



Designation: B 221 – 06

## Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes<sup>1</sup>

This standard is issued under the fixed designation B 221; 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 ( $\epsilon$ ) 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<sup>2</sup> covers aluminum and aluminum-alloy extruded bar, rod, wire, profile, and tube in the aluminum alloys (Note 1) and tempers shown in Table 2.

NOTE 1—Throughout this specification, the use of the term *alloy* in the general sense includes aluminum as well as aluminum alloy.

NOTE 2—For rolled or cold-finished bar and rod refer to Specification B 211, for drawn seamless tube used in pressure applications, Specification B 210, for structural pipe and tube, Specification B 429, and for seamless pipe and tube used in pressure applications, Specification B 241/B 241M.

NOTE 3—Structural pipe and tube produced in accordance with B 221 is not intended for fluid-carrying applications involving pressure. Refer to either Specification B 210 or B 241/B 241M, as appropriate, for seamless pipe and tube used in fluid-carrying applications involving pressure.

1.2 Alloy and temper designations are in accordance with ANSI H35.1. The equivalent Unified Numbering System alloy designations are those of Table 1 preceded by A9; for example, A91100 for Aluminum 1100 in accordance with Practice E 527.

1.3 For acceptance criteria for inclusion of new aluminum and aluminum alloys in this specification, see Annex A2.

1.4 A complete metric companion to B 221 has been developed—B 221M; therefore, no metric equivalents are presented in this specification.

### 2. Referenced Documents

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

2.2 *ASTM Standards*:<sup>3</sup>

<sup>1</sup> 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 Aluminum Alloy Wrought Products.

Current edition approved Nov. 1, 2006. Published December 2006. Originally approved in 1947. Last previous edition approved in 2005 as B 221 – 05.

<sup>2</sup> For ASME Boiler and Pressure Vessel Code applications see related Specification SB-221 in Section 11 of this Code.

<sup>3</sup> 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.

- B 210 Specification for Aluminum and Aluminum-Alloy Drawn Seamless Tubes
- B 211 Specification for Aluminum and Aluminum-Alloy Bar, Rod, and Wire
- B 241/B 241M Specification for Aluminum and Aluminum-Alloy Seamless Pipe and Seamless Extruded Tube
- B 429 **DESIG ATTRIBUTE B0429 DIDN'T MATCH, MATCHED WITH B0429\_B0429M** Specification for Aluminum-Alloy Extruded Structural Pipe and Tube
- B 557 Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products
- B 594 Practice for Ultrasonic Inspection of Aluminum-Alloy Wrought Products for Aerospace Applications
- B 660 Practices for Packaging/Packing of Aluminum and Magnesium Products
- B 666/B 666M Practice for Identification Marking of Aluminum and Magnesium Products
- B 807 **DESIG ATTRIBUTE B0807 DIDN'T MATCH, MATCHED WITH B0807\_B0807M** Practice for Extrusion Press Solution Heat Treatment for Aluminum Alloys
- B 881 Terminology Relating to Aluminum- and Magnesium-Alloy Products
- B 918 Practice for Heat Treatment of Wrought Aluminum Alloys
- B 945 Practice for Aluminum Alloy Extrusions Press Cooled from an Elevated Temperature Shaping Process for Production of T1, T2, T5 and T10–Type Tempers
- E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications
- E 34 Test Methods for Chemical Analysis of Aluminum and Aluminum-Base Alloys
- E 55 Practice for Sampling Wrought Nonferrous Metals and Alloys for Determination of Chemical Composition
- E 527 Practice for Numbering Metals and Alloys in the Unified Numbering System (UNS)
- E 607 Test Method for Atomic Emission Spectrometric Analysis Aluminum Alloys by the Point to Plane Technique Nitrogen Atmosphere
- E 716 Practices for Sampling Aluminum and Aluminum Alloys for Spectrochemical Analysis
- E 1004 Practice for Determining Electrical Conductivity

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



TABLE 1 Chemical Composition Limits A,B,C

Table with columns: Alloy, Silicon, Iron, Copper, Manganese, Magnesium, Chromium, Zinc, Titanium, Vanadium, Other Elements (Each, Total), Aluminum. Rows include alloys 1060, 1100, 2014, 2024, 2219, 3003, Alclad 3003, 3004, 3102, 5052, 5083, 5086, 5154, 5454, 5456, 6005, 6005A, 6060, 6061, 6063, 6066, 6070, 6082, 6105, 6162, 6262, 6351, 6463, 6560, 7005, 7072, 7075, 7116, 7129, 7178.

