Designation: B1005 – 17

Standard Specification for Copper-Clad Aluminum Bar for Electrical Purposes (Bus Bar)[1]

This standard is issued under the fixed designation B1005; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers copper clad aluminum rectangular bar for electrical (bus) applications.

1.2 Six classes of copper-clad aluminum bar are covered as follows:

Class 20A—Nominal 20 volume % copper, annealed.
Class 25A—Nominal 25 volume % copper, annealed.
Class 30A—Nominal 30 volume % copper, annealed.
Class 20H—Nominal 20 volume % copper, hard-worked.
Class 25H—Nominal 25 volume % copper, hard-worked.
Class 30H—Nominal 30 volume % copper, hard-worked

1.3 The values stated in inch-pound units are to be regarded as the standard, except for resistivity and density, where the SI units are the standard. The values given in parentheses are for information only.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 The following documents of the issue in effect on date of material purchase form a part of this specification to the extent referenced herein:

2.2 *ASTM Standards:*[2]

B193 Test Method for Resistivity of Electrical Conductor Materials
B354 Terminology Relating to Uninsulated Metallic Electrical Conductors
E3 Guide for Preparation of Metallographic Specimens
E8/E8M Test Methods for Tension Testing of Metallic Materials
E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
E290 Test Methods for Bend Testing of Material for Ductility

3. Terminology

3.1 *Definitions*—Refer to Terminology B354 for definition of product terms used in this specification.

4. Ordering Information

4.1 Orders for materials to this specification shall include the following information:

4.1.1 This specification designation (which includes the number, the year, and the revision letter, if applicable),
4.1.2 Quantity in weight or pieces,
4.1.3 Classes, (see 1.2),
4.1.4 Edge contour (Section 12),
4.1.5 Cross-Sectional Dimensions: Thickness and Width (Section 13),

4.2 Additionally, orders for material to this specification shall include the following information when required by the purchaser:

4.2.1 Whether witness of inspection by the purchaser's representative is required prior to material shipment (Section 15),
4.2.2 Whether certification is required (Section 17),
4.2.3 Whether an alternative tensile sampling selection procedure is acceptable (Section 7).

5. Manufacture

5.1 The products covered by this specification shall consist of a solid core of aluminum with a continuous outer copper layer bonded to the core throughout and shall be of such quality that the resulting products comply with the requirements in this specification.

6. Quality Assurance

6.1 *Responsibility for Inspection and Tests*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection and test

[1] This specification is under the jurisdiction of ASTM Committee B01 on Electrical Conductors and is the direct responsibility of Subcommittee B01.06 on Bi-Metallic Conductors.

Current edition approved April 1, 2017. Published May 2017. DOI: 10.1520/B1005-17.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

requirements specified herein. The producer may use his own or any other suitable facilities for the performance of the inspection and test requirements specified herein, unless disapproved by the purchaser in the order or at the time of contract signing. The purchaser shall have the right to perform any of the inspections and tests set forth in this specification where such inspections are deemed necessary to assure that material conforms to prescribed requirements.

6.2 *Lot Definition*—An inspection of the lot shall consist of an identifiable quantity of same mill form, and nominal dimensions and subjected to inspection at one time.

7. Tensile Properties

7.1 *Limits*—The material shall conform to the tensile properties in Table 1.

7.2 *Number of Specimens:*

7.2.1 For material having a nominal weight of less than 1 lb/ft (up through 1.8 kg/linear m), one tension test specimen shall be taken for each 2000 1b (1000 kg), or fraction thereof, in the lot.

7.2.2 For material having a nominal weight of greater than 1 lb/ ft (over 1.8 kg/linear m), one tension test specimen shall be taken for each 2000 ft (600 m), or fraction thereof, in the lot.

7.2.3 One tension test specimen shall be taken from a random bar representing each 3000 lb of bar, or fraction thereof, of the same temper, thickness, and width in the shipment.

7.2.4 Other procedures for selecting samples may be employed if agreed upon between the producer and the supplier or purchaser.

7.3 The geometry of test specimens and the location in the product from which they are taken shall conform to Test Methods E8/E8M.

7.4 *Test Methods*——The tensile testing shall be in accordance with Test Methods E8/E8M.

7.5 *Retests*—When there is evidence that the test specimen is defective or is not representative of the lot of material, retesting shall be performed in accordance with Test Methods E8/E8M.

