SECTION B

STRENGTH ANALYSIS

SECTION B1

JOINTS AND FASTENERS

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B 1.0.0 Joints and Fasteners

B 1.1.0 Mechanical Joints and Fasteners

B 1.1.1 Riveted Joints

Although the actual state of stress in a riveted joint is complex, it is customary to ignore such considerations as stress concentration at the edge of rivet holes, unequal division of load among fasteners, and nonuniform distribution of shear stress across the section of the rivet and of the bearing stress between rivet and plate. Simplifying assumptions are made, which are summarized as follows:

(1) The applied load is assumed to be transmitted entirely by the rivets, friction between the connected plates being ignored.

(2) When the center of cross-sectional area of each of the rivets is on the line of action of the load, or when the centroid of the total rivet area is on this line, the rivets of the joint are assumed to carry equal parts of the load if of the same size; and to be loaded proportionally to their section areas otherwise.

(3) The shear stress is assumed to be uniformly distributed across the rivet section.

(4) The bearing stress between plate and rivet is assumed to be uniformly distributed over an area equal to the rivet diameter times the plate thickness.

(5) The stress in a tension member is assumed to be uniformly distributed over the net area.

(6) The stress in a compression member is assumed to be uniformly distributed over the gross area.

The design of riveted joints on the basis of these assumptions is the accepted practice, although none of them is strictly correct.

The possibility of secondary failure due to secondary causes, such as the shearing or tearing out of a plate between rivet and edge of plate or between adjacent rivets, the bending or insufficient upsetting of long rivets, or tensile failure along a zigzag line when rivets are staggered, are guarded against in standard specifications by provisions summarized as follows:

(1) The distance from a rivet to a sheared edge shall not be less than 1 3/4 diameters, or to a planed or rolled edge, 1 1/2 diameters.

(2) The minimum rivet spacing shall be 3 diameters.

B 1.1.1 Riveted Joints (Cont'd)

(3) The maximum rivet pitch in the direction of stress shall be 7 diameters, and at the ends of a compression member it shall be 4 diameters for a distance equal to 1 1/2 times the width of the member.

(4) In the case of a diagonal or zigzag chain of holes extending across a part, the net width of the part shall be obtained by deducting from the gross width the sum of the diameters of all the holes in the chain, and adding, for each gauge space in the chain, the quantity $S^2/4g$, where S = longitudinal spacing of any two successive holes in the chain and g = the spacing transverse to the direction of stress of the same two holes. The critical net section of the part is obtained from that chain which gives the least net width.

(5) The shear and bearing stresses shall be calculated on the basis of the nominal rivet diameter, the tensile stresses on the hole diameter.

If the rivets of a joint are so arranged that the line of action of the load does not pass through the centroid of the rivet areas then the effect of eccentricity must be taken into account.

B 1.1.2 Bolted Joints

Bolted joints that are designed on the basis of shear and bearing are analyzed in the same way as riveted joints. The simplifying assumptions listed in Section B 1.1.1 are valid for short bolts where bending of the shank is negligible.

In general when bolts are designed by tension, the Factor of Safety should be at least 1.5 based on design load to take care of eccentricities which are impossible to eliminate in practical design. Avoid the use of aluminum bolts in tension.

Hole-filling fasteners (such as conventional solid rivets) should not be combined with non-hole-filling fasteners (such as conventional bolt or screw installation).

B 1.1.3 Protruding-Head Rivets and Bolts

The load per rivet or bolt, at which the shear or bearing type of failure occurs, is separately calculated and the lower of the two governs the design. The ultimate shear and tension stress, and the ultimate loads for steel AN bolts and pins are given in Table B 1.1.3.1 and B 1.1.3.2. Interaction curves for combined shear and tension loading on AN bolts are given in Fig. B 1.1.3-1. Shear and tension ultimate loads for MS internal wrenching bolts are specified in Table B 1.1.3.3.

B 1.1.3 Protruding-Head Rivets and Bolts (Cont'd)

In computing aluminum rivet shear strength, the correction factors given in Table B 1.1.3.5 should be used to compensate for the reductions in rivet shear strength resulting from high bearing stresses on the rivet at D/t ratios in excess of 3.0 for single-shear joints, and 1.5 for double-shear joints. The basic shear strength for protruding-head aluminum-alloy rivets is given in Table B 1.1.3.6.

The yield and ultimate bearing stresses for various materials at room and elevated temperatures are given in the strength properties stated for each alloy or group of alloys, and are applicable to riveted or bolted joints where cylindrical holes are used and where $D/t < 5.5$. Where $D/t > 5.5$, tests to substantiate yield and ultimate bearing strengths must be performed. These bearing stresses are applicable only for the design of rigid joints where there is no possibility of relative motion of the parts joined without deformation of the parts. Yield and ultimate stresses at low temperatures will be higher than those specified for room temperature; however, no quantitative data are available.

