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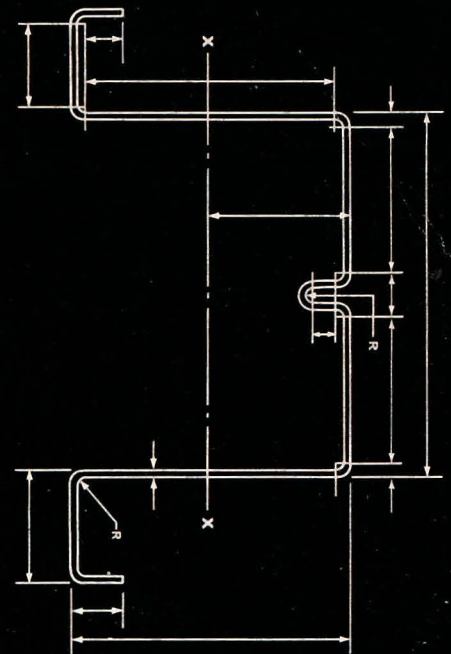
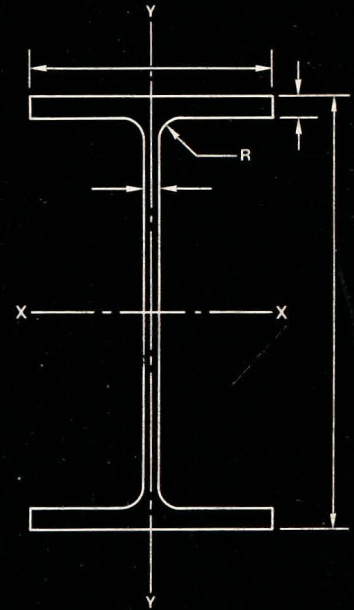
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Aluminum Construction Manual

SPECIFICATIONS FOR ALUMINUM STRUCTURES



THE ALUMINUM ASSOCIATION



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ALUMINUM CONSTRUCTION MANUAL

Specifications for Aluminum Structures

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THE ALUMINUM ASSOCIATION
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Second Printing November 1968

In this second printing, several minor additions and corrections have been made.

Specifically, mechanical properties and buckling constants for alloy 3005-H25 and recently adopted tempers of alclad 3004 sheet have been added to appropriate tables. Temper designations for alloys 2014 and 6061 have been corrected to delete the -T6 temper for plate and add the -T6510 and -T6511 tempers for extrusions. Buckling constants for alloys 5005-H36 and 5052-H36 have been corrected in Table 3.3.1b. In Table 3.3.2 the value of F_{tuw} for 5086-H111 extrusions has been revised from 38 to 35 ksi. Corrections have been made in Table 3.3.6 to replace B_e with B_c in Specification 7, and F_{cy} with F_{sy} in Specifications 20 and 21. In addition, a paragraph has been included on page 47 permitting the use of a weighted average allowable tensile stress for trapezoidal formed sheet beams and an Addendum dealing with alloys not covered in the first printing has been provided beginning on page 62.

FOREWORD

This part of the Aluminum Construction Manual deals with specifications for allowable stresses in structures. It is a compilation of methods for determining allowable stresses based largely on information generated within the aluminum industry.

Much of the material published in these specifications has been previously published in other forms. Some of it is new. It represents the best current thinking of the industry with regard to allowable stress determinations.

We have attempted to present this material in a form that can be widely and generally useful. For this reason commentary has been included with the specifications. It is indented and in smaller type. We will welcome suggestions that users may have regarding the content and form of these specifications.

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ALUMINUM CONSTRUCTION MANUAL

Specifications for Aluminum Structures

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ALUMINUM CONSTRUCTION MANUAL

Specifications for Aluminum Structures

Section 1. General

1.1 Scope. These specifications shall apply to the design of aluminum alloy load carrying members.

1.2 Materials. The principal materials to which these specifications apply are aluminum alloys registered with The Aluminum Association. Those frequently used for structural members are listed in Table 3.3.1, Section 3, with minimum mechanical properties and applicable buckling formula constants. Applicable ASTM specifications are Designations B209, B210, B211, B221, B234, B241, B247, B308, and B429.

1.3 Allowable Stresses.

1.3.1 Building Type Structures. Basic allowable tensile stresses for buildings and similar structures shall be the lesser of the minimum yield strength divided by a factor of safety of 1.65, or the minimum ultimate tensile strength divided by a factor of safety of 1.95. Other allowable stresses for buildings and similar structures shall be based upon the factors of safety shown in Table 3.3.3.

1.3.2 Bridge Type Structures. Basic allowable tensile stresses for bridge type structures shall be the lesser of the minimum yield strength divided by a factor of safety of 1.85, or the minimum ultimate tensile strength divided by a factor of safety of 2.2. Other allowable stresses for bridge and similar structures shall be based upon the factors of safety shown in Table 3.3.3.

*The factors of safety referred to in 1.3.1 and 1.3.2 above are similar to those used in the AISI and AISC specifications and the suggested specifications for aluminum structures of the ASCE Task Committee on Lightweight Alloys. In calculating appropriate stresses for alloys listed in Tables 3.3.7–3.3.27, Section 3, factors of safety for building type structures have been used. Tables for alloys 6061-T6, 6063-T5 and 6063-T6 based on factors of safety for bridge type structures are included in the Appendix.

Section 2. Design Procedure

2.1 Properties of Sections. Properties of sections, such as cross sectional area, moment of inertia, section modulus, radius of gyration, etc. shall be determined in accordance with accepted methods of structural analysis.

* In these specifications indented small type is used to designate explanatory notes or commentary.

2.2 Procedure. Computations for forces, moments, stresses and deflections shall be in accordance with accepted methods of elastic structural analysis and engineering design.

2.3 Loading.

2.3.1 Dead Load. The dead load to be used in the design of the structure is the weight of the structure and all material permanently attached to and supported by the structure.

2.3.2 Live Load. Static and dynamic live loads, as well as snow, ice and wind loads shall be based on appropriate building codes. Where building codes do not apply, requirements shall be established from performance specifications for the structure.

In computing stresses, loads produced by wind and seismic forces acting alone or in combination with dead and live loads may be reduced by 25 percent. However, the section shall not be less than that required for the dead and other live loads acting alone. In the case of wind and ice loads, the form of the structure and any of its exposed components (e.g. increased area exposed to wind due to icing) shall be considered.

Section 3. Allowable Stresses

3.1 Introduction. The nomenclature of terms used in developing the allowable stresses is given in Section 3.2. Minimum mechanical properties and buckling formula constants for each alloy (non-welded material) included in these specifications are listed in Tables 3.3.1a and b. Minimum mechanical properties for welded material are shown in Table 3.3.2.

