

MATERIAL DATA

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- These figures show the APPROXIMATE ranges of mechanical properties and cannot be used as a basis of acceptance or rejection of material.
- They are NOT GUARANTEED and are given only as an indication of what may be expected and should under no circumstances be used in specifying the raw materials. It must not be assumed that these properties will be obtained in all cases, as they vary widely with permissible variations in analysis, size of section, rolling conditions, grain size, and methods of heat treatment.
- Dependable mechanical properties can only be obtained through carefully controlled heat treatment or special processing.





ALUMINUM SHEET AND PLATE RECOMMENDED MINIMUM BEND RADII FOR 90 DEGREE COLD FORMING OF SHEET AND PLATE^{1,2,3,4}

Alloy and Temper	Radii for various thicknesses expressed in terms of thickness (<i>t</i>)								
	¹ / ₆₄ in.	¹ / ₃₂ in.	¹ / ₁₆ in.	¹ / ₈ in.	³ / ₁₆ in.	¹ / ₄ in.	³ / ₈ in.	¹ / ₂ in.	
1100-O	0	0	0	0	¹ / ₂ <i>t</i>	1 <i>t</i>	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	
H14	0	0	0	1 <i>t</i>	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	2 <i>t</i>	2 ¹ / ₂ <i>t</i>	
2024-T3 & T351	2 ¹ / ₂ <i>t</i>	3 <i>t</i>	4 <i>t</i>	5 <i>t</i>	5 <i>t</i>	6 <i>t</i>	7 <i>t</i>	7 ¹ / ₂ <i>t</i>	
3003-O	0	0	0	0	¹ / ₂ <i>t</i>	1 <i>t</i>	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	
H14	0	0	0	1 <i>t</i>	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	2 <i>t</i>	2 ¹ / ₂ <i>t</i>	
5052-O	0	0	0	¹ / ₂ <i>t</i>	1 <i>t</i>	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	1 ¹ / ₂ <i>t</i>	
H32	0	0	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	1 ¹ / ₂ <i>t</i>	1 ¹ / ₂ <i>t</i>	1 ¹ / ₂ <i>t</i>	2 <i>t</i>	
H34	0	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	2 <i>t</i>	2 <i>t</i>	2 ¹ / ₂ <i>t</i>	2 ¹ / ₂ <i>t</i>	3 <i>t</i>	
5086-H32	0	¹ / ₂ <i>t</i>	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	1 ¹ / ₂ <i>t</i>	2 <i>t</i>	2 ¹ / ₂ <i>t</i>	3 <i>t</i>	
6061-O	0	0	0	1 <i>t</i>	1 <i>t</i>	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	2 <i>t</i>	
T4	0	0	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	2 ¹ / ₂ <i>t</i>	3 <i>t</i>	3 ¹ / ₂ <i>t</i>	4 <i>t</i>	
T6 & T651	1 <i>t</i>	1 <i>t</i>	1 ¹ / ₂ <i>t</i>	2 ¹ / ₂ <i>t</i>	3 <i>t</i>	3 ¹ / ₂ <i>t</i>	4 ¹ / ₂ <i>t</i>	5 <i>t</i>	
7075-T6 & T651	3 <i>t</i>	4 <i>t</i>	5 <i>t</i>	6 <i>t</i>	6 <i>t</i>	8 <i>t</i>	9 <i>t</i>	9 ¹ / ₂ <i>t</i>	

¹The radii listed are the minimum recommended for bending sheets and plates without fracturing in a standard press brake with air bend dies. Other types of bending operations may require larger radii or permit smaller radii. The minimum permissible radii will also vary with the design and condition of the tooling.

²Alclad sheet in the heat-treatable alloys can be bent over slightly smaller radii than the corresponding tempers of the bare alloy.

³Heat-treatable alloys can be formed over appreciably smaller radii immediately after solution heat treatment.

⁴Not applicable for Tread Plate or Cast Tool and Jig Plate.

