of benzol conforming to the latest issue of B.S. No. D.10, under the conditions of immersion described in paragraph (*d*). Throughout the test the solvent mixture shall be maintained at a temperature of 20° C. ± 5°.

After removal from the solvent mixture, the sample shall be allowed to dry for 30 minutes and the impregnating or coating compound shall then show no signs of softening, absorption or other deterioration.

The sample shall then be placed in a suitably ventilated oven and maintained at a temperature of 40° C. ± 2° for 24 hours. On removal from the oven the sample shall be straightened and rewound and the impregnating or coating compound shall then show no signs of hardening, cracking or other deterioration.

At the completion of the voltage and insulation resistance tests, the sample shall be dismantled and inspected for any penetration of the solvent mixture into the cable.

(*f*) *Voltage and Insulation Resistance Tests.* The three coils tested in accordance with paragraphs (*c*) (ii), (*d*) and (*e*) and the remaining coil shall have 1 in. of any metal shield removed from each end and shall then be subjected to voltage and insulation resistance tests as follows :

(i) **Voltage Test.** The test pieces shall be immersed in water at a temperature of 20° C. ± 5°, under the conditions of immersion described in paragraph (*d*). After one hour's immersion, and while still immersed, the test voltage shall be applied between all conductors and the metal rod and metal shield, if any, also between each pair of adjacent conductors in a multi-core cable, for 15 minutes without failure.

The test voltage shall be approximately sine wave form, having a frequency of approximately 50 cycles per second and an R.M.S. value of 500 volts.

(ii) **Insulation Resistance Test.** Immediately following the voltage test and without removing the test pieces from the water, the insulation resistance between each of the conductors and the metal rod shall be measured at 500 volts D.C. after this voltage has been maintained for 1 minute. The effect of surface leakage shall be excluded by suitable guarding.

The insulation resistance so measured shall be not less than 1000 megohms per yard of the cable immersed, and the values obtained from the coils which have been subjected to the tests described in paragraphs (*c*) (ii), (*d*) and (*e*) shall not be lower than that obtained from the remaining coil.

(*g*) *Test on Varnished Cambric.* Test pieces approximately 12 in. long of each of the varnished cambric layers shall be removed from a portion of the cable and shall be immersed for 15 minutes in a bath of aircraft oil conforming to the latest issue of British Air Ministry Material Specification No. D.T.D. 109 at a temperature of 100° C. ± 3°.

A second set of similar test pieces shall be immersed for 15 minutes in a mixture of 75 parts by volume of white spirit conforming to B.S. Specification No. 245 and 25 parts by volume of benzol conforming to the latest issue of B.S. No. D.10. Throughout the test the solvent mixture shall be maintained at a temperature of 20° C. ± 5°.

These test pieces shall exhibit no signs of either softening or disintegration and flaking of the varnish as determined by inspection of the varnished cambric test pieces themselves and the fluids in which they were immersed.

(*h*) *Flame Test.* A sample of the cable 8 in. long shall have the braid and varnished cambric tape removed from each end for a distance of 1 in. The sample shall then be held by the bare conductor in a horizontal position, in still air, and the centre of the insulation ignited by means of an igniter conforming to Fig. 1. The igniter shall be removed immediately the cable has become ignited.

The flame shall either snuff itself out before it has travelled 2 in. either way from the point of ignition, regardless of the rate of travel, or, if it does not snuff itself out, it shall not be propagated faster than 1 in. in 30 seconds for the entire length of the insulation.

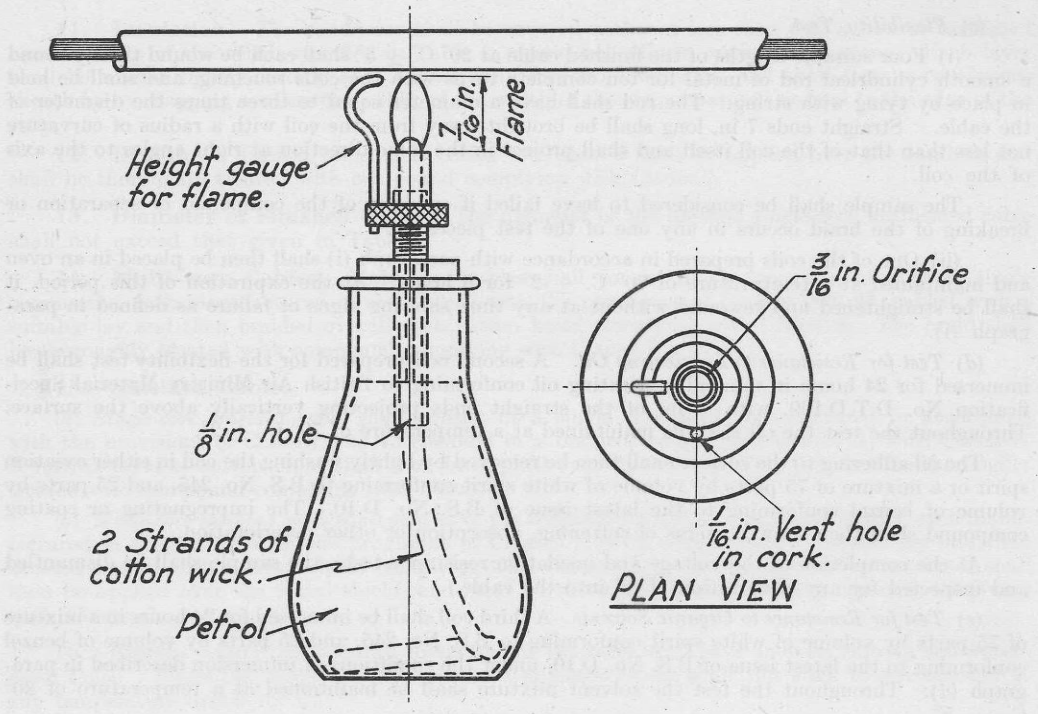

Fig. 1. Igniter for Flame Test.

