Designation: B 236M – 00
METRIC

Standard Specification for Aluminum Bars for Electrical Purposes (Bus Bars) [Metric][1]

This standard is issued under the fixed designation B 236M; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope *

1.1 This specification covers Aluminum 1350 bar for electric conductors in the tempers shown in Table 1.

1.2 Aluminum and temper designations are in accordance with ANSI H35.1M. The equivalent Unified Numbering System designation is A91350 in accordance with Practice E 527.

NOTE 1—For Alloy 6101 bus conductors, refer to Specification B 317.

NOTE 2—Prior to 1975, Aluminum 1350 was designated as EC aluminum.

1.3 This specification is the metric counterpart of Specification B 236.

1.4 For acceptance criteria for inclusion of new aluminum and aluminum alloys in this specification, see Annex A1.

2. Referenced Documents

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

2.2 *ASTM Standards:*

B 193 Test Method for Resistivity of Electrical Conductor Materials[2]

B 557M Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products [Metric][3]

B 660 Practices for Packaging/Packing of Aluminum and Magnesium Products[3]

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications[4]

E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys[5]

E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition[5]

E 227 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique[5]

TABLE 1 Tensile Property Limits[A,B]

Temper	Specified Thickness, mm		Tensile Strength, min, MPa	Yield Strength, min, (0.2 % offset) MPa
	Over	Through		
H12	3.20	25.00	85	55
H112	3.20	12.50	75	40
	12.50	25.00	70	30
	25.00	40.00	60	25
H111	All		60	25

[A] For purposes of determining conformance with this specification, each value for tensile strength and yield strength shall be rounded to the nearest 1 MPa in accordance with the rounding-off method of Practice E 29.

[B] See Appendix X2.

E 290 Test Method for Semi-Guided Bend Test for Ductility of Metallic Materials[6]

E 527 Practice for Numbering Metals and Alloys (UNS)[7]

E 607 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Point-to-Plane Technique, Nitrogen Atmosphere[8]

E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis[8]

E 1004 Test Method for Electromagnetic (Eddy-Current) Measurements of Electrical Conductivity[9]

E 1251 Test Method for Optical Emission Spectrometric Analysis of Aluminum and Aluminum Alloys by the Argon Atmosphere, Point-to-Plane, Unipolar Self-Initiating Capacitor Discharge[8]

2.3 *ANSI Standards:*

H35.1M Alloy and Temper Designation Systems for Aluminum[3]

H35.2M Dimensional Tolerances for Aluminum Mill Products[3]

2.4 *Military Standard:*

MIL-STD-129 Marking for Shipment and Storage[10]

2.5 *Federal Standard:*

Fed. Std. No. 123 Marking for Shipment (Civil Agencies)[10]

3. Terminology

3.1 *Definitions:*

[1] This specification is under the jurisdiction of ASTM Committee B07 on Light Metals and Alloys and is the direct responsibility of Subcommittee B07.03 on Wrought Aluminum-Alloy Products.

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[2] *Annual Book of ASTM Standards*, Vol 02.03.

[3] *Annual Book of ASTM Standards*, Vol 02.02.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

[5] *Annual Book of ASTM Standards*, Vol 03.05.

[6] *Annual Book of ASTM Standards*, Vol 03.01.

[7] *Annual Book of ASTM Standards*, Vol 01.01.

[8] *Annual Book of ASTM Standards*, Vol 03.06.

[9] *Annual Book of ASTM Standards*, Vol 03.03.

[10] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

***A Summary of Changes section appears at the end of this standard.**

3.1.1 *bus conductor*—a rigid electric conductor of any cross section.

3.1.2 *bar*—a solid product that is long in relation to cross section, which is square or rectangular (excluding plate and flattened wire) with sharp or rounded corners or edges, or is a regular hexagon or octagon, and in which at least one perpendicular distance between parallel faces is over 10 mm.

3.1.2.1 *extruded bar*—bar brought to final dimensions by extruding.

3.1.2.2 *rolled bar*—bar brought to final dimensions by hot rolling.