ALUMINUM
NOMINAL CHEMICAL COMPOSITION†
OF WROUGHT ALLOYS

Alloy	Per Cent of Alloying Elements—Aluminum and Normal Impurities Constitute Remainder									
	Copper	Silicon	Man-ganese	Mag-nesium	Zinc	Tita-nium	Chro-mium	Lead	Bis-muth	
1060		99.60% minimum aluminum								
1100	0.12	99.00% minimum aluminum								
1230*		99.30% minimum aluminum								
1350		99.50% minimum aluminum								
2011	5.5	..	..	..	..	..	..	0.40	0.40
2014	4.4	0.8	0.8	0.50	..	..	..	..	..
2017	4.0	0.50	0.7	0.6	..	..	..	..	..
2024	4.4	..	0.6	1.5	..	..	..	..	..
3003	0.12	..	1.2	..	..	..	..	..	..
3004	..	..	1.2	1.0	..	..	..	..	..
3105	..	..	0.6	0.50	..	..	..	..	..
4032	0.9	12.2	..	1.0	..	..	..	..	Ni 0.9
4043	..	5.2	..	..	..	..	..	..	..
5005	..	..	..	0.8	..	..	..	..	..
5050	..	..	..	1.4	..	..	..	..	..
5052	..	..	..	2.5	..	..	0.25	..	..
5083	..	..	0.7	4.4	..	..	0.15	..	..
5086	..	..	0.45	4.0	..	..	0.15	..	..
5154	..	..	..	3.5	..	..	0.25	..	..
5356	..	..	0.12	5.0	..	0.13	0.12	..	..
5454	..	..	0.8	2.7	..	..	0.12	..	..
5456	..	..	0.8	5.1	..	..	0.12	..	..
5457	..	..	0.3	1.0	..	..	..	..	..
5554	..	..	0.8	2.7	..	0.12	0.12	..	..
5556	..	..	0.8	5.1	..	0.12	0.12	..	..
5657	..	..	..	0.8	..	..	..	..	..
6013	0.8	0.8	0.5	1.0	..	..	..	..	..
6020	0.6	.65	..	0.9	..	..	..	..	Sn1.2
6061	0.28	0.6	..	1.0	..	..	0.20	..	..
6063	..	0.40	..	0.7	..	..	..	..	..
6101	..	0.5	..	0.6	..	..	..	..	..
6262	0.28	0.6	..	1.0	..	..	0.09	0.55	0.55
7075	1.6	..	..	2.5	5.6	..	0.23	..	..

*Cladding on 2024
†Source: Aluminum Association Inc.

ALUMINUM TYPICAL MECHANICAL PROPERTIES OF WROUGHT ALLOYS

These typical properties are average for various forms, sizes, and methods of manufacture and may not exactly describe any one particular product or size and do not imply availability in all products. They should not be used in specifying the raw material.

Alloy and Temper	UNS Number	Tensile Strength ^a (ksi)	Yield (.2%) Strength ^a (ksi)	% Elongation -2"	
				1/16" Thick Specimen	1/2" Diam. Specimen
1100-O	A91100	13.0	5.0	35	45
1100-H12	A91100	16.0	15.0	12	25
1100-H14	A91100	18.0	17.0	9	20
1100-H16	A91100	21.0	20.0	6	17
1100-H18	A91100	24.0	22.0	5	15
1100-H19	A91100	27.0	24.0	..	12
2011-T3	A92011	55.0	43.0	..	15
2011-T451	A92011	40.6	18.0	..	16
2011-T8	A92011	59.0	45.0	..	12
2014-O	A92014	27.0	14.0	..	18
2014-T4,-T451	A92014	62.0	42.0	..	20
2014-T6,-T651	A92014	70.0	60.0	..	13
Alclad 2014-O	A92014	25.0	10.0	21	..
Alclad 2014-T3	A92014	63.0	40.0	20	..
Alclad 2014-T4,-T451	A92014	61.0	37.0	22	..
Alclad 2014-T6,-T651	A92014	68.0	60.0	10	..
2017-H13	A92017	35.0	..	..	15
2017-O	A92017	26.0	10.0	..	22
2017-T4,-T451	A92017	62.0	40.0	..	22
2024-O	A92024	27.0	11.0	20	22
2024-T3	A92024	70.0	50.0	18	..
2024-T361 ¹	A92024	72.0	57.0	13	..
2024-T4,-T351	A92024	68.0	47.0	20	19
2024-T6	A92024	69.0	57.0	..	10
2024-T81,-T851	A92024	70.0	65.0	7	8
2024-T861 ¹	A92024	75.0	71.0	6	7
Alclad 2024-O	A92024	26.0	11.0	20	..
Alclad 2024-T3	A92024	65.0	45.0	18	..
Alclad 2024-T361 ¹	A92024	67.0	53.0	11	..
Alclad 2024-T4,-T351	A92024	64.0	42.0	19	..
Alclad 2024-T81,-T851	A92024	65.0	60.0	6	..
Alclad 2024-T861 ¹	A92024	70.0	66.0	6	..
3003-O	A93003	16.0	6.0	30	40
3003-H12	A93003	19.0	18.0	10	20
3003-H14	A93003	22.0	21.0	8	16
3003-H16	A93003	26.0	25.0	5	14
3003-H18	A93003	29.0	27.0	4	10
3003-H22	A93003	23.0	20.0	..	12
Alclad 3003-O	A93003	16.0	6.0	30	40
Alclad 3003-H12	A93003	19.0	18.0	10	20
Alclad 3003-H14	A93003	22.0	21.0	8	16
Alclad 3003-H16	A93003	26.0	25.0	5	14
Alclad 3003-H18	A93003	29.0	27.0	4	10

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ALUMINUM TYPICAL MECHANICAL PROPERTIES OF WROUGHT ALLOYS

These figures are not guaranteed.

