

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.
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AEROSPACE STANDARD

AS 654

CABLE, SPECIAL PURPOSE, ELECTRICAL:
WIRE, ELECTRICAL (IGNITION, HIGH-TENSION)

Issued 10-30-64
Revised

1. SCOPE - This Aerospace Standard covers insulated, high-tension, shielded, special purpose cable and unshielded electrical cable for ignition systems of internal combustion engines for aircraft.
2. CLASSIFICATION - Cable shall be of the following types, grades, classes, and sizes, as specified (see 6.2).

Type I - Unshielded
Type II - Shielded
Grade A - Temperature range of +250° to -35°F
Grade B - Temperature range of +450° to -65°F
Grade C - Temperature range of +250° to -65°F
Grade D - Temperature range of +600° to -65°F
Class 1 - Copper conductor (19 strands min.)
Class 2 - Copper conductor (37 strands min.)
Class 3 - Corrosion-resistant steel conductor (7 strands min.)
Size 5 - 5 millimeter outside diameter
Size 7 - 7 millimeter outside diameter

3. APPLICABLE DOCUMENTS

- 3.1 The following specifications and standards of the issue in effect on the date of invitation for bids form a part of this standard.

3.1.1 Federal Specifications

O-A-548 - Antifreeze, Ethylene Glycol, Inhibited
QQ-W-343 - Wire, Electrical and Nonelectrical, Copper (Uninsulated)

3.1.2 Military Specifications

MIL-J-5161 - Jet Fuel, Referee
MIL-A-6091 - Fluid; Anti-Icing (Isopropyl Alcohol)
MIL-L-6082 - Lubricating Oil; Aircraft-Engine
MIL-L-7808 - Lubricating Oil; Aircraft Turbine Engine Synthetic Base
MIL-I-13811 - Insulating Compound, Electrical, Ignition
MIL-F-13927 - Fungus Resistance Test; Automotive Electrical Components, General Specification for

Section 8.3 of the SAE Technical Board rules provide that: "All technical reports, including standards approved and practices recommended, are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any SAE standard or recommended practice, and no commitment to conform to or be guided by any technical report. In formulating and approving technical reports, the Board and its Committees will not investigate or consider patents which may apply to the subject matter. Prospective users of the report are responsible for protecting themselves against liability for infringement of patents."

3.1.3 Military Standards

MIL-Std-105 - Sampling Procedures and Tables for Inspection by Attributes

MIL-Std-129 - Marking for Shipment and Storage

3.2 Other Publications - The following documents form a part of this standard. Unless otherwise specified, the issue in effect on date of invitation for bids shall apply.

Consolidated Freight Classification Rules and Container Specifications

(Application for copies should be addressed to the Consolidated Classification Committee, 202 Chicago Union Station, Chicago 6, Illinois.)

National Motor Freight Classification Rules and Container Specifications

(Application for copies should be addressed to the National Classification Board, 1424 Sixteenth Street, N. W., Washington 6, D.C.)

4. REQUIREMENTS

4.1 Qualification - Cable furnished under this standard shall be a product which has been tested and has passed the qualification tests specified herein. Subsequent to such qualification, no change shall be made in materials, design, or construction of a considered type, grade, class, and size of cable without approval of the purchaser. Upon request by the purchaser, the manufacturer shall furnish a certified report showing results of complete qualification testing.

4.2 Extension of Qualification - Qualification of cable of a given type, class, grade, and size submitted by a manufacturer may serve to qualify other cable or similar construction by the same manufacturer. Extension of qualification shall apply as follows:

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<u>SAMPLE</u>	<u>QUALIFIED</u>
<u>Type II</u>	<u>TYPE I & II</u>
<u>Grade</u>	<u>Grade</u>
A	A
B	B
C	C
D	D
<u>Class</u>	<u>Class</u>
1	1 & 3
2	1, 2 & 3
3	3 only
<u>Size</u>	<u>Size</u>
5	5 & 7
7	7 only

4.3 Materials - The materials used in the manufacture and testing of cable covered by this standard shall be as specified herein and in the applicable specification forming a part of this standard. Materials not specifically covered by this standard or the applicable specifications shall be suitable for the intended purpose and free of defects which may affect the serviceability and appearance of the finished cable.