For convenience, "unit" sheet bearing strength for rivets, based on a stress of 100 ksi and nominal hole diameters, is given in Table B 1.1.3.7. Factors representing the ratio of actual sheet bearing strength to 100 ksi are given in Table B 1.1.3.8. Table B 1.1.3.9 contains unit bearing strength of sheets on bolts. For magnesium-alloy riveting, it is unnecessary to use the correction factors of Table B 1.1.3.5, which account for high bearing stresses on the rivet.

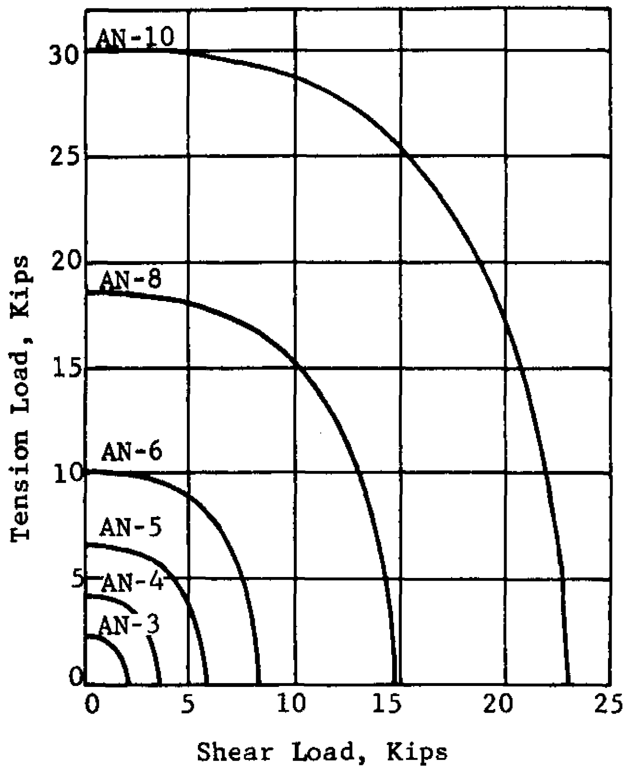
Table B 1.1.3.1 Ultimate Strength of Bolts

Bolt Size	Nominal Shank Area	Basic Minor Dia	Basic Area at Minor Dia	Steel Bolts Heat Treat 125,000 psi Min			Steel Bolts Heat Treat 160,000 psi Min		Al Alloy Bolts Heat Treat 62,000 psi Min	
				Tension (lb)	Single Shear (lb)	Bending (in.lb)	Tension (lb)	Single Shear (lb)	Tension (lb)	Single Shear (lb)
10-32	.0283	.1494	.0175	2,210	2,125		2,800	2,620		
1/4-28	.0494	.2036	.0326	4,080	3,680	192	5,000	4,650	1,310	1,715
5/16-24	.0767	.2584	.0524	6,500	5,750	375	8,200	7,300	2,110	2,685
3/8-24	.1105	.3209	.0809	10,100	8,290	647	12,700	10,500	3,260	3,870
7/16-20	.1503	.3725	.1090	13,600	11,250	1,028	17,100	14,300	4,400	5,250
1/2-20	.1964	.4350	.1486	18,500	14,700	1,534	23,400	18,650	6,000	6,850
9/16-18	.2485	.4903	.1888	23,600	18,700	2,184	29,800	23,600	....	8,700
5/8-18	.3068	.5528	.2400	30,100	23,000	2,996	38,000	29,150	....	10,750
3/4-16	.4418	.6688	.3513	44,000	33,150	5,177	55,600	41,950	....	15,500
7/8-14	.6013	.7822	.4805	60,000	45,050	8,221	76,200	57,100	....	21,050
1-14	.7854	.9072	.6464	80,700	58,900	12,272	102,500	74,600	....	27,500
1 1/8-12	.9940	1.0167	.8118	101,800	73,750	17,470	128,800	94,450	....	34,500
1 1/4-12	1.2272	1.1417	1.0237	130,200	91,050	23,970	162,600	116,600	....	42,500
1 3/8-12	1.4849	1.2667	1.2602	....	....	....	200,300	141,050		
1 1/2-12	1.7671	1.3917	1.5212	....	....	....	241,200	167,900		

Table B 1.1.3.2 Shear and Tensile Strengths, Areas, and Moments of Inertia of Steel Bolts and Pins