3.1.2.3 *sawed-plate bar*—bar brought to final thickness by hot or cold rolling and to final width by sawing (sawed edges).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *capable of*—The term *capable of* as used in this specification means that the test need not be performed by the producer of the material. However, should testing by the purchaser establish that the material does not meet these requirements, the material shall be subject to rejection.

4. Ordering Information

4.1 Orders for material 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 pieces or kilograms,

4.1.3 Temper (8.1),

4.1.4 Edge contour (Section 12),

4.1.5 Diameter for rounds; distance across flats for square-cornered squares, hexagons, or octagons; width and depth for square-cornered rectangles,

4.1.6 Length (specific or stock) (Section 14),

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

4.2.1 Whether inspection or witness of inspection and tests by the purchaser's representative is required prior to material shipment (16.1),

4.2.2 Whether marking for identification is required (18.1),

4.2.3 Whether Practices B 660 applies and, if so, the levels of preservation, packaging, and packing required (19.3), and

4.2.4 Whether certification of the material by the producer is required (Section 20).

5. Manufacture

5.1 The products covered by this specification shall be produced by extruding or rolling, at the option of the producer, provided that the production method results in material that meets all requirements of this specification.

5.2 Bars in the H12 temper shall be furnished with a rolled mill finish; bars in the H111 temper, with an as-extruded mill finish; and bars in the H112 temper, with a rolled mill finish except that the edges shall be as sawed.

6. Responsibility for 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 requirements specified herein. Except as otherwise specified in the contract or order, 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. 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 lot shall consist of an identifiable quantity of material of the same aluminum designation, temper, and thickness subjected to inspection at one time.

7. Chemical Composition Requirements

7.1 The material shall conform to the composition in Table 2. Conformance shall be determined by the producer by analyzing samples taken at the time the ingots or continuously cast bars are poured, or samples taken from the finished or semifinished product. If the producer has determined the composition of the material during the course of manufacture, he shall not be required to sample and analyze the finished product.

NOTE 3—It is standard practice in the United States aluminum industry to determine conformance to the composition limits prior to further processing of ingots into wrought products. Due to the continuous nature of the process, it is not practical to keep a specific ingot analysis identified with a specific quantity of finished material.

7.2 *Number of Samples*—The number of samples taken for determination of chemical composition shall be as follows:

7.2.1 When samples are taken at the time the ingots are poured, at least one sample shall be taken for each group of ingots poured simultaneously from the same source of molten metal.

7.2.2 When samples are taken from the finished or semifinished product, a sample shall be taken to represent each 2000 kg or fraction thereof, in the shipment, except that not more than one sample shall be required per piece.

7.3 *Methods of Sampling*—Samples for determination of

TABLE 2 Chemical Requirements[A]

Element	Composition, %
Silicon, max	0.10
Iron, max	0.40
Copper, max	0.05
Manganese, max	0.01
Chromium, max	0.01
Zinc, max	0.05
Boron, max	0.05
Gallium, max	0.03
Vanadium + titanium, total, max	0.02
Other elements, each,[B] max	0.03
Other elements, total,[BC] max	0.10
Aluminum,[D] min	99.50

[A] Analysis shall be made for the elements for which limits are shown in this table.

[B] *Others* includes all unlisted metallic elements. The producer may analyze samples for trace elements not specified in the specification. However, such analysis is not required and may not cover all metallic *Others* elements. Should any analysis by the producer or the purchaser establish that an *Others* element exceeds the limit of *Each* or that the aggregate of several *Others* elements exceeds the limit of *Total*, the material shall be considered non-conforming.

[C] *Other Elements*—Total shall be the sum of unspecified metallic elements 0.010 % or more, rounded to the second decimal before determining the sum.

[D] The aluminum content shall be calculated by subtracting from 100.00 % the sum of all metallic elements present in amounts of 0.010 % or more each, rounded to the second decimal before determining the sum.

chemical composition shall be taken in accordance with one of the following methods:

7.3.1 Samples for chemical analysis shall be taken from the material by drilling, sawing, milling, turning, or clipping a representative piece or pieces to obtain a prepared sample of not less than 75 g. Sampling shall be in accordance with Practice E 55.