8. Bend Properties

8.1 *Limits:*

8.1.1 Class 20A, 25A and Class 30A bars shall withstand a flatwise bend at room temperature, through an angle of 90° around mandrel having a radius shown in Table 2 without cracking or obvious orange peel or evidence of slivers or other imperfections on the surface (the cladding layer), or blister

TABLE 1 Tensile and Elongation Requirements

Copper Volume %	Tensile Strength		Elongation, min % in 9.84 in. (250 mm)	
	Minimum H Classes ksi (MPa)	Maximum A Classes ksi (MPa)	H Classes	A Classes
20	23.2 (160)	18.1 (125)	3	25
25	24.6 (170)	18.5 (126)	3.5	28
30	26.1 (180)	18.8 (130)	3.8	30

TABLE 2 The Diameter of the Bending Cylinder

Thickness, in. (mm)	Bending Diameter in. (mm)
<0.394 (10.0)	0.623 (16)
≥0.394 (10.0)	1.260 (32)

phenomenon inside the bending width. In macrostructure, near the curved areas, interface holes or cracks should not appear, and no separation phenomenon between the cladding layer and the aluminum core. For a flatwise bend, the mandrel shall be 90° from the rolling direction, and across the greater (width) dimension of the bar. The required 90° bend shall be in the rolling direction. This is a longitudinal guided bend as defined and shown in Test Method E290, Fig. 6.

8.2 *Number of Specimens*—The number of specimens (test frequency) shall be the same as for tension tests as required in 7.2.

8.3 *Test Specimens*—Bend test specimens shall be a full section of the material with a minimum length of 13 in. (330 mm).

8.4 *Test Methods*—Bend tests shall be made in accordance with Test Method E290.

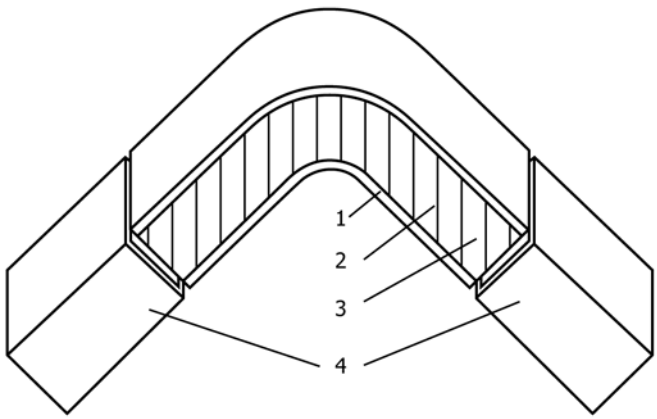
8.5 *Bending Result Secondary Test:*

8.5.1 Removing 1/2 straight segment of at each end of the samples after the bending test, retain contains 1/2 part of bending parts, as shown in Fig. 1.

8.5.2 Removing the cladding layer on one narrow side of the bending sample contain the bending part, then grind and polish the section of the remove cladding layer until the aluminum core exposes according to the provisions of Guide E3.

8.5.3 Checking the macrostructure on the section near the interface.

8.5.4 For the requirements of lateral bending property, the bending angle and bending diameter should be indicated in the purchase order (or contract) with the consultation of the two sides between supply and purchase.



Where:
1 = The cladding layer;
2 = The aluminum core;
3 = The observed section;
4 = The cut straight segment.

FIG. 1 Schematic Fixture for Preparation of Metallographic Specimens After Bending Test

9. Interface Bonding

9.1 *Limits*—Interface bonding strength for bars having a width ≥1.18 in. (30mm) and a thickness ≥ 0.236 in. (6mm) be no less than 5.8018 Ksi (40 MPa). Other specifications for interface bonding strength may be employed if agreed upon between the producer and the supplier or purchaser.

9.2 *Test Method*—The interface shear strength test of the products should be carried out according to the provisions of Annex A1.

9.3 *Retests*—The interface bonding strength of the product should be evaluated according to the measured interface bonding force per unit area size of the aluminum core and cladding layer.

10. Density

10.1 The nominal density shall be taken as shown in Table 3. The density tolerance is ±3%.

11. Electrical Properties

11.1 *Limits*—The resistivity or conductivity of specimens selected shall conform to the maximum resistivity or conductivity requirements specified in Table 4. To determine conformance with this specification, each value for electrical resistivity shall be rounded to the nearest unit in the last right-hand place of figures, in accordance with the rounding method of Practice E29.

11.2 *Number of Specimens*—One specimen shall be taken from a random bar representing each 1000 kg of bar, or fraction thereof, of the same class and thickness in the inspection lot.