The allowable stresses for the alloys are determined by applying the appropriate factors of safety to the listed minimum properties and buckling constants. The factors of safety are listed in Table 3.3.3. The formulas for buckling constants are presented in Tables 3.3.4a and b. General formulas for allowable stresses are given in Table 3.3.6. An explanation of these formulas is presented in Section 3.4. The last number of each paragraph designation in Section 3.4 corresponds to the Specification no. of Tables 3.3.6 to 3.3.27, e.g. 3.4.12 refers to Specification no. 12. Allowable stresses for some alloys to be used in buildings and similar structures have been determined in accordance with these procedures. They are presented in Tables 3.3.7 to 3.3.27. For bridge and similar type structures see Appendix.

allowable stresses/nomenclature

3.2 Nomenclature

English units are used throughout these specifications. *Ksi* indicates thousands of pounds per square inch; kips indicates thousands of pounds.

A	= Area, in ² .	F_{ec}	= $\pi^2 E / [n_u (L/r)^2]$, where L/r is slenderness ratio for member considered as a column tending to fail in the plane of the applied bending moments, ksi
A_w	= Area of cross section lying within 1.0 in. of a weld, in ² .	F_n	= allowable stress for cross section 1.0 in. or more from weld, ksi
a_1	= shorter dimension of rectangular panel, in.	F_{pw}	= allowable stress on cross section, part of whose area lies within 1.0 in. of a weld, ksi
a_2	= longer dimension of rectangular panel, in.	F_s	= allowable shear stress for members subjected only to torsion or shear, ksi
a_e	= equivalent width of rectangular panel, in.	F_{su}	= shear ultimate strength, ksi
B, D, C	= buckling formula constants, with following subscript:	F_{suw}	= shear ultimate strength within 1.0 in. of a weld, ksi
	c – compression in columns	F_{sy}	= shear yield strength, ksi
	p – compression in flat plates	F_{syw}	= shear yield strength within 1.0 in. of a weld, ksi
	t – compression in round tubes	F_{tu}	= tensile ultimate strength, ksi
	tb – bending in round tubes	F_{tuw}	= tensile ultimate strength across a butt weld, ksi
	b – bending in rectangular bars	F_{ty}	= tensile yield strength, ksi
	s – shear in flat plates	F_{tyw}	= tensile yield strength across a butt weld (0.2 percent offset in 10-in. gage length), ksi
b	= width of sections, in.	F_y	= either F_{ty} or F_{cy} , whichever is smaller, ksi
b/t	= width to thickness ratio of rectangular element of a cross section	g	= spacing of rivet or bolt holes perpendicular to direction of load, in.
c	= distance from neutral axis to extreme fiber, in.	G	= modulus of elasticity in shear, ksi
D	= diameter, in.	h	= clear height of shear web, in.
d	= depth of section or beam, in.	I	= moment of inertia, in. ⁴
E	= compressive modulus of elasticity, ksi	I_h	= moment of inertia of horizontal stiffener, in. ⁴
f	= calculated stress, ksi	I_s	= moment of inertia of transverse stiffener to resist shear buckling, in. ⁴
f_a	= average compressive stress on cross section of member produced by axial compressive load, ksi	I_x	= moment of inertia of a beam about axis perpendicular to web, in. ⁴
f_b	= maximum bending stress (compression) caused by transverse loads or end moments, ksi	I_y	= moment of inertia of a beam about axis parallel to web, in. ⁴
f_s	= shear stress caused by torsion or transverse shear, ksi	J	= torsion constant, in. ⁴
F	= allowable stress, ksi	k_1	= coefficient for determining slenderness limit S_2 for sections for which the allowable compressive stress is based on crippling strength.
F_a	= allowable compressive stress for member considered as an axially loaded column, ksi	k_2	= coefficient for determining allowable compressive stress in sections with slenderness ratio above S_2 for which the allowable compressive stress is based on crippling strength.
F_b	= allowable compressive stress for member considered as a beam, ksi	k_c	= coefficient for compression members.
F_{bu}	= bearing ultimate strength, ksi	k_t	= coefficient for tension members.
F_{buw}	= bearing ultimate strength within 1.0 in. of a weld, ksi	L	= length of compression member between points of lateral support, or twice the length of a cantilever column (except where analysis shows that a shorter length can be used), in.
F_{by}	= bearing yield strength, ksi	L/r	= slenderness ratio for columns
F_{byw}	= bearing yield strength within 1.0 in. of a weld, ksi		
F_c	= allowable compressive stress, ksi		
F_{cy}	= compressive yield strength, ksi		
F_{cyw}	= compressive yield strength across a butt weld (0.2 percent offset in 10 in. gage length), ksi		

L_b = length of beam between points at which the compression flange is supported against lateral movement, or length of cantilever beam from free end to point at which the compression flange is supported against lateral movement, in.

L_h = total length of portion of column lying within 1.0 in. of a weld (excluding welds at ends of columns that are supported at both ends), in.

L_w = increased length to be substituted in column formula to determine allowable stress for welded column, in.

M = bending moment, in.-kips.

M_c = bending moment at center of span resulting from applied bending loads, in.-kips.

M_m = maximum bending moment in span resulting from applied bending loads, in.-kips.

M_1, M_2 = bending moments at two ends of a beam, in.-kips.

n_a = factor of safety on appearance of buckling

n_u = factor of safety on ultimate strength

n_y = factor of safety on yield strength

P = local load concentration on bearing stiffener, kips.

r = least radius of gyration of a column, in.

r_L = radius of gyration of lip or bulb about face of flange from which lip projects, in.

r_y = radius of gyration of a beam (about axis parallel to web), in. (For beams that are unsymmetrical about the horizontal axis, r_y should be calculated as though both flanges were the same as the compression flange.)

R = outside radius of round tube or maximum outside radius for an oval tube, in.

R_b = radius of curvature of tubular members, in.

s = spacing of transverse stiffeners (clear distance between stiffeners for stiffeners consisting of a pair of members, one on each side of the web, center-to-center distance between stiffeners consisting of a member on one side of the web only), in.; spacing of rivet or bolt holes parallel to direction of load, in.

S_c = section modulus of a beam, compression side, in.³

S_t = section modulus of a beam, tension side, in.³

S_1, S_2 = slenderness limits (see Table 3.3.6)

t = thickness of flange, plate, web or tube, in. (For tapered flanges, t is the average thickness.)