7.3.2 Sampling for spectrochemical analysis shall be in accordance with Practices E 716. Samples for other methods of analysis shall be taken by methods suitable for the form of material being analyzed and the type of analytical method used.

7.4 *Methods of Analysis*—The determination of chemical composition shall be made in accordance with suitable chemical (Test Methods E 34), or spectrochemical (Test Methods E 227, E 607, and E 1251), methods. Other methods may be used only when no published ASTM method is available. In case of dispute, the methods of analysis shall be agreed upon between the producer and purchaser.

8. Tensile Properties

8.1 *Limits*—The bars shall conform to the requirements for tensile properties as specified in Table 1.

8.2 *Number of Specimens*—One tension test specimen shall be taken from a random bar representing each 1500 kg of bar, or fraction thereof, of the same temper, thickness, and width in the shipment.

8.3 *Test Methods*—The tension test shall be made in accordance with Test Methods B 557M.

9. Bend Properties

9.1 *Limits*:

9.1.1 *Flatwise Bend*—Bars in the H12, and H111, and H112 tempers shall be capable of being bent flatwise at room temperature, through an angle of 90° around a pin or mandrel having a radius equal to the thickness of the specimen, without cracking or evidence of slivers or other imperfections.

9.1.2 *Edgewise Bend*—Bars in the H12 and H111 tempers whose width-to-thickness ratios are not in excess of 12 and whose width is 100 mm or less, shall be capable of being bent at room temperature edgewise 90° around a mandrel having a radius shown in Table 3 without cracking or localized thinning to less than 90 % of the maximum thickness within the central 60° of the bend when measured along the outer edge of the bend. Bending requirements for bar wider than 100 mm shall be as agreed upon by the producer and the purchaser.

9.2 *Test Specimens*—Bend test specimens shall be a full section of the material.

TABLE 3 Edgewise Bend Radii

Specified Width, mm		Mandrel Radius, mm
Over	Through	
...	12.50	12.5
12.50	25.00	25
25.00	40.00	40
40.00	50.00	50
50.00	65.00	65
65.00	75.00	75
75.00	90.00	90
90.00	100.00	100

9.3 *Test Methods*—Bend tests shall be made in accordance with Test Method E 290.

10. Density

10.1 The density of Aluminum 1350 shall be taken as 2705 kg/m^3.

11. Electrical Properties

11.1 *Limits*—The resistivity of specimens selected shall not exceed 0.0283 $\Omega \cdot mm^2/m$ at 20°C corresponding to a conductivity not less than 61.0 % of the International Annealed Copper Standard. 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 E 29.

11.2 *Number of Specimens*—One specimen shall be taken from a random bar representing each 1500 kg of bar, or fraction thereof, of the same temper 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 B 193 or E 1004, provided that, in case of dispute, the results secured by Test Methods B 193 shall be the basis for acceptance.

12. Edge Contours

12.1 Unless otherwise specified bar shall be furnished with square corners. When specified, bar shall be furnished with rounded corners, rounded edges or full rounded edges, as shown in Table 19.1.11 for rolled bar and Table 19.3.4 for extruded bar or with corners and edges for sawed-plate bar as shown in Table 19.2.4, of ANSI H35.2M.

13. Dimensional Tolerances

13.1 Bars ordered to this specification shall meet the requirements of ANSI H35.2M. Table 4 lists the dimensions involved and the applicable H35.2M table numbers.

14. Length

14.1 When stock lengths are specified, short lengths per Table 5 may be furnished.

15. General Quality

15.1 The bars shall be supplied with as-sawed square ends. The edges of sawed plate bus bar shall be as sawed. Unless otherwise specified the bars shall be supplied in the mill finish and shall be 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.