4.4 Construction

4.4.1 Type I (Unshielded Cable) - Type I cable shall consist of a stranded conductor, insulation, layer of braid and a sheath.

4.4.2 Type II (Shielded Cable) - Type II cable shall consist of Type I cable covered with a closely woven metal shielding.

4.5 Components

4.5.1 Conductor - The conductor shall be composed of wires of composition, quality, and tempers suitable for stranding and insulating. It shall be continuous throughout its length, without weld, splice, or joint, except that individual wires may be spliced as specified in 4.5.4. The conductor shall be uniformly circular in cross section, and shall be free of abrasions, kinks, and flats. The number of individual wires, the diameter of the wire and the diameter of the conductor shall be as specified in Table I.

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TABLE I

Number and Diameter of Wires and Diameter of Conductors

Class	No. of Wires (Min.)	Wire Diameter		Conductor Diameter Maximum
		Minimum	Maximum	
1 - Copper	19	0.0111 inch	0.0116 inch	.061 inch
2 - Copper	37	0.0111 inch	0.0116 inch	.085 inch
3 - Steel	7	0.0126 inch	0.0134 inch	.041 inch

4.5.2 Wire - The wire shall be free from lumps, kinks, splits, abrasions, scraped or corroded surface, and any other defects caused in the manufacture or handling of the wire.

4.5.2.1 Class 1 and 2 - Wire strands used in Class I conductors of Grade A and Grade C cable shall be soft or drawn annealed copper coated with commercially pure tin in accordance with Type S of Specification QQ-W-343. Wire strands used in Class 1 and 2 conductors of Grades B and D cable shall be soft or drawn annealed copper conforming to Type S of Specification QQ-W-343 and coated with nickel of not less than 50 Mu in. in thickness. The coated strands shall show no exposed copper when tested as specified in 5.3.2.

4.5.2.1.1 Continuity of Coating - The tinned wire shall show no evidence of blackening (except within 1/2 inch of the out ends) when tested as specified in 5.3.2.

4.5.2.1.2 Elongation - The wire shall have an elongation of not less than 1 inch in 10 inches of length when tested as specified in 5.3.3.

4.5.2.2 Class 3 - The wire for stranded Class 3 conductor shall be of first class quality, annealed, corrosion-resistant steel, containing by weight 7.0 to 20.0% chromium and 7.0 to 12.0% nickel.

4.5.3 Stranding - The stranding shall be left-hand lay. Stranding for the Class 1 and Class 2 conductor may be bunched or concentric. Stranding for the Class 3 conductor shall be concentric. The stranding shall not tend to unlay, and the completed conductor shall not tend to spread out when an uninsulated portion is cut.

4.5.4 Splicing - Individual wires may be spliced provided the splices are made in a neat, workmanlike manner, and do not so increase the conductor diameter that it will not pass the tests specified herein.

4.6 Insulation - An insulation shall be applied over the entire cable length, concentric with the conductor. The insulation shall form a close fit over the conductor without adherence, and when stripped, it shall leave the conductor clean and in condition for soldering. As applied, extruded insulation shall be seamless and free of foreign material.