V = shear force on web at stiffener location, kips

α = a factor equal to unity for a stiffener consisting of equal members on both sides of the web and equal to 3.5 for a stiffener consisting of a member on one side only

3.3 Tables Relating To Allowable Stresses

Section 3.3 consists of tables concerning formulas for determining allowable stresses and constants and coefficients needed for these formulas. It also includes tables applicable to those alloys and tempers that should be of most use in designing aluminum structures. These tables are:

3.3.1a Minimum Mechanical Properties For Aluminum Alloys

3.3.1b Buckling Formula Constants For Aluminum Alloys

3.3.2 Minimum Mechanical Properties, Welded Aluminum Alloys

3.3.3 Factors of Safety For Use With Aluminum Allowable Stress Specifications

3.3.4a Formulas For Buckling Constants—For all products whose temper designation begins with -O, -H, -T1, -T2, -T3, or -T4

3.3.4b Formulas For Buckling Constants—For products whose temper designation begins with -T5, -T6, -T7, -T8, or -T9

3.3.5 Values of Coefficients k_t and k_c

3.3.6 General Formulas For Determining Allowable Stresses

Allowable Stresses for Building Structures of

3.3.7 Alloy 1100-H14

3.3.8 Alloy 2014-T6, -T651

3.3.9 Alloy 3003-H14

3.3.10 Alloy 3003-H16

3.3.11 Alclad 3004-H16

3.3.12 Alclad 3004-H34

3.3.13 Alloy 5005-H14

3.3.14 Alloy 5050-H34

3.3.15 Alloy 5052-H34

3.3.16 Alloy 5083-H111 Extrusions

3.3.17 Alloy 5083-H321 Sheet & Plate

3.3.18 Alloy 5086-H111 Extrusions

3.3.19 Alloy 5086-H34

3.3.20 Alloy 5454-H111 Extrusions

3.3.21 Alloy 5454-H34 Sheet & Plate

3.3.22 Alloy 5456-H111 Extrusions

3.3.23 Alloy 5456-H321 Sheet & Plate

3.3.24 Alloy 5456-H343

3.3.25 Alloy 6061-T6, -T651

3.3.26 Alloy 6063-T5 Extrusions

3.3.27 Alloy 6063-T6 Extrusions

Tables of allowable stresses for bridge and similar type structures are given in the Appendix for alloys 6061 and 6063.

TABLE 3.3.1a
MINIMUM MECHANICAL PROPERTIES
FOR ALUMINUM ALLOYS

Values Are Given in Units of ksi (1000 lb/in²)

Alloy And Temper	Product*	Thickness Range* in.	TENSION		COM- PRES- SION F_{cy} ksi	SHEAR		BEARING		Compressive Modulus of Elasticity† E ksi
			$F_{tu}†$ ksi	$F_{ty}†$ ksi		F_{su} ksi	F_{sy} ksi	F_{bu} ksi	F_{by} ksi	
1100-H12 -H14	(Sheet, Plate Rolled Rod & Bar Drawn Tube)	All All	14 16	11 14	10 13	9 10	6.5 8	28 32	18 21	10,100 10,100
2014-T6 -T651	Sheet Plate	0.040-0.249 0.250-2.000	66 67	58 59	59 58	40 40	33 34	125 127	93 94	10,900 10,900
-T6,T6510** -T6,T651	Extrusions Rolled Rod & Bar Drawn Tube	All All	60 65	53 55	55 53	35 38	31 32	114 124	85 88	10,900 10,900
Alclad 2014-T6 -T651	Sheet Sheet Plate	0.020-0.039 0.040-0.249 0.250-0.499	63 64 64	55 57 57	56 58 56	38 39 39	32 33 33	120 122 122	88 91 91	10,800 10,800 10,800
3003-H12 -H14 -H16 -H18	Sheet & Plate Sheet & Plate Sheet Sheet	0.017-2.000 0.009-1.000 0.006-0.162 0.006-0.128	17 20 24 27	12 17 21 24	10 14 18 20	11 12 14 15	7 10 12 14	34 40 46 49	19 25 31 34	10,100 10,100 10,100 10,100
3003-H12 -H14 -H16 -H18	Drawn Tube Drawn Tube Drawn Tube Drawn Tube	All All All All	17 20 24 27	12 17 21 24	10 16 19 21	11 12 14 15	7 10 12 14	34 40 46 49	19 25 31 34	10,100 10,100 10,100 10,100
Alclad 3003-H12 -H14 -H16 -H18	Sheet & Plate Sheet & Plate Sheet Sheet	0.017-2.000 0.009-1.000 0.006-0.162 0.006-0.128	16 19 23 26	11 16 20 23	9 13 17 19	10 12 14 15	6.5 9 12 13	32 38 44 47	18 24 30 32	10,100 10,100 10,100 10,100
Alclad 3003-H14 -H18	Drawn Tube Drawn Tube	0.010-0.500 0.010-0.500	19 26	16 23	15 20	12 15	9 13	38 47	24 32	10,100 10,100
3004-H32 -H34 -H36	Sheet & Plate Sheet & Plate Sheet	0.017-2.000 0.009-1.000 0.006-0.162	28 32 35	21 25 28	18 22 25	17 19 20	12 14 16	56 64 70	36 40 45	10,100 10,100 10,100
3004-H34 -H36	Drawn Tube Drawn Tube	0.018-0.450 0.018-0.450	32 35	25 28	24 27	19 20	14 16	64 70	40 45	10,100 10,100
Alclad 3004-H32 -H34 -H36 -H14 -H16 -H131,H241,H341 -H151,H261,H361	Sheet Sheet Sheet Sheet Sheet Sheet Sheet	0.017-0.249 0.009-0.249 0.006-0.162 0.009-0.249 0.006-0.162 0.024-0.050 0.024-0.050	27 31 34 32 35 31 34	20 24 27 26 30 26 30	17 21 24 22 26 22 26	16 18 19 19 20 18 19	12 14 16 15 17 15 17	54 62 68 64 66 62 66	34 38 43 39 45 39 45	10,100 10,100 10,100 10,100 10,100 10,100 10,100
3005-H25	Sheet	0.013-0.050	26	22	20	15	13	49	35	10,100
5005-H12 -H14 -H16 -H32 -H34 -H36	Sheet & Plate Sheet & Plate Sheet Sheet & Plate Sheet & Plate Sheet	0.018-2.000 0.009-1.000 0.006-0.162 0.017-2.000 0.009-1.000 0.006-0.162	18 21 24 17 20 23	14 17 20 12 15 18	13 15 18 11 14 16	11 12 14 11 12 13	8 10 12 7 8.5 11	34 40 48 34 40 48	22 25 30 20 24 29	10,100 10,100 10,100 10,100 10,100 10,100