11.3 *Test Specimens*—Specimens for determining resistivity or conductivity shall preferably be a full section of the material, but may be of any suitable size or shape appropriate to the instrument used in making the determination.

11.4 *Test Methods*—Electrical resistivity or conductivity shall be determined in accordance with Test Methods B193, provided that, in case of dispute, the results secured by Test Methods B193 shall be the basis for acceptance

12. Edge Contours

12.1 Unless otherwise specified, the bar shall be furnished with rounded corners. When specified, the bar shall be furnished with either rounded corners, rounded edges or full rounded edges.

13. Dimensional Tolerances

13.1 *Width and Thickness Limits*—Product width and thickness tolerances should be in accordance with the provisions of Table 5.

13.2 *Thickness of the Copper Layer Limits:*

TABLE 3 Density at 20°C

Classes	Density, g/cm^3
20A and 20H	3.94
25A and 25H	4.25
30A and 30H	4.56

TABLE 4 Maximum Resistivity or Conductivity Values

Class	Volume Conductivity at 20°C %IACS	Resistivity Equivalents at 20°C		
		Volume		Mass/Unit Length
		Ω·mm^2/m	μΩ·cm	Ω·g/m^2
20A	67.6	0.02550	2.550	0.1005
20H	66.4	0.02596	2.596	0.1023
25A	69.0	0.02498	2.498	0.1062
25H	67.7	0.02548	2.548	0.1083
30A	71.1	0.02424	2.424	0.1105
30H	69.6	0.02477	2.477	0.1130

TABLE 5 Width and Thickness Tolerances in. (mm)

Width	Width Tolerances
≤1.18 (30)	±0.020 (0.50)
>1.18 (30) to 3.94 (100)	±0.032 (0.80)
>3.94 (100)	±0.047 (1.20)
Thickness	Thickness Tolerances
>0.118 (3.0) to 0.236 (6.0)	±0.004 (0.10)
>0.236 (6.0) to 0.394 (10.0)	±0.006 ((0.15)
>0.394 (10.0)	±0.008 (0.20)

13.2.1 For the wide and narrow edge of cross section, cladding layer thickness may not be evenly distributed, but the permissible minimum shall in accordance with Table 6.

13.2.2 *Copper Thickness Test Method*—Determination of the minimum copper thickness shall be performed by microscopic examination of a cross section mounted end of bar in which the aluminum core is revealed by grinding and polishing in accordance with Guide E3 or by any other suitable method agreed upon between the manufacturer and the purchaser.

14. General Quality

14.1 Product surface should be smooth, no defects such as nick, concave, convex, dew aluminum and obvious rusty spot. No flash and burr at narrow edge.

14.2 Each bar shall be examined to determine conformance to this specification with respect to general quality and identification marking. On approval of the purchaser, the producer may use a system of statistical quality control for such examinations.

14.3 Unless otherwise specified, the material shall be supplied in the mill finish and shall he uniform as defined by the requirements of this specification and shall be commercially sound. Any requirement not so covered is subject to negotiation between producer and purchaser.

15. Source Inspection

15.1 If the purchaser desires that his representative inspect or witness the inspection and testing of the material prior to shipment, such agreement shall be made by the purchaser and producer as part of the purchase contract.

TABLE 6 Minimum Copper Thickness

Thickness of Product in. (mm)	Thickness of Cladding Layer in. (mm)
≤0.236 (6)	0.008 (0.20)
>0.236 (6)	0.016 (0.40)

15.2 When such inspection or witness of inspection and testing is agreed upon, the producer shall afford the purchaser's representative all reasonable facilities to satisfy him that the material meets the requirements of this specification. Inspection and tests shall be conducted so there is no unnecessary interference with the producer's operations.

16. Rejection and Retest

16.1 If any material fails to conform to all of the applicable requirements of this specification, it shall be cause for rejection of the inspection lot.

16.2 When there is evidence that a failed specimen was not representative of the inspection lot and when no other sampling plan is provided or approved by the purchaser through the contract or purchase order, at least two additional specimens shall be selected to replace each test specimen that failed. All specimens so selected for retest shall meet the requirements of the specification or the lot shall be subject to rejection.

16.3 Material in which non-conforming conditions are discovered subsequent to inspection may be rejected.

16.4 If material is rejected by the purchaser, the producer or supplier is responsible only for replacement of the material to the purchaser. As much as possible of the rejected material shall be returned to the producer or supplier.