A Limits are in weight percent maximum unless shown as a range, or stated otherwise.

B Analysis shall be made for the elements for which limits are shown in this table.

C For the purpose of determining conformance to these limits, an observed value or a calculated value obtained from analysis shall be rounded to the nearest unit in the last right-hand place of the figures used in expressing the specified limit, in accordance with the rounding-off method of Practice E 29.

D Others includes listed elements for which no specific limit is shown as well as 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 nonconforming.

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

F 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.

G Upon agreement between the purchaser and the producer or supplier, a Zr + Ti limit of 0.20 % max is permitted. Properties in Specification (Table 2) are not based on the Zirconium and Titanium algorithm.

H Zirconium, 0.10–0.25 %. The total for other elements does not include zirconium.

I Manganese plus chromium shall total 0.12–0.50.

J In 1965 the requirements for 6062 were combined with those for 6061 by revising the minimum chromium from “0.15 %” to “0.04 %.” This action cancelled alloy 6062.

K Bismuth and lead shall be 0.40–0.7 % each.

L Zirconium 0.08–0.20 %. The total for other elements does not include zirconium.

M Composition of cladding alloy applied during the course of manufacture. Samples from finished tube shall not be required to conform to these limits.

N Upon agreement between the purchaser and the producer or supplier, a Zr + Ti limit of 0.25 % max is permitted. Properties in Specification (Table 2) are not based on the Zirconium and Titanium algorithm.

O Gallium 0.03 % max.

Using the Electromagnetic (Eddy-Current) Method
E 1251 Test Method for Analysis of Aluminum and Aluminum Alloys by Atomic Emission Spectrometry
G 47 Test Method for Determining Susceptibility to Stress-Corrosion Cracking of 2XXX and 7XXX Aluminum Alloy Products
Method of Test for Exfoliation Corrosion Susceptibility in

7XXX Series Copper-Containing Aluminum Alloys (EXCO Test) (G 34-72)4
2.3 ANSI Standards:

4 The applicable edition in the use of this specification is G 34–72, which is available in the gray pages of the Annual Book of ASTM Standards, Vol 02.02.

- H35.1** Alloy and Temper Designation Systems for Aluminum  
**H35.2** Dimensional Tolerances for Aluminum Mill Products  
 2.4 *Federal Standard*:<sup>5</sup>  
**Fed. Std. No. 123** Marking for Shipment (Civil Agencies)  
 2.5 *Military Standard*:<sup>5</sup>  
**MIL-STD-129** Marking for Shipment and Storage

2.6 *AMS Specification*:<sup>6</sup>  
 AMS 2772 Heat Treatment of Aluminum Alloy Raw Materials

### 3. Terminology

#### 3.1 Definitions:

Refer to Terminology **B 881** for definitions of product terms used in this specification.

<sup>5</sup> Available from Standardization Documents Order Desk, DODSSP, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, <http://www.dodssp.daps.mil>.

<sup>6</sup> Available from Society of Automotive Engineers (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, <http://www.sae.org>.

**TABLE 2 Mechanical Property Limits<sup>A,B</sup>**

NOTE 1—Strength values shown in parentheses are for information only.