TABLE 3.3.1a (cont'd)

Alloy And Temper	Product*	Thickness Range* in.	TENSION		COM- PRES- SION F_{cy} ksi	SHEAR		BEARING		Compressive Modulus of Elasticity† E ksi
			$F_{tu}†$ ksi	$F_{ty}†$ ksi		F_{su} ksi	F_{sy} ksi	F_{bu} ksi	F_{by} ksi	
5050-H32	Sheet	0.017-0.249	22	16	14	14	9	44	27	10,100
-H34	Sheet	0.009-0.249	25	20	18	15	12	50	32	10,100
-H32	Rolled Rod & Bar	All	22	16	15	13	9	44	27	10,100
-H34	Drawn Tube	All	25	20	19	15	12	50	32	10,100
5052-H32	(Sheet & Plate	All	31	23	21	19	13	60	39	10,200
-H34	Rolled Rod & Bar	All	34	26	24	20	15	65	44	10,200
-H36	Drawn Tube	0.006-0.162	37	29	26	22	17	70	46	10,200
5083-H111	Extrusions	up thru 0.500	40	24	21	24	14	78	41	10,400
-H111	Extrusions	0.501 and over	40	24	21	23	14	78	38	10,400
-H321	Sheet & Plate	0.188-1.500	44	31	26	26	18	84	53	10,400
-H323	Sheet	0.051-0.249	45	34	32	26	20	88	58	10,400
-H343	Sheet	0.051-0.249	50	39	37	29	23	95	66	10,400
-H321	Plate	1.501-3.000	41	29	24	24	17	78	49	10,400
5086-H111	Extrusions	up thru 0.500	36	21	18	21	12	70	36	10,400
-H111	Extrusions	0.501 and over	36	21	18	21	12	70	34	10,400
-H112	Plate	0.250-0.499	36	18	17	22	10	72	31	10,400
-H112	Plate	0.500-1.000	35	16	16	21	9	70	28	10,400
-H112	Plate	1.001-2.000	35	14	15	21	8	70	28	10,400
-H112	Plate	2.001-3.000	34	14	15	21	8	68	28	10,400
-H32	(Sheet & Plate)	All	40	28	26	24	16	78	48	10,400
-H34	Drawn Tube	All	44	34	32	26	20	84	58	10,400
5454-H111	Extrusions	up thru 0.500	33	19	16	20	11	64	32	10,400
-H111	Extrusions	0.501 and over	33	19	16	19	11	64	30	10,400
-H112	Extrusions	up thru 5.000	31	12	13	19	7	62	24	10,400
-H32	Sheet & Plate	0.020-2.000	36	26	24	21	15	70	44	10,400
-H34	Sheet & Plate	0.020-1.000	39	29	27	23	17	74	49	10,400
5456-H111	Extrusions	up thru 0.500	42	26	22	25	15	82	44	10,400
-H111	Extrusions	0.501 and over	42	26	22	24	15	82	42	10,400
-H112	Extrusions	up thru 5.000	41	19	20	24	11	82	38	10,400
-H321	Sheet & Plate	0.188-1.250	46	33	27	27	19	87	56	10,400
-H321	Plate	1.251-1.500	44	31	25	25	18	84	53	10,400
-H321	Plate	1.501-3.000	41	29	25	25	17	82	49	10,400
-H323	Sheet	0.051-0.249	48	36	34	28	21	94	61	10,400
-H343	Sheet	0.051-0.249	53	41	39	31	24	101	70	10,400
6061-T6,T651	Sheet & Plate	0.010-4.000	42	35	35	27	20	88	58	10,100
-T6,T651**	Extrusions	up thru 3.000	38	35	35	24	20	80	56	10,100
-T6,T651	Rolled Rod & Bar	up thru 8.000	42	35	35	27	20	88	56	10,100
-T6	Drawn Tube	0.025-0.500	42	35	35	27	20	88	56	10,100
-T6	Pipe	up thru 0.999	42	35	35	27	20	88	56	10,100
-T6	Pipe	over 0.999	38	35	35	24	20	80	56	10,100
6063-T5	Extrusions	up thru 0.500	22	16	16	13	9	46	26	10,100
-T5	Extrusions	over 0.500	21	15	15	12	8.5	44	24	10,100
-T6	Extrusions	All	30	25	25	19	14	63	40	10,100

* Most product and thickness ranges are taken from The Aluminum Association's 1968-1969 edition of "Aluminum Standards and Data."

† F_{tu} and F_{ty} are minimum specified values (except for Alclad 3004-H14, -H16 and F_{ty} for Alclad 3003-H18) other strength properties are corresponding minimum expected values.

‡ For deflection calculations an average modulus of elasticity is used; numerically this is 100 ksi lower than the value in this column.