17. Certification

17.1 The producer or supplier shall, upon request, furnish to the purchaser a certificate stating that the material has beer sampled, tested and inspected in accordance with this specification, and has met the requirements.

18. Packaging and Package Marking

18.1 The material shall be packaged to provide adequate protection during normal handling and transportation and each package shall contain only one size or shape and temper of material unless otherwise agreed. The type of packing and gross weight of containers shall, unless otherwise agreed, be at the producer or supplier's discretion, provided they are such as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the delivery point.

19. Keywords

19.1 bus bar; copper clad aluminum bar; electrical

ANNEX

(Mandatory Information)

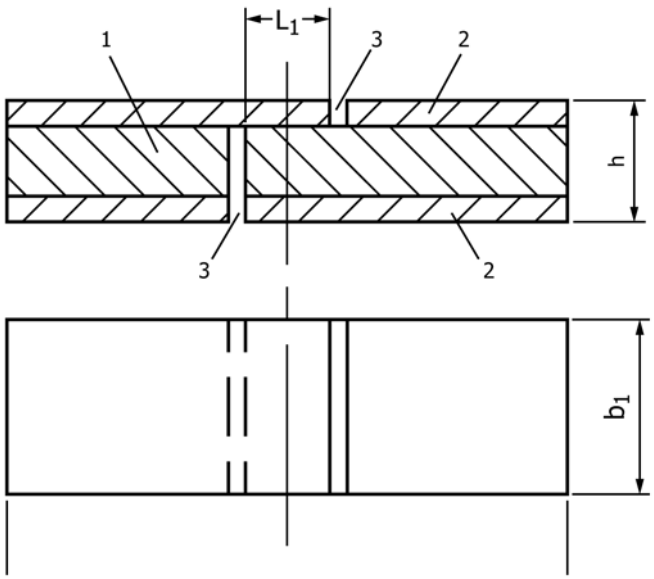
A1. THE TEST METHOD OF INTERFACIAL SHEAR STRENGTH

A1.1 Sample

A1.1.1 Sample length is 3.937 in. (100 mm), sample width (b_1) is 0.787 in. (20.00 mm) ±0.004 in. (0.10 mm), sample shear plane width (L_1) is 0.157 in. (4.00 mm) ±0.004 in. (0.10 mm), grooving width is less than 0.079 in. (2 mm). Sample cut by mechanical processing or EDM, during the process the shear plane should not be damaged. And the shape and size of the sample is shown in Fig. A1.1.

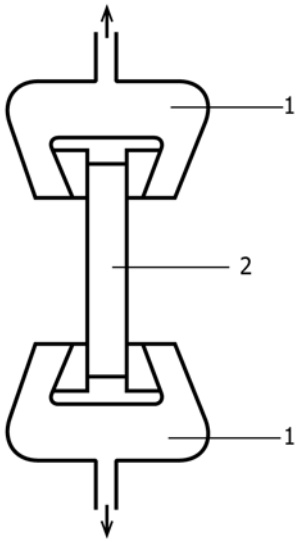
A1.2 The Test Specimen

A1.2.1 The sample is clamped in the universal material testing machine, clamping length of the sample is 0.787 in. (20 mm), as shown in Fig. A1.2. The universal material testing machine will provide the axial tension to the sample. The clamp movement speed shall remain under 1.969 in./min (50 mm/min), until the shear deformation occurs between the core material and cladding layer resulting in complete separation. By means of the records of a force-displacement curve, or the load recorder (such as a computer), the maximum force (F_{max}) added on the sample during the test is achieved.



Where:
1 = Aluminum core;
2 = Cladding layer;
3 = Grooving.

FIG. A1.1 The Shape and Size of Sample



Where:
1 = Fixture;
2 = Sample.

FIG. A1.2 Schematic Diagram of Test Method of Interface Shear Strength

A1.3 The Assessment of Test Results

A1.3.1 The interface shear strength calculated with the formula Eq A1.1 and the strength value should not be less than 5.8 Ksi (40 MPa).

$$\tau = \frac{F_{\max}}{S_1} \quad \text{(A1.1)}$$

where:

τ = interface shear strength, keeping one decimal places, units are kips per square inch;
F_{max} = maximum shear force, keeping one decimal places, units are pounds;
S_1 = the shear plane area of the sample, referring to formula Eq A1.2, keeping two decimal places, units are square inch.

$$S_1 = L_1 \times b_1 \quad \text{(A1.2)}$$

where:

L_1 = shear plane width, keeping two decimal places, units are inch;
b_1 = sample width, keeping two decimal places, units are inch.