16. Source Inspection

16.1 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 4 List of ANSI Tables of Dimensional Tolerances[A]

Table No.	Dimension
For Rolled Bar Supplied in H12 Temper	
19.1.4	Thickness, Rolled Bar
19.1.5	Width, Rolled Bar
19.1.6	Length, Rolled Bar
19.1.7	Straightness, Rolled Bar
19.1.8	Flatness, Rolled Bar
19.1.9	Angularity, Rolled Bar
19.1.10	Squareness of Saw Cuts, Rolled Bar
For Sawed-Plate Bus Bar Supplied in H112 Temper	
19.1.6	Length, Sawed-Plate Bar
19.1.7	Straightness, Sawed-Plate Bar
19.1.8	Flatness, Sawed-Plate Bar
19.2.1	Thickness, Sawed-Plate Bar
19.2.2	Width, Sawed-Plate Bar
For Extruded Bus Bar Supplied in H111 Temper	
19.3.1	Thickness and Width, Extruded Bus Bar
19.3.2	Length, Extruded Bus Bar
19.3.3	Flatness, Extruded Bus Bar
19.3.5	Twist, Extruded Bus Bar
19.3.6	Straightness, Extruded Bus Bar
19.3.7	Angularity, Extruded Bus Bar
19.3.8	Squareness of Cut Ends, Extruded Bus Bar

[A]ANSI H35.2M.

TABLE 5 Schedule of Lengths (Stock with Short Lengths)

Stock Length			Shortest Permissible Length,[A] % of Stock Length	Maximum Permissible Mass of Short Lengths, % of Lot Mass
Area, mm[B]		mm		
Over	Through			
...	150	1800–6000 incl.	75	20
150	650	1800–6000 incl.	70	30
650	1500	1800–6000 incl.	70	30
1500	2500	1800–6000 incl.	60	30
2500	6000	1800–6000 incl.	60	30

[A]Expressed to the nearest 150 mm.
[B]Width times thickness, disregarding any rounded corners or edges.

16.2 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.

17. Retest and Rejection

17.1 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.

17.2 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 this specification or the lot shall be subject to rejection.

17.3 Material in which defects are discovered subsequent to inspection may be rejected.

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

18. Identification Marking of Product

18.1 When identification marking is specified in the purchase order, the bar shall be marked near one end with the producer's name or trademark, aluminum designation, and temper. Identification characters shall have a minimum height of 6 mm. The marking material shall have adequate resistance to obliteration during normal handling and shall be removable by normal cleaning methods; however, ghost images of the characters may remain.

18.2 Marking systems which employ additional information, larger characters, and greater frequencies are acceptable under this specification.

19. Packaging and Package Marking

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

19.2 Each shipping container shall be marked with the purchase order number, material size, specification number, aluminum number, and temper, gross and net masses, and the producer's name or trademark.

19.3 When specified in the contract or purchase order, material shall be preserved, packaged, and packed in accordance with the requirements of Practices B 660. The applicable levels shall be as specified in the contract or order. Marking for shipment of such material shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

20. Certification

20.1 The producer or supplier shall, on request, furnish to the purchaser a certificate stating that each lot has been sampled, tested, and inspected in accordance with this specification, and has met the requirements.

21. Keywords

21.1 aluminum; bus bars; electrical

ANNEX

(Mandatory Information)

A1. ACCEPTANCE CRITERIA FOR INCLUSION OF NEW ALUMINUM AND ALUMINUM ALLOYS IN THIS SPECIFICATION

A1.1 Prior to acceptance for inclusion in this specification, the composition of wrought or cast aluminum or aluminum alloy shall be registered in accordance with ANSI H35.1(M). The Aluminum Association[11] holds the Secretariat of ANSI H35 Committee and administers the criteria and procedures for registration.

A1.2 If it is documented that the Aluminum Association could not or would not register a given composition, an alternative procedure and the criteria for acceptance shall be as follows:

A1.2.1 The designation submitted for inclusion does not utilize the same designation system as described in ANSI H35.1(M). A designation not in conflict with other designation systems or a trade name is acceptable.

A1.2.2 The aluminum or aluminum alloy has been offered for sale in commercial quantities within the prior twelve months to at least three identifiable users.

A1.2.3 The complete chemical composition limits are submitted.

A1.2.4 The composition is, in the judgment of the responsible subcommittee, significantly different from that of any other aluminum or aluminum alloy already in the specification.

A1.2.5 For codification purposes, an alloying element is any element intentionally added for any purpose other than grain refinement and for which minimum and maximum limits are specified. Unalloyed aluminum contains a minimum of 99.00 % aluminum.