** Values also apply to -T6511 temper.

TABLE 3.3.1b
BUCKLING FORMULA CONSTANTS FOR ALUMINUM ALLOYS

Alloy And Temper	Product	COMPRESSION IN COLUMNS			COMPRESSION IN FLAT PLATES			COMPRESSION IN ROUND TUBES			BENDING IN ROUND TUBES			BENDING IN REC- TANGULAR BARS			SHEAR IN FLAT PLATES		
		B_c ksi	D_c ksi	C_c	B_p ksi	D_p ksi	C_p	B_t ksi	D_t ksi	C_t	B_{rb} ksi	D_{rb} ksi	C_{rb}	B_b ksi	D_b ksi	C_b	B_s ksi	D_s ksi	C_s
1100-H12 -H14	(Sheet, Plate) Rolled Rod Drawn Tube	11.0	0.044	165	12.8	0.056	153	12.7	0.372	607	19.1	0.875	160	17.0	0.085	133	8.5	0.030	188
		14.5	0.067	144	17.0	0.086	133	16.7	0.536	461	25.1	1.260	133	22.6	0.131	115	10.6	0.042	168
2014-T6 -T651 -T6,T6510** -T6,T651	Sheet	68.6	0.544	52	79.1	0.674	48	74.3	3.132	94	109.5	8.754	39	119.4	1.530	52	44.4	0.283	64
	Plate	67.3	0.529	52	77.7	0.656	48	73.0	3.059	95	109.5	8.754	41	117.1	1.486	53	45.8	0.297	63
	Extrusions	63.6	0.486	54	73.3	0.602	50	69.1	2.841	100	99.7	7.724	39	110.3	1.360	54	41.5	0.256	66
	Rolled Bar Drawn Tube	61.1	0.458	55	70.5	0.567	51	66.5	2.699	103	99.7	7.724	44	105.9	1.278	55	42.9	0.269	65
Alclad 2014-T6 -T6 -T651	Sheet (0.039)*	64.8	0.502	53	74.8	0.622	49	70.4	2.922	98	103.6	8.157	40	112.6	1.408	53	42.9	0.271	65
	Sheet (0.249)*	67.3	0.531	52	77.7	0.659	48	73.0	3.068	94	107.6	8.571	39	117.1	1.493	52	44.4	0.285	64
	Plate	64.8	0.502	53	74.8	0.622	49	70.4	2.922	98	105.6	8.363	42	112.6	1.408	53	44.4	0.285	64
3003-H12 -H14 -H16 -H18	Sheet & Plate	11.0	0.044	165	12.8	0.056	153	12.7	0.372	607	19.1	0.875	160	17.0	0.085	133	9.2	0.034	181
	Sheet & Plate	15.7	0.075	138	18.4	0.096	127	18.1	0.594	415	27.1	1.397	127	24.5	0.147	111	13.5	0.060	149
	Sheet	20.4	0.112	121	24.2	0.145	111	23.5	0.843	330	35.3	1.984	106	32.2	0.222	97	16.4	0.081	135
	Sheet	22.8	0.133	115	27.1	0.172	105	26.3	0.977	294	39.4	2.298	99	36.1	0.264	91	19.4	0.104	124
3003-H12 -H14 -H16 -H18	Drawn Tube	12.2	0.052	157	14.2	0.065	145	14.1	0.424	506	21.1	0.999	150	18.8	0.100	126	9.2	0.034	181
	Drawn Tube	18.0	0.093	129	21.3	0.120	119	20.8	0.715	365	31.2	1.683	115	28.3	0.183	103	13.5	0.060	149
	Drawn Tube	21.6	0.123	118	25.7	0.159	108	24.9	0.909	310	37.4	2.140	102	34.1	0.243	94	16.4	0.081	135
	Drawn Tube	24.0	0.144	112	28.6	0.187	102	27.7	1.046	279	41.5	2.461	96	38.1	0.286	89	19.4	0.104	124
Alclad 3003-H12 -H14 -H16 -H18	Sheet & Plate	9.9	0.038	174	11.5	0.047	162	11.4	0.321	640	17.1	0.756	172	15.2	0.072	140	8.5	0.030	188
	Sheet & Plate	14.5	0.067	144	17.0	0.086	133	16.7	0.536	461	25.1	1.260	133	22.6	0.131	115	12.0	0.051	158
	Sheet	19.2	0.103	125	22.8	0.132	115	22.2	0.779	342	33.2	1.832	111	30.2	0.202	100	16.4	0.081	135
	Sheet	21.6	0.123	118	25.7	0.159	108	24.9	0.909	310	37.4	2.140	102	34.1	0.243	94	17.9	0.093	129
Alclad 3003-H14 -H18	Drawn Tube	16.8	0.084	133	19.9	0.108	123	19.4	0.654	398	29.2	1.538	121	26.4	0.165	107	12.0	0.051	158
	Drawn Tube	22.8	0.133	115	27.1	0.172	105	26.3	0.977	294	39.4	2.298	99	36.1	0.264	91	17.9	0.093	129
3004-H32 -H34 -H36	Sheet & Plate	20.4	0.112	121	24.2	0.145	111	23.5	0.843	330	35.3	1.984	106	32.2	0.222	97	16.4	0.081	135
	Sheet & Plate	25.3	0.155	109	30.1	0.201	100	29.0	1.116	271	43.6	2.626	92	40.0	0.309	86	19.4	0.104	124
	Sheet	29.0	0.190	102	34.6	0.248	93	33.2	1.334	237	49.8	3.140	85	46.1	0.381	81	22.5	0.130	115
3004-H34 -H36	Drawn Tube	27.7	0.178	104	33.1	0.232	95	31.8	1.260	247	47.7	2.966	87	44.1	0.356	82	19.4	0.104	124
	Drawn Tube	31.4	0.215	98	37.7	0.282	89	36.0	1.486	220	54.0	3.497	80	50.1	0.433	77	22.5	0.130	115
Alclad 3004-H32 -H34 -H36 -H14 -H16 -H131,H241,H341 -H151,H261,H361	Sheet	19.2	0.103	125	22.8	0.132	115	22.2	0.779	342	33.2	1.832	111	30.2	0.202	100	16.4	0.081	135
	Sheet	24.0	0.144	112	28.6	0.187	102	27.7	1.046	279	41.5	2.461	96	38.1	0.286	89	19.4	0.104	124
	Sheet	27.7	0.178	104	33.1	0.232	95	31.8	1.260	247	47.7	2.966	87	44.1	0.356	82	22.5	0.130	115
	Sheet	25.3	0.155	109	30.1	0.201	100	29.0	1.116	271	43.6	2.626	92	40.0	0.309	86	21.0	0.117	120
	Sheet	30.2	0.202	100	36.1	0.265	91	34.6	1.410	229	51.9	3.317	82	48.1	0.407	79	24.1	0.144	112
	Sheet	25.3	0.155	109	30.1	0.201	100	29.0	1.116	271	43.6	2.626	92	40.0	0.309	86	21.0	0.117	120
	Sheet	30.2	0.202	100	36.1	0.265	91	34.6	1.410	229	51.9	3.317	82	48.1	0.407	79	24.1	0.144	112
	Sheet	25.3	0.155	109	30.1	0.201	100	29.0	1.116	271	43.6	2.626	92	40.0	0.309	86	21.0	0.117	120
3005-H25	Sheet	22.8	0.133	115	27.1	0.172	105	26.3	0.977	294	39.4	2.298	99	36.1	0.264	91	17.9	0.093	129
5005-H12 -H14 -H16 -H32 -H34 -H36	Sheet & Plate	14.5	0.067	144	17.0	0.086	133	16.7	0.536	461	25.1	1.260	133	22.6	0.131	115	10.6	0.042	168
	Sheet & Plate	16.8	0.084	133	19.9	0.108	123	19.4	0.654	398	29.2	1.538	121	26.4	0.165	107	13.5	0.060	149
	Sheet	20.4	0.112	121	24.2	0.145	111	23.5	0.843	330	35.3	1.984	106	32.2	0.222	97	16.4	0.081	135
	Sheet & Plate	12.2	0.052	157	14.2	0.065	145	14.1	0.424	506	21.1	0.999	150	18.8	0.100	126	9.2	0.034	181
	Sheet & Plate	15.7	0.075	138	18.4	0.096	127	18.1	0.594	415	27.1	1.397	127	24.5	0.147	111	13.5	0.060	149
	Sheet	18.0	0.093	129	21.3	0.120	119	20.8	0.715	365	31.2	1.683	115	28.3	0.183	103	19.4	0.104	124

*Maximum thickness indicated in parentheses. See Table 3.3.1a for corresponding thickness range.