23. Re-tests. If any test piece fails to fulfil the test requirements specified in Clause 22, five further test samples shall be selected by the inspector from the same continuous length of unspliced cable for testing in the same manner. Should any of these further samples fail to pass the same test the whole batch shall be rejected.

APPENDIX A.

Method of Calculating the Coverage of Metal Braid of Shielded Cables.

The percentage coverage of the metal braid of shielded cables shall be calculated as follows :

(*a*) *Single-core Cables.*

Remove a strand of the shielding from a short length of the cable. Count the number of parallel wires which lay between two successive turns of that strand and add the number of wires in the strand removed.

Designate the total number ..... A

Measure the diameter of one wire, and designate this dimension ..... B

Measure the distance along the axis of the cable between the centres of two consecutive turns of the track left by the removal of the strand, and designate this distance..... C

Measure the diameter of the cable over the shielding and subtract from this distance twice the thickness of one wire (2 × B). Calculate the circumference of the circle having a diameter equal to the dimension thus obtained.

Designate this ..... D

Designate the angle of advance of one strand ..... α

Calculate this angle from the following equation :—

$$\tan \alpha = C/D$$

$$\text{the percentage coverage} = P + P\,(1 - P) \times 100$$

$$\text{where } P = \frac{A \times B}{C \times \cos \alpha}$$

(*b*) *Multi-core Cables.*

The procedure is exactly as for single-core cables except that the value " D " shall be determined as follows :

Measure the perimeter of the cable over the metal braid and calculate the diameter of a circle having a circumference equal to this dimension. Subtract from this diameter twice the thickness of one wire (2 × B). Calculate the circumference of the circle having a diameter equal to the dimension thus obtained.

Designate this ..... D

APPENDIX B.

Solutions for the Tinning Test.

The solutions for the tinning test described in Clause 22 (*b*) shall be as follows :

(i) *Hydrochloric Acid Solution.* Commercial hydrochloric acid (specific gravity 1·12) shall be diluted to a specific gravity of 1·088 measured at 60° F. (15·6° C.).

A portion of hydrochloric acid solution having a volume of 180 ml. shall be considered to be exhausted when 20 test pieces have been immersed in it for two cycles.

(ii) *Sodium Polysulphide Solution.* The sodium polysulphide solution shall be made in the following manner :

Dissolve about 25 g. of pure sodium sulphide crystals in distilled water and make up to 100 ml. Add powdered sulphur in excess of the quantity required to saturate the solution (about 25 g. per 100 ml.) and boil for about one hour with occasional stirring.

Cool and filter the solution and then dilute with distilled water to a specific gravity of 1·142 measured at 60° F. (15·6° C.).

Throughout the test the sodium polysulphide solution shall have sufficient strength to blacken thoroughly a piece of clean untinned copper in five seconds.

TABLE I.

Single Conductor, Unshielded, Low Tension Cable.

Cable Size Number A.W.G.	Cross Sectional Area of Conductors, sq. in.			Minimum number of wires	Width of varnished cambric—nominal in.		Minimum thickness of braid in.	Maximum diameter of finished cable in.	Maximum Resistance per 1000 yd. Ohms
	Nominal	Minimum	Maximum		Minimum	Maximum			
00	·1046	·1030	·1098	1666	1	1½	0·020	0·575	·237
0	·0829	·0817	·0870	1666	1	1¼	0·020	0·525	·299
2	·0522	·0514	·0548	1064	1	1¼	0·020	0·440	·478
4	·0327	·0322	·0343	133	¾	1	0·020	0·370	·799
6	·0206	·0203	·0216	133	⅝	¾	0·015	0·300	1·231
8	·0129	·0127	·0136	49	½	⅝	0·015	0·250	1·923
10	·00810	·00797	·00850	49	½	⅝	0·015	0·208	3·08
12	·00512	·00504	·00537	19	⅜	½	0·015	0·186	4·91
14	·00329	·00324	·00345	19	⅜	½	0·015	0·166	7·54
16	·00203	·00199	·00213	19	⅜	½	0·015	0·146	12·06
18	·00128	·00126	·00134	16	⅜	½	0·015	0·136	19·6
20	·00079	·00077	·00083	10	⅜	½	0·015	0·126	31·4

For the purposes of this specification as an Australian standard the term "Inspector" shall be interpreted in the manner directed by the Australian Airworthiness Authority concerned.

This Specification, prepared by the Special Committee on Aircraft Materials and Components, was approved on behalf of the Council of the Association on 19th July, 1941.

NOTE.

In order to keep abreast of progress in the industries concerned, Australian standards are subject to periodical review. Suggestions for improvement, addressed to the Headquarters of the Association, will be welcomed.

Printed by Simmons Limited, 31-33 Parramatta Road, Glebe, Sydney.