Temper	Specified Section or Wall Thickness, in.	Area, in. <sup>2</sup>	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in. or 4 × Diameter, min, % <sup>C,D</sup>		
			min	max	min	max			
Aluminum 1060 <sup>E</sup>									
O	all	all	8.5	14.0	2.5	...	25		
H112	all	all	8.5	...	2.5	...	25		
Aluminum 1100 <sup>E</sup>									
O	all	all	11.0	15.5	3.0	...	25		
H112	all	all	11.0	...	3.0	...	25		
Alloy 2014 <sup>E</sup>									
O	all	all	...	30.0	...	18.0	12		
T4	}	all	...	50.0	...	35.0	12		
T4510 <sup>F</sup>		all	...	...	...	...	...		
T4511 <sup>F</sup>	}	all	all	50.0	...	29.0	12		
T42 <sup>G</sup>				60.0	...	53.0	7		
T6		}	up through 0.499	all	64.0	...	58.0	7	
T6510 <sup>F</sup>					68.0	...	60.0	7	
T6511 <sup>F</sup>	}	0.500–0.749	all	68.0	...	58.0	6		
				0.750 and over	up through 25	68.0	...	58.0	6
				over 25 through 32	...	...	...		
T62 <sup>G</sup>	}	up through 0.749	all	60.0	...	53.0	7		
				0.750 and over	up through 25	60.0	...	53.0	7
				over 25 through 32	60.0	...	53.0	6	
Alloy 2024 <sup>E</sup>									
O	all	all	...	35.0	...	19.0	12		
T3	}	up through 0.249	all	57.0	...	42.0	12 <sup>H</sup>		
T3510 <sup>F</sup>				0.250–0.749	all	60.0	...	44.0	12 <sup>H</sup>
T3511 <sup>F</sup>				0.750–1.499	all	65.0	...	46.0	10
	}	1.500 and over	up through 25	70.0	...	52.0 <sup>I</sup>	10		
				over 25 through 32	68.0	...	48.0 <sup>J</sup>	8	
T42 <sup>G</sup>	}	up through 0.749	all	57.0	...	38.0	12		
				0.750–1.499	all	57.0	...	38.0	10
				1.500 and over	up through 25	57.0	...	38.0	10
				over 25 through 32	57.0	...	38.0	8	
T81	}	0.050–0.249	all	64.0	...	56.0	4		
T8510 <sup>F</sup>				0.250–1.499	all	66.0	...	58.0	5
T8511 <sup>F</sup>				1.500 and over	up through 32	66.0	...	58.0	5
Alloy 2219 <sup>E</sup>									
O	all	all	...	32.0	...	18.0	12		
T31									

**TABLE 2** *Continued*

Temper	Specified Section or Wall Thickness, in.	Area, in. <sup>2</sup>	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in. or 4 × Diameter, min, % <sup>C,D</sup>	
			min	max	min	max		
T3510 <sup>F</sup>	{ up through 0.499	up through 25	42.0	...	26.0	...	14	
T3511 <sup>F</sup>		0.500–2.999	up through 25	45.0	...	27.0	...	14
T62 <sup>G</sup>	{ up through 0.999	up through 25	54.0	...	36.0	...	6	
		1.000 and over	up through 25	54.0	...	36.0	...	6
T81	}	up through 2.999	up through 25	58.0	...	42.0	...	6
T8510 <sup>F</sup>								
T8511 <sup>F</sup>								
Alloy 3003 <sup>E</sup>								
O	all	all	14.0	19.0	5.0	...	25	
H112	all	all	14.0	...	5.0	...	25	
Alloy Alclad 3003 <sup>E</sup>								
O	all	all	13.0	18.0	4.5	...	25	
H112	all	all	13.0	...	4.5 <sup>K</sup>	...	25	
Alloy 3004 <sup>E</sup>								
O	all	all	23.0	29.0	8.5	...	...	
Alloy 3102								
H112 <sup>L</sup>	0.028–0.050	all	11.0	18.0	4.0	...	25	
Alloy 5052								
O	all	all	25.0	35.0	10.0	...	...	
Alloy 5083 <sup>E</sup>								
O	up through 5.000 <sup>M</sup>	up through 32	39.0	51.0	16.0	...	14	
H111	up through 5.000 <sup>M</sup>	up through 32	40.0	...	24.0	...	12	
H112	up through 5.000 <sup>M</sup>	up through 32	39.0	...	16.0	...	12	
Alloy 5086 <sup>E</sup>								
O	up through 5.000 <sup>M</sup>	up through 32	35.0	46.0	14.0	...	14	
H111	up through 5.000 <sup>M</sup>	up through 32	36.0	...	21.0	...	12	
H112	up through 5.000 <sup>M</sup>	up through 32	35.0	...	14.0	...	12	
Alloy 5154 <sup>E</sup>								
O	all	all	30.0	41.0	11.0	...	...	
H112	all	all	30.0	...	11.0	...	...	
Alloy 5454 <sup>E</sup>								
O	up through 5.000 <sup>M</sup>	up through 32	31.0	41.0	12.0	...	14	
H111	up through 5.000 <sup>M</sup>	up through 32	33.0	...	19.0	...	12	
H112	up through 5.000 <sup>M</sup>	up through 32	31.0	...	12.0	...	12	
Alloy 5456 <sup>E</sup>								
O	up through 5.000 <sup>M</sup>	up through 32	41.0	53.0	19.0	...	14	
H111	up through 5.000 <sup>M</sup>	up through 32	42.0	...	26.0	...	12	
H112	up through 5.000 <sup>M</sup>	up through 32	41.0	...	19.0	...	12	
Alloy 6005								
T1	{ up through 0.500	all	25.0	...	15.0	...	16	
T5		up through 0.124	all	38.0	...	35.0	...	8
		0.125–1.000	all	38.0	...	35.0	...	10
Alloy 6005A								
T1	up through 0.249	all	25.0	...	14.5	...	15	
T5	up through 0.249	all	38.0	...	31.0	...	7	
	0.250–0.999	all	38.0	...	31.0	...	9	
T61	up through 0.249	all	38.0	...	35.0	...	8	
	0.250–0.999	all	38.0	...	35.0	...	10	
Alloy 6060								
T51	up through 0.125	all	22.0	...	16.0	...	8	
T61	up through 0.124		30.0	...	25.0	...	8	
	0.125–1.000		30.0	...	25.0	...	10	
Alloy 6061 <sup>E</sup>								