TABLE 3.3.1b (cont'd)
BUCKLING FORMULA CONSTANTS FOR ALUMINUM ALLOYS

buckling constants

Alloy And Temper	Product	COMPRESSION IN COLUMNS			COMPRESSION IN FLAT PLATES			COMPRESSION IN ROUND TUBES			BENDING IN ROUND TUBES			BENDING IN REC- TANGULAR BARS			SHEAR IN FLAT PLATES		
		B_c ksi	D_c ksi	C_c	B_p ksi	D_p ksi	C_p	B_t ksi	D_t ksi	C_t	B_{tb} ksi	D_{tb} ksi	C_{tb}	B_b ksi	D_b ksi	C_b	B_s ksi	D_s ksi	C_s
5050-H32	Sheet	15.7	0.075	138	18.4	0.096	127	18.1	0.594	415	27.1	1.397	127	24.5	0.147	111	12.0	0.051	158
-H34	Sheet	20.4	0.112	121	24.2	0.145	111	23.5	0.843	330	35.3	1.984	106	32.2	0.222	97	16.4	0.081	135
-H32	Rolled Bar	16.8	0.084	133	19.9	0.108	123	19.4	0.654	398	29.2	1.538	121	26.4	0.165	107	12.0	0.051	158
-H34	Drawn Tube	21.6	0.123	118	25.7	0.159	108	24.9	0.909	310	37.4	2.140	102	34.1	0.243	94	16.4	0.081	135
5052-H32	(Sheet & Plate)	24.0	0.143	112	28.6	0.186	103	27.7	1.042	281	41.5	2.453	96	38.1	0.285	89	17.9	0.092	130
-H34	(Rolled Rod)	27.7	0.177	104	33.1	0.231	96	31.8	1.256	250	47.7	2.956	88	44.1	0.355	83	21.0	0.116	120
-H36	Drawn Tube	30.2	0.201	100	36.1	0.263	91	34.6	1.405	230	51.9	3.306	83	48.1	0.405	79	24.1	0.143	112
5083-H111	Extrusions (All)	24.0	0.142	113	28.6	0.184	104	27.7	1.036	286	41.5	2.437	97	38.1	0.282	90	19.4	0.103	126
-H321	Sheet & Plate (1.500)*	30.2	0.199	101	36.1	0.261	92	34.6	1.396	235	51.9	3.285	84	48.1	0.401	80	25.6	0.156	110
-H323	Sheet	37.7	0.278	90	45.5	0.367	82	43.0	1.867	192	64.6	4.394	73	60.5	0.565	71	28.8	0.185	104
-H343	Sheet	44.1	0.352	84	53.2	0.466	76	50.1	2.289	166	75.2	5.386	66	71.0	0.718	66	33.5	0.233	96
-H321	Plate (3.000)*	27.7	0.175	105	33.1	0.229	97	31.8	1.248	254	47.7	2.937	89	44.1	0.351	84	24.1	0.142	113
5086-H111	Extrusions (All)	20.4	0.111	123	24.2	0.143	113	23.5	0.835	339	35.3	1.965	108	32.2	0.219	98	16.4	0.080	137
-H112	Plate (0.500)*	19.2	0.101	127	22.8	0.130	116	22.2	0.771	351	33.2	1.814	113	30.2	0.199	101	13.5	0.059	151
-H112	Plate (1.000)*	18.0	0.092	131	21.3	0.118	120	20.8	0.708	375	31.2	1.667	118	28.3	0.181	104	12.0	0.050	160
-H112	Plate (2.000)*	16.8	0.083	135	19.9	0.106	125	19.4	0.647	406	27.1	1.384	109	26.4	0.163	108	10.6	0.041	171
-H112	Plate (3.000)*	16.8	0.083	135	19.9	0.106	125	19.4	0.647	406	27.1	1.384	109	26.4	0.163	108	10.6	0.041	171
-H32	(Sheet & Plate)	30.2	0.199	101	36.1	0.261	92	34.6	1.396	235	51.9	3.285	84	48.1	0.401	80	22.5	0.128	117
-H34	(Drawn Tube)	37.7	0.278	90	45.4	0.367	82	43.0	1.867	192	64.6	4.394	73	60.5	0.565	71	28.8	0.185	104
5454-H111	Extrusions (All)	18.0	0.092	131	21.3	0.118	120	20.8	0.708	375	31.2	1.667	118	28.3	0.181	104	14.9	0.069	144
-H112	Extrusions	14.5	0.066	146	17.0	0.084	135	16.7	0.530	468	23.1	1.116	118	22.6	0.129	117	9.2	0.033	184
-H32	Sheet & Plate	27.7	0.175	105	33.1	0.229	97	31.8	1.248	254	47.7	2.937	89	44.1	0.351	84	21.0	0.115	121
-H34	Sheet & Plate	31.4	0.212	99	37.7	0.278	91	36.0	1.472	226	54.0	3.463	82	50.1	0.426	78	24.1	0.142	113
5456-H111	Extrusions (All)	25.3	0.152	110	30.1	0.198	101	29.0	1.105	279	43.6	2.600	94	40.0	0.304	88	21.0	0.115	121
-H112	Extrusions	22.8	0.131	116	27.1	0.170	107	26.3	0.967	301	37.4	2.119	93	36.1	0.260	92	14.9	0.069	144
-H321	Sheet & Plate	31.4	0.212	99	37.7	0.278	91	36.0	1.472	226	54.0	3.463	82	50.1	0.426	78	27.2	0.170	107
-H321	Plate (1.500)*	29.0	0.187	103	34.6	0.245	94	33.2	1.321	244	49.8	3.110	86	46.1	0.376	82	25.6	0.156	110
-H321	Plate (3.000)*	29.0	0.187	103	34.6	0.245	94	33.2	1.321	244	49.8	3.110	86	46.1	0.376	82	24.1	0.142	113
-H323	Sheet	40.3	0.307	88	48.5	0.406	80	45.9	2.033	180	68.8	4.784	70	64.7	0.624	69	30.3	0.201	101
-H343	Sheet	46.7	0.383	81	56.4	0.509	74	53.0	2.464	157	79.5	5.799	63	75.3	0.784	64	35.2	0.250	94
6061-T6,T651	Sheet & Plate	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6,T6510**	Extrusions	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6,T651	Rolled Rod	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6	Drawn Tube	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6	Pipe (0.999)*	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
-T6	Pipe	39.4	0.246	66	45.0	0.301	61	43.2	1.558	141	64.8	4.458	55	66.8	0.665	67	25.8	0.131	81
6063-T5	Extrusions (0.500)*	17.3	0.072	99	19.5	0.086	93	19.2	0.529	275	28.8	1.513	95	28.3	0.183	103	11.0	0.036	124
-T5	Extrusions	16.2	0.065	102	18.2	0.078	96	18.0	0.484	289	26.9	1.384	99	26.4	0.165	107	10.4	0.033	128
-T6	Extrusions	27.6	0.145	78	31.4	0.175	73	30.5	0.978	188	45.7	2.800	70	46.1	0.381	81	17.6	0.074	98
	Pipe																		