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- 4.6.1 Insulation Material - The compound shall be nonhygroscopic and free of foreign material and of any substance having a deteriorating effect on any part of the cable.
- 4.7 Braid - A braid shall be added over the insulating compound. The braid shall be glass or other approved nonhygroscopic, fungus resistant material. The braid shall be free of any substance that may have a deteriorating effect upon, or be affected by, the insulating compound or the sheath.
- 4.8 Sheath - A sheath of nonhygroscopic, flexible, non-cracking waterproof material, slow-burning or non-flammable, and resistant to oil as specified in 4.11.5 and to the growth of objectionable fungi, and which will not within specified temperature ranges interact unfavorably with the insulation, braid or shielding, shall be applied over the braid. The sheath shall have a thickness of not less than 0.018 inch when formed from an elastomeric material, and not less than 0.006 inch when formed from a semi-rigid material.
- 4.8.1 Cable and Insulation Eccentricity - The eccentricity of the conductor in relation to the completed cable, in the case of Type I, and to the unshielded cable, in the case of Type II, shall not exceed 6 percent of the cable diameter when calculated by the formula specified in a. below. The eccentricity of the conductor in relation to the insulation, as calculated by the formula specified in b. below, shall not exceed 12 percent.
- a. Cable eccentricity, percent =
$$\frac{(X - Y)}{2D} \times 100$$
- where: X = Maximum cable wall thickness, inches
Y = Minimum cable wall thickness, inches
D = Diameter of cable, inch
- b. Insulation eccentricity, percent =
$$\frac{(X - Y)}{X + Y} \times 100$$
- where: X = Maximum wall thickness, inches
Y = Minimum wall thickness, inches
- 4.8.2 Exterior Finish - Type I cable shall have an even, smooth, exterior finish, sufficiently slippery for easy assembly of the cable in conduit. The finish shall also assure that adjacent layers of the cable will not adhere when wound on reels or spools for shipment for storage, at temperatures up to 160°F.

4.9 Cable Dimensions

- 4.9.1 Outside Diameter - The outside diameter of Type I completed cable shall be as shown in Table II. When portions of the cable are slightly flattened or of oval cross section, the average of two diameters measured 90 degrees apart at any section shall be within the specified dimensions.

TABLE II

Outside Diameters, Type I Cable.

Diameter (Nom) Millimeters	Actual (Min) Inches	Diameter (Max) Inches
5	0.196	0.206
7	0.270	0.285

- 4.9.2 Lengths - The maximum length of any piece of cable longer than 200 feet shall be determined by the size of the reel or spool with relation to convenience in handling, shipping and storage. In no case shall the drum or the reel or spool be less than 8 inches in diameter. Unless otherwise specified, not more than 30 percent of the cable in each order may be delivered in lengths of 50 to 200 feet, and the remainder shall be in lengths over 200 feet.
- 4.10 Shielding - Shielding for Type II cable shall consist of a close and uniform woven wire applied directly over the sheath. Each carrier shall have no less than 5 No. 34 AWG (.0063) wires. Unless otherwise specified, shielding for Grade A and C cable shall be tin plated copper. Unless otherwise specified, shielding for Grade B cable shall be silver or nickel plated copper wire having a minimum plate thickness of 100 microinches. Unless otherwise specified, Grade D cable shielding shall be nickel or nickel clad copper having a minimum plate thickness of 100 microinches.
- 4.10.1 Coverage - The shielding shall provide no less than 85% coverage of the underlying sheath. Percent of coverage shall be calculated as specified in 5.3.14.
- 4.11 Characteristics of Completed Cable
- 4.11.1 Tensile Load - Cable shall withstand a tensile load of 55 pounds for not less than 1 minute and shall show no evidence of rupture or separation of its components either during or after the test.
- 4.11.2 Dielectric Characteristics
- 4.11.2.1 Dielectric Strength - The dielectric strength of the cable shall be such that specimens subjected to test 5.3.11 shall resist, without failure, the following test potentials: 5mm, 30 kilovolts; 7mm, 34 kilovolts.

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4.11.2.2 Dielectric Flaws - Type I cable and Type II cable before shielding is applied, shall be subjected to test specified in 5.3.1. After test, cable shall be inspected for flaws and for sections having insulation defects, which shall be removed from the cable. Completed cable shall be certified as having passed the dielectric-flaws test, as specified, and that flaws and defective sections have been removed.