**TABLE 2** *Continued*

Temper	Specified Section or Wall Thickness, in.	Area, in. <sup>2</sup>	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in. or 4 × Diameter, min, % <sup>C,D</sup>	
			min	max	min	max		
O	all	all	...	22.0	...	16.0	16	
T1	up through 0.625	all	26.0	...	14.0	...	16	
T4	}	all	26.0	...	16.0	...	16	
T4510 <sup>F</sup>								
T4511 <sup>F</sup>								
T42 <sup>G</sup>	all	all	26.0	...	12.0	...	16	
T51	up through 0.625	all	35.0	...	30.0	...	8	
T6, T62 <sup>G</sup>	}	all	38.0	...	35.0	...	8	
T6510 <sup>F</sup>								
T6511 <sup>F</sup>								
Alloy 6063								
O	all	all	...	19.0	...	...	18	
T1	{	up through 0.500	all	17.0	...	9.0	...	12
		0.501–1.000	all	16.0	...	8.0	...	12
T4, T42 <sup>G</sup>	{	up through 0.500	all	19.0	...	10.0	...	14
		0.501–1.000	all	18.0	...	9.0	...	14
T5	{	up through 0.500	all	22.0	...	16.0	...	8
		0.501–1.000	all	21.0	...	15.0	...	8
T52	{	up through 1.000	all	22.0	30.0	16.0	25.0	8
T54		up through 0.124	all	33.0	...	30.0	...	8
		0.125–0.499	all	33.0	...	30.0	...	10
T6, T62 <sup>G</sup>		up through 0.124	all	30.0	...	25.0	...	8
	{	0.125–1.000	all	30.0	...	25.0	...	10
Alloy 6066								
O	all	all	...	29.0	...	18.0	16	
T4, T4510, T4511 <sup>F</sup>	all	all	40.0	...	25.0	...	14	
T42 <sup>G</sup>	all	all	40.0	...	24.0	...	14	
T6, T6510, T6511 <sup>F</sup>	all	all	50.0	...	45.0	...	8	
T62 <sup>G</sup>	all	all	50.0	...	42.0	...	8	
Alloy 6070								
T6, T62	up through 2.999	up through 32	48.0	...	45.0	...	6	
Alloy 6082								
T6, T6511	{	0.200–0.750	all	45.0	...	38.0	...	6
		0.751–6.000	all	45.0	...	38.0	...	8
		6.001–8.000	all	41.0	...	35.0	...	6
Alloy 6105								
T1	up through 0.500	all	25.0	...	15.0	...	16	
T5	{	up through 0.124	all	38.0	...	35.0	...	8
		0.125–1.000	all	38.0	...	35.0	...	10
Alloy 6162								
T5, T5510, <sup>F</sup> T5511 <sup>F</sup>	up thru 1.000	all	37.0	...	34.0	...	7	
T6, T6510, <sup>F</sup> T6511 <sup>F</sup>	up thru 0.249	all	38.0	...	35.0	...	8	
	0.250–0.499	all	38.0	...	35.0	...	10	
Alloy 6262								
T6	}	all	all	38.0	...	35.0	...	10
T6510 <sup>F</sup>								
T6511 <sup>F</sup>								
Alloy 6351								
T1	up through 0.499	up through 20	26.0	...	13.0	...	15	
T11	up through 0.749	all	26.0	...	16.0	...	16	
T4	up through 0.749	all	32.0	...	19.0	...	16	
T5	up through 0.249	all	38.0	...	35.0	...	8	
	0.250–1.000	all	38.0	...	35.0	...	10	
T51	0.125–1.000	all	36.0	...	33.0	...	10	
T54	up through 0.500	all	30.0	...	20.0	...	10	