* Maximum thickness indicated in parentheses. See Table 3.3.1a for corresponding thickness range.

** Values also apply to -T6511 temper.



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TABLE 3.3.2
MINIMUM MECHANICAL PROPERTIES FOR
WELDED ALUMINUM ALLOYS†

(Gas Tungsten Arc or Gas Metal Arc Welding With No Postweld Heat Treatment)

Alloy And Temper	Product And Thickness Range in.	TENSION		COM- PRES- SION $F_{cyw}^{\ddagger}$ ksi	SHEAR		BEARING	
		$F_{tuw}^{\dagger}$ ksi	$F_{tyw}^{\ddagger}$ ksi		F_{suw} ksi	F_{syw} ksi	F_{buw} ksi	F_{byw} ksi
1100-H12,H14	All	11	4.5	4.5	8	2.5	23	8
3003-H12,H14,H16,H18	All	14	7	7	10	4	30	12
Alclad 3003-H12,H14,H16,H18	All	13	6	6	10	3.5	30	11
3004-H32,H34,H36	All	22	11	11	14	6.5	46	20
Alclad 3004-H32,H34,H14,H16	All	21	11	11	13	6.5	44	19
3005-H25	Sheet 0.013-0.050	17	9	9	12	5	36	15
5005-H12,H14,H32,H34	All	14	7	7	9	4	28	10
5050-H32,H34	All	18	8	8	12	4.5	36	12
5052-H32,H34	All	25	13	13	16	7.5	50	19
5083-H111	Extrusions	39	21	20	23	12	78	32
-H321	Sheet & Plate 0.188-1.500	40	24	24	24	14	80	36
-H321	Plate 1.501-3.000	39	23	23	24	13	78	34
-H323,H343	Sheet	40	24	24	24	14	80	36
5086-H111	Extrusions	35	18	17	21	10	70	28
-H112	Plate 0.250-0.499	35	17	17	21	9.5	70	28
-H112	Plate 0.500-1.000	35	16	16	21	9	70	28
-H112	Plate 1.001-2.000	35	14	14	21	8	70	28
-H32,H34	Sheet & Plate	35	19	19	21	11	70	28
5154-H38	Sheet	30	15	15	19	8.5	60	23
5454-H111	Extrusions	31	16	15	19	9.5	62	24
-H112	Extrusions	31	12	12	19	7	62	24
-H32,H34	Sheet & Plate	31	16	16	19	9.5	62	24
5456-H111	Extrusions	41	24	22	24	14	82	38
-H112	Extrusions	41	19	19	24	11	82	38
-H321	Sheet & Plate 0.188-1.500	42	26	24	25	15	84	38
-H321	Plate 1.501-3.000	41	24	23	25	14	82	36
-H323,H343	Sheet	42	26	26	25	15	84	38
6061-T6,T651*	All	24	20	20	15	12	50	30
-T6,T651**	Over 0.375	24	15	15	15	9	50	30
6063-T5,T6	All	17	11	11	11	6.5	34	22

†Filler wires used are those recommended in Table 7.1.3.1. Values of F_{tuw} are ASME weld qualification test values.

‡0.2 percent offset in 10 in. gage length across a butt weld.

*Values when welded with 5183, 5356, or 5556 alloy filler wire. Values also apply to -T6510, -T6511 extrusion tempers.

**Values when welded with 4043, 5154, 5254, or 5554 alloy filler wire. Values also apply to -T6510, -T6511 extrusion tempers.

TABLE 3.3.3
FACTORS OF SAFETY FOR USE WITH ALUMINUM
ALLOWABLE STRESS SPECIFICATIONS

	Building And Similar Type Structures	Bridge And Similar Type Structures
<i>Tension Members</i>		
F.S. on tensile strength, n_u	1.95	2.20
F.S. on yield strength, n_y	1.65	1.85
<i>Columns</i>		
F.S. on buckling strength, n_u	1.95	2.20
F.S. on crippling strength of thin sections, n_u	1.95	2.20
F.S. on yield strength for short columns, n_y	1.65	1.85
<i>Beams</i>		
F.S. on tensile strength, n_u	1.95	2.20
F.S. on tensile yield strength, n_y	1.65	1.85
F.S. on compressive yield strength for short beams, n_y	1.65	1.85
F.S. on buckling strength, n_y	1.65	1.85
F.S. on crippling strength of thin sections, n_y	1.65	1.85
F.S. on shear buckling of webs, n_a	1.20	1.35
<i>Connections</i>		
F.S. on bearing strength.....	$1.2 \times 1.95 = 2.34$	2.64
F.S. on bearing yield strength, n_y	1.65	1.85
F.S. on shear strength of rivets and bolts.....	$1.2 \times 1.95 = 2.34$	2.64
F.S. on shear strength of fillet welds.....	$1.2 \times 1.95 = 2.34$	2.64
F.S. on tensile strength of butt welds, n_u	1.95	2.20
F.S. on tensile yield strength of butt welds, n_y	1.65	1.85

TABLE 3.3.4a
FORMULAS FOR BUCKLING CONSTANTS

For All Products Whose Temper Designation Begins With -O, -H, -T1, -T2, -T3, or -T4