4.11.2.3 Capacitance - The dielectric constant of the cable insulation shall be such that the capacitance of the completed cable does not exceed the values shown in Table III when tested as specified in 5.3.5.

TABLE III
CAPACITANCE

Cable Size Millimeters	Class 1 Picofarads	Capacitance per foot of cable	
		Class 2 Picofarads	Class 3 Picofarads
5	50	--	37
7	45	52	33

4.11.3 Resistance to Life Cycle Test - When subjected to tests specified in 5.3.7 (5.3.7.1 thru 5.3.7.7), Type I cable Type II cable before shield is applied shall show no evidence of sheath decomposition or other damage and shall meet the requirements of 4.11.2.1.

4.11.4 Low-Temperature Resistance - When subjected to tests specified in 5.3.8, cable shall show no evidence of cracking, breaking, or separation and shall resist specified high potential without dielectric or other resultant failure.

4.11.5 Hot-Oil Resistance - When subjected to tests specified in 5.3.9, cable shall show no evidence of cracking, rupture, decomposition, loss of specified dielectric strength, or other resultant damage, and cable diameter shall not swell more than 20% (30% for Grade B) (see 5.3.9.4).

4.11.6 High-Temperature Resistance - When subjected to tests specified in 5.3.10 (5.3.10.1 thru 5.3.10.2), cable shall show no sheath or insulation breakdown, and the conductor shall not be corroded.

4.11.7 Flammability - When tested as specified in 5.3.12, no burning or charred particles shall fall from the cable, and the flame shall not travel along the cable at a rate of more than 1/2 inch per minute.

4.11.8 Fungus Resistance - When tested as specified in 5.3.13, cable shall show no evidence of damage affecting its performance, and thereafter shall meet the requirements of 4.11.2.1.

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- 4.11.9 Corona Effect - When subjected to the tests specified in 5.3.6, cable shall not deteriorate, crack, or burn over the ends, and shall resist specified high potential without dielectric or other resultant failure.

4.12 Identification of Completed Cable

- 4.12.1 Cable - The type, grade, class, and nominal size of cable, manufacturer's name or trade-mark, manufacturer's designation, and the date of manufacture shall be applied to the exterior surface of the sheath of Type I cable at intervals of not more than 2 feet. The date of manufacture shall be indicated, unless otherwise specified, by two numbers separated by a dash, the first number being the quarter and the second the calendar year of manufacture. Additional marking shall conform to requirements on applicable drawings or in procurement documents (see 6.2).

- 4.12.2 Spools or reels - Each spool or reel shall be plainly marked on both ends with the information listed below, and any other information specified (see 6.2). If paper labels are used, they shall be protected by a compound conforming to Specification MIL-I-13811 to prevent deterioration of marking.

Cable: Ignition, High-Tension

Specification AS _____

Type _____ Grade _____

Class _____ Size _____

Length, feet _____

Order No. _____

Stock No. _____

Date of Manufacture _____

Manufacturer's Name or Trademark _____

- 4.13 Age - Bulk cable, on spools, reels, or coils shall be not more than four quarters old, succeeding the quarter marked on the cable, at the time of acceptance by the purchaser.
- 4.14 Workmanship - Cable shall be free of imperfections of manufacture which will materially affect the appearance or serviceability or will prevent satisfaction of requirements specified herein.

5. QUALITY ASSURANCE PROVISIONS

- 5.1 Acceptance Inspection - The acceptance inspection shall consist of Groups I and II tests, and process control tests.

- 5.1.1 Inspection Lot - Unless otherwise specified, a lot shall consist of all cables of one type, grade, class and size offered for inspection at one time, except that the inspection lot shall not exceed 100,000 feet or one weeks production, whichever is less. The inspection lot shall be expressed in units of thousands of feet (total footage in inspection lot divided by 1000).