**TABLE 2** *Continued*

Temper	Specified Section or Wall Thickness, in.	Area, in. <sup>2</sup>	Tensile Strength, ksi		Yield Strength (0.2 % offset), ksi		Elongation in 2 in. or 4 × Diameter, min, % <sup>C,D</sup>
			min	max	min	max	
T6	{ up through 0.124 0.125–0.749	all	42.0	...	37.0	...	8
		all	42.0	...	37.0	...	10
Alloy 6463							
T1	up through 0.500	up through 20	17.0	...	9.0	...	12
T5	up through 0.500	up through 20	22.0	...	16.0	...	8
T6	{ up through 0.124 0.125–0.500	up through 20	30.0	...	25.0	...	8
		up through 20	30.0	...	25.0	...	10
Alloy 6560							
T5	0.090–0.125	all	22.0	...	16.0	...	8
T6	0.090–0.125	all	30.0	...	25.0	...	8
Alloy 7005							
T53	up through 0.750	all	50.0	...	44.0	...	10
Alloy 7075 <sup>E</sup>							
O	all	all	...	40.0	...	24.0	10
T6, T62 <sup>G</sup> T6510 <sup>F</sup> T6511 <sup>F</sup>	{ up through 0.249 0.250–0.499 0.500–1.499 1.500–2.999 3.000–4.499	all	...	78.0	...	70.0	7
		all	...	81.0	...	73.0	7
		all	...	81.0	...	72.0	7
		all	...	81.0	...	72.0	7
		{ up through 20 over 20 through 32	...	81.0	...	71.0	7
		...	...	78.0	...	70.0	6
T73 T73510 <sup>F</sup> T73511 <sup>F</sup>	{ 4.500–5.000 0.062–0.249 0.250–1.499 1.500–2.999 3.000–4.499	up through 32	...	78.0	...	68.0	6
		up through 20	...	68.0	...	58.0	7
		up through 25	...	70.0	...	61.0	8
		up through 25	...	69.0	...	59.0	8
		up through 20 over 20 through 32	...	68.0	...	57.0	7
...	...	65.0	...	55.0	7		
T76 T76510 <sup>F</sup> T76511 <sup>F</sup>	{ up through 0.049 0.050–0.124 0.125–0.249 0.250–0.499 0.500–1.000 1.001–2.000 2.001–3.000 3.001–4.000	all	...	73.0	...	63.0	7
		all	...	74.0	...	64.0	7
		up through 20	...	74.0	...	64.0	7
		up through 20	...	75.0	...	65.0	7
		up through 20	...	75.0	...	65.0	7
		up through 20	...	75.0	...	65.0	7
		up through 20	...	74.0	...	64.0	7
		up through 20	...	74.0	...	63.0	7
Alloy 7116							
T5	0.125–0.500	all	48.0	...	42.0	...	8
Alloy 7129							
T5, T6	up through 0.500	all	55.0	...	49.0	...	9
Alloy 7178 <sup>E</sup>							
O	all	up through 32	...	40.0	...	24.0	10
T6 T6510 <sup>F</sup> T6511 <sup>F</sup>	{ up through 0.061 0.062–0.249 0.250–1.499 1.500–2.499 2.500–2.999	up through 20	...	82.0	...	76.0	...
		up through 20	...	84.0	...	76.0	5
		up through 25	...	87.0	...	78.0	5
		{ up through 25 over 25 through 32	...	86.0	...	77.0	5
		...	...	84.0	...	75.0	5
up through 32	...	82.0	...	71.0	...	5	