Type of Member and Stress	Intercept, ksi	Slope, ksi	Intersection
Compression in Columns and Beam Flanges	$B_c = F_{cy} \left[1 + \left(\frac{F_{cy}}{1000} \right)^{1/2} \right]$	$D_c = \frac{B_c (6B_c)^{1/2}}{20(E)}$	$C_c = \frac{2B_c}{3D_c}$
Compression in Flat Plates	$B_p = F_{cy} \left[1 + \frac{(F_{cy})^{1/3}}{7.6} \right]$	$D_p = \frac{B_p (6B_p)^{1/2}}{20(E)}$	$C_p = \frac{2B_p}{3D_p}$
Compression in Round Tubes Under Axial End Load	$B_t = F_{cy} \left[1 + \frac{(F_{cy})^{1/5}}{5.8} \right]$	$D_t = \frac{B_t (B_t)^{1/3}}{3.7(E)}$	C_t *
Compressive Bending Stress in Solid Rec- tangular Bars	$B_b = 1.3F_{cy} \left[1 + \frac{(F_{cy})^{1/3}}{7} \right]$	$D_b = \frac{B_b (6B_b)^{1/2}}{20(E)}$	$C_b = \frac{2B_b}{3D_b}$
Compressive Bending Stress in Round Tubes	$B_{tb} = 1.5F_y \left[1 + \frac{(F_y)^{1/5}}{5.8} \right]$	$D_{tb} = \frac{B_{tb} (B_{tb})^{1/3}}{2.7(E)}$	$C_{tb} = \left(\frac{B_{tb} - B_t}{D_{tb} - D_t} \right)^2$
Shear Stress in Flat Plates	$B_s = F_{sy} \left[1 + \frac{(F_{sy})^{1/3}}{6.2} \right]$	$D_s = \frac{B_s (6B_s)^{1/2}}{20(E)}$	$C_s = \frac{2B_s}{3D_s}$
Crippling of Flat Plates in Compression or Bending	$k_1 = 0.50$	$k_2 = 2.04$	

* C_t can be found from a plot of the curves of allowable stress based on elastic and inelastic buckling or by a trial and error solution.

formulas for constants

TABLE 3.3.4b
FORMULAS FOR BUCKLING CONSTANTS

For Products Whose Temper Designation Begins With -T5, -T6, -T7, -T8, or -T9

Type of Member and Stress	Intercept, ksi	Slope, ksi	Intersection
Compression in Columns and Beam Flanges	$B_c = F_{cy} \left[1 + \left(\frac{F_{cy}}{2250} \right)^{1/2} \right]$	$D_c = \frac{B_c (B_c)}{10 (E)}^{1/2}$	$C_c = 0.41 \frac{B_c}{D_c}$
Compression in Flat Plates	$B_p = F_{cy} \left[1 + \left(\frac{F_{cy}}{11.4} \right)^{1/3} \right]$	$D_p = \frac{B_p (B_p)}{10 (E)}^{1/2}$	$C_p = 0.41 \frac{B_p}{D_p}$
Compression in Round Tubes Under Axial End Load	$B_t = F_{cy} \left[1 + \left(\frac{F_{cy}}{8.7} \right)^{1/5} \right]$	$D_t = \frac{B_t (B_t)}{4.5 (E)}^{1/3}$	C_t *
Compressive Bending Stress in Solid Rectangular Bars	$B_b = 1.3 F_{cy} \left[1 + \left(\frac{F_{cy}}{7} \right)^{1/3} \right]$	$D_b = \frac{B_b (6 B_b)}{20 (E)}^{1/2}$	$C_b = \frac{2 B_b}{3 D_b}$
Compressive Bending Stress in Round Tubes	$B_{tb} = 1.5 F_y \left[1 + \left(\frac{F_y}{8.7} \right)^{1/5} \right]$	$D_{tb} = \frac{B_{tb} (B_{tb})}{2.7 (E)}^{1/3}$	$C_{tb} = \left(\frac{B_{tb} - B_t}{D_{tb} - D_t} \right)^2$
Shear Stress in Flat Plates	$B_s = F_{sy} \left[1 + \left(\frac{F_{sy}}{9.3} \right)^{1/3} \right]$	$D_s = \frac{B_s (B_s)}{10 (E)}^{1/2}$	$C_s = 0.41 \frac{B_s}{D_s}$
Crippling of Flat Plates in Compression	$k_1 = 0.35$	$k_2 = 2.27$	
Crippling of Flat Plates in Bending	$k_1 = 0.50$	$k_2 = 2.04$	

* C_t can be found from a plot of the curves of allowable stress based on elastic and inelastic buckling or by a trial and error solution.

TABLE 3.3.5
VALUES OF COEFFICIENTS k_t and k_c *

Alloy and Temper	Non-welded or Regions Farther Than 1.0 in. From a Weld		Regions Within 1.0 in. of a Weld	
	k_t	k_c	k_t	k_c †
2014-T6, -T651‡	1.25	1.12	—	—
Alclad 2014-T6, -T651	1.25	1.12	—	—
6061-T6, -T651‡	1.0	1.12	1.0	1.0
6063-T5, -T6, -T83	1.0	1.12	1.0	1.0
All Others Listed in Table 3.3.1	1.0	1.10	1.0	1.0

* These coefficients are used in the formulas in Table 3.3.6.

† If the weld yield strength exceeds 0.9 of the parent metal yield strength, the allowable compressive stress within 1.0 in. of a weld should be taken equal to the allowable stress for non-welded material.

‡ Values also apply to -T6510, -T6511 extrusion tempers.

Methods of Rounding Off Numbers in Tables 3.3.6 to 3.3.27

The allowable stresses in Specifications 1-6 and for slenderness $\leq S_1$ in Specifications 7-21 are obtained by rounding off stresses below 5 ksi to the nearest 0.1 ksi; stresses between 5 and 15 ksi to the nearest 0.5 ksi; and stresses over 15 ksi to the nearest 1.0 ksi. To obtain allowable stresses for slenderness between S_1 and S_2 , the constant is rounded off to the nearest 0.1 ksi. The coefficient of the slenderness ratio is rounded off according to the rule: for numbers between 2×10^n and $2 \times 10^{n+1}$, round off to nearest 0.1×10^n , where n is any positive or negative integer. This same rule is applied to the coefficients in the expressions for allowable stresses for slenderness $\geq S_2$.

Slenderness limits S_1 and S_2 are based on the rounded off expressions for allowable stress obtained as described above. Values of S_1 and S_2 between 10 and 250 are rounded off to the nearest 1.0. Smaller values are rounded off to the nearest 0.1, and larger values to the nearest 10. If S_2 is not more than 5 per cent larger than S_1 , the allowable stress for slenderness between S_1 and S_2 is taken to be the same as the allowable stress for slenderness $\leq S_1$. In this case there is no value for S_1 and the value of S_2 is recalculated by equating the allowable stress for slenderness less than S_2 to the allowable stress for slenderness $\geq S_2$, using rounded off values.