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Alloy and Temper	UNS Number	Tensile Strength ³ (ksi)	Yield (.2%) Strength ³ (ksi)	% Elongation -2"	
				1/16" Thick Specimen	1/2" Diam. Specimen
3004-O	A93004	26.0	10.0	20	25
3004-H32	A93004	31.0	25.0	10	17
3004-H34	A93004	35.0	29.0	9	12
3004-H36	A93004	38.0	33.0	5	9
3004-H38	A93004	41.0	36.0	5	6
Alclad 3004-O	A93004	26.0	10.0	20	25
Alclad 3004-H32	A93004	31.0	25.0	10	17
Alclad 3004-H34	A93004	35.0	29.0	9	12
Alclad 3004-H36	A93004	38.0	33.0	5	9
Alclad 3004-H38	A93004	41.0	36.0	5	6
3105-H14	A93105	25.0	22.0	5	..
4032-T6,T651	A94032	54.0	50.0	..	7
5005-O	A95005	18.0	6.0	25	..
5005-H12	A95005	20.0	19.0	10	..
5005-H14	A95005	23.0	22.0	6	..
5005-H16	A95005	26.0	25.0	5	..
5005-H18	A95005	29.0	28.0	4	..
5005-H32	A95005	20.0	17.0	11	..
5005-H34	A95005	23.0	20.0	8	..
5005-H36	A95005	26.0	24.0	6	..
5005-H38	A95005	29.0	27.0	5	..
5050-O	A95050	21.0	8.0	24	..
5052-O	A95052	28.0	13.0	25	30
5052-H32	A95052	33.0	28.0	12	18
5052-H320*	A95052	29.0	19.0	..	8
5052-H34	A95052	38.0	31.0	10	14
5052-H36	A95052	40.0	35.0	8	10
5052-H38	A95052	42.0	37.0	7	8
5083-O	A95083	42.0	21.0	..	22
5083-H112	A95083	43.0	23.0	20	22
5083-H321,-H116	A95083	46.0	33.0	..	16
5083-H323	A95083	47.0	36.0	10	..
5083-H343	A95083	52.0	41.0	8	..
5086-O	A95086	38.0	17.0	22	..
5086-H32,-H116	A95086	42.0	30.0	12	..
5086-H34	A95086	47.0	37.0	10	..
5086-H36	A95086	50.0	41.0	8	..
5086-H112	A95086	39.0	19.0	14	..
5154-O	A95154	35.0	17.0	27	..
5154-H112	A95154	35.0	17.0	25	..
5154-H32	A95154	39.0	30.0	15	..

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ALUMINUM TYPICAL MECHANICAL PROPERTIES OF WROUGHT ALLOYS

These figures are not guaranteed.

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Alloy and Temper	UNS Number	Tensile Strength ³ (ksi)	Yield (.2%) Strength ³ (ksi)	% Elongation -2"	
				1/16" Thick Specimen	1/2" Diam. Specimen
5154-H34	A95154	42.0	33.0	13	..
5154-H36	A95154	45.0	36.0	12	..
5154-H38	A95154	48.0	39.0	10	..
5454-O	A95454	36.0	17.0	22	..
5454-H32	A95454	40.0	30.0	10	..
5454-H34	A95454	44.0	35.0	10	..
5454-H112	A95454	36.0	18.0	18	..
5456-O	A95456	45.0	23.0	..	24
5456-H112	A95456	45.0	24.0	..	22
5456-H321,-H116	A95456	51.0	37.0	..	16
5457-O	A95457	19.0	7.0	22	..
5457-H25	A95657	26.0	23.0	12	..
5457-H28	A95457	30.0	27.0	6	..
5657-H25	A95657	23.0	20.0	..	10
6013-T8	A96013	64.0	62.0	..	11
6020-T9	A96020	58.0	53.0	..	8
6020-T651	A96020	45.0	40.0	..	15
6061-O	A96061	18.0	8.0	25	30
6061-T4,-T451	A96061	35.0	21.0	22	25
6061-T6,-T651,-T6511	A96061	45.0	40.0	12	17
6061-T6511*	A96061	42.0	38.0	..	10
Alclad 6061-O	A96061	17.0	7.0	25	..
Alclad 6061-T4,-T451	A96061	33.0	19.0	22	..
Alclad 6061-T6,-T651	A96061	42.0	37.0	12	..
6063-O	A96063	13.0	7.0	..	..
6063-T1	A96063	22.0	13.0	20	..
6063-T4	A96063	25.0	13.0	22	..
6063-T5, T52	A96063	27.0	21.0	12	..
6063-T6	A96063	35.0	31.0	12	..
6063-T83	A96063	37.0	35.0	9	..
6063-T831	A96063	30.0	27.0	10	..
6063-T832	A96063	42.0	39.0	12	..
6101-T61	A96101	32.0	28.0	15	..
6262-T6511 ²	A96262	45.0	41.0	..	15
6262-T8	A96262	42.0	32.0	..	10
6262-T9	A96262	58.0	55.0	..	10
7075-O	A97075	33.0	15.0	17	16
7075-T6,-T651	A97075	83.0	73.0	11	11
Alclad 7075-O	A97075	32.0	14.0	17	..
Cast Tool and Jig Plate	..	26.0	15.0	..	..

¹Tempers T361 and T861 were formerly designated T36 and T86, respectively.

²For stress-relieved tempers, the characteristics and properties other than those specified may differ somewhat from the corresponding characteristics and properties of material in the basic temper.

³1 ksi = 1,000 psi

*Minimum Properties (Manifold Quality)