A1.2.6 Standard limits for alloying elements and impurities are expressed to the following decimal places:

Less than 0.001 %	0.000X
0.001 to but less than 0.01 %	0.00X
0.01 to but less than 0.10 %	
Unalloyed aluminum made by a refining process	0.0XX
Alloys and unalloyed aluminum not made by a refining process	0.0X
0.10 through 0.55 %	0.XX
(It is customary to express limits of 0.30 through 0.55 % as 0.X0 or 0.X5.)	
Over 0.55 %	0.X, X.X, etc.
(except that combined Si + Fe limits for 99.00 % minimum aluminum must be expressed as 0.XX or 1.XX)	

A1.2.7 Standard limits for alloying elements and impurities are expressed in the following sequence: Silicon; Iron; Copper; Manganese; Magnesium; Chromium; Nickel; Zinc (Note A1.1); Titanium; Other Elements, Each; Other Elements, Total; Aluminum (Note A1.2).

NOTE A1.1—Additional specified elements having limits are inserted in alphabetical order of their chemical symbols between zinc and titanium, or are specified in footnotes.

NOTE A1.2—Aluminum is specified as *minimum* for unalloyed aluminum and as a *remainder* for aluminum alloys.

[11] The Aluminum Association, 900 19th St., NW, Washington, DC 20006.

APPENDIXES

(Nonmandatory Information)

X1. ADDITIONAL INFORMATION

X1.1 Edgewise bending is much more severe and is more difficult than flatwise bending. Success in making satisfactory edgewise bends depends to a considerable extent upon the equipment and procedures used. The radius (in terms of width of bar) around which a bar can be bent edgewise depends upon the tensile properties and also upon the ratio of width to thickness, *W/t* of the bar. When bars are bent edgewise the changes in dimensions appear to be a function of the geometry of the bend regardless of the tensile properties of the bar. With a bend radius of 1 *W*, the thickness along the inner edge increases about 20 % and along the outer edge it decreases about 16 %. For 1350-H12 a radius greater than 1 *W* will normally be required for bars having a *W/t* exceeding 12. In special cases where these width/thickness ratios are exceeded, a larger bend radius should be used. Table X1.1 reflects the influence of bar dimensions.

TABLE X1.1 Influence of Bar Dimensions on Edgewise Bend Characteristics

NOTE 1—Symbols used in the table are explained as follows:
×—H111 and H12 tempers required to meet edgewise bend test.
□—Neither H111 nor H12 tempers required to meet edgewise bend test.
*—Bending requirements for bar wider than 100 mm shall be as agreed upon by the producer and the purchaser.
†—Second preference width in ANSI H32.3.

Thickness, mm	Width, mm														
	12	16	20	25	30	40	50	60	70†	80	90†	100	120	160	200
3.0	×	×	×	×	...	□	□	...	...	...	...	...	...	...	...
5.0	×	×	×	×	×	×	...	□	□	□	...	...	...	...	...
8.0	...	...	...	...	...	*	×	×	×	×	*	□	*	*	*
12	...	...	...	...	...	...	×	×	×	×	...	×	*	*	*
16	...	...	...	...	...	...	...	...	...	...	...	×	*	*	*
20	...	...	...	...	...	...	...	...	...	...	...	×	*	*	*
25	...	...	...	...	...	...	...	...	...	...		×	*	*	*

X2. BASIS FOR ESTABLISHMENT OF MECHANICAL PROPERTY LIMITS

X2.1 Standard mechanical property limits for the respective size ranges are based on an analysis of data from standard production material and are established at a level at which at least 99 % of the population of the values obtained from all standard material in the size range meets the established value at a confidence level of 95 %. Refer to the paper "Statistical Aspects of Mechanical Property Assurance" in the Related Material section of the *Annual Book of ASTM Standards*, Vol 02.02. Mechanical property limits in this metric issue of B236 have been derived from the inch-pound system limits that were developed under the above principles. As test data on metric-dimensioned specimens are accumulated, some refinement of limits can be anticipated.

SUMMARY OF CHANGES

This section identifies the principal changes to this standard that have been incorporated since the last issue.

(*1*) Deleted references to Test Method E 101.