Material				Low Carbon Steel	Heat-treated steel			AN standard bolt designation specification MIL-B-1812
Ultimate tensile strength, ksi				55	100	125	125	
Ultimate shear strength, ksi				35	65	75	75	
Size of pin or bolt	Machine screw size, No.	Area of solid section, in.^{2}	Moment of inertia of solid, in^4	Ultimate single shear strength at full diameter, lb			Ultimate tensile strength (in thread), lb	
1/16		0.003068	0.00000075	107	199	230		
3/32		.006902	.00000379	242	449	518		
0.112	4	.009852	.00000772	345	640	739		
1/8		.012272	.00001198	430	798	920		
0.138	6	.014957	.00001781	523	972	1,122		
5/32		.01918	.00002926	671	1,247	1,438		
0.164	8	.02112	.00003549	739	1,372	1,584		
3/16		.02761	.00006066	966	1,794	2,070		
0.190	10	.02835	.00006399	992	1,842	2,126	2,210	AN-3
0.216	12	.03664	.0001069	1,282	2,381	2,748		
7/32		.03758	.0001125	1,315	2,442	2,818		
1/4		.04908	.0001918	1,717	3,190	3,680	4,080	AN-4
5/16		.07669	.0004682	2,684	4,984	5,750	6,500	AN-5
3/8		.1105	.9009710	3,868	7,183	8,280	10,100	AN-6
7/16		.1503	.001797	5,261	9,770	11,250	13,600	AN-7
1/2		.1963	.003069	6,871	12,760	14,700	18,500	AN-8
9/16		.2485	.004914	8,697	16,152	18,700	23,600	AN-9
5/8		.3068	.007492	10,738	19,942	23,000	30,100	AN-10
3/4		.4418	.01553	15,463	28,717	33,150	44,000	AN-12
7/8		.6013	.02878	21,046	39,085	45,050	60,000	AN-14
1		.7854	.04908	27,489	51,651	58,900	80,700	AN-16
1 1/8						73,750	101,800	AN-18
1 1/4						91,050	130,200	AN-20

B 1.1.3 Protruding-Head Rivets and Bolts (Cont'd)



Interaction Formula

$$\frac{x^3}{a^3} + \frac{y^2}{b^2} = 1$$

Where:
- x = shear load
- y = tension load
- a = shear allowable
- b = tension allowable

Note: Curves not applicable where shear nuts are used. Curves are based on the results of combined load tests of bolts with nuts fingertight.

Fig. B 1.1.3-1 Combined Shear and Tension on AN Steel Bolts.

Table B 1.1.3.3 Shear and Tensile Strengths of Internal Wrenching Bolts

Material		Heat-treated alloy steel (160-180 ksi)		Material		Heat-treated alloy steel (160-180 ksi)	
Specification		MIL-S-8503 and MIL-S-6049	MIL-S-5000	Specification		MIL-S-8503 and MIL-S-6049	MIL-S-5000
Size	Standard	Ultimate tensile strength (minimum), lb	Double shear strength (minimum), lb	Size	Standard	Ultimate tensile strength (minimum), lb	Double shear strength (minimum), lb
1/4	MS20004	5,000	9,300	3/4	MS20012	55,600	83,900
5/16	MS20005	8,200	14,600	7/8	MS20014	76,200	114,200
3/8	MS20006	12,700	21,000	1	MS20016	102,500	149,200
7/16	MS20007	17,100	28,600	1 1/8	MS20018	128,800	188,900
1/2	MS20008	23,400	37,300	1 1/4	MS20020	162,600	233,200
9/16	MS20009	29,800	47,200	1 3/8	MS20022	200,300	282,100
5/8	MS20010	38,000	58,300	1 1/2	MS20024	241,200	335,800

Note: Nuts designed to develop the ultimate tensile strength of the bolts are required in applications depended upon to develop the tabulated bolt loads.

Table B 1.1.3.4 Ultimate Tension Loads For Solid Rivets
2024-T3 and 2024-T36 Alclad Sheet

	Universal Head						All Flush Riveting						
DIA.	3/32	1/8	5/32	3/16	1/4	5/16	3/32	1/8	5/32	3/16	1/4	5/16	DIA.
Head Tension	296	521	810	1506	2695	4200	261	445	729	1445	2610	3642	Head Tension
.016	130	160											.016
.020	145	175											.020
.025	170	210	220				75						.025
.032	199	248	290	390			104	146					.032
.040	233	290	380	490			138	200	235				.040
.045	254	317	435	550	970		160	232	275				.045
.051		348	490	622	1020		185	272	318	415			.051
.064		414	640	782	1130	1175	242	362	430	589	725		.064
.072		456	725	882	1195	1260		415	490	695	825		.072
.080		497		980	1265	1495			560	807	925	1092	.080
.091				1110	1355	1800			645	952	1062	1270	.091
.100				1220	1430	2065			720	1075	1175	1420	.100
.102				1240	1446	2120				1105	1200	1450	.102
.110				1340	1512	2350				1218	1300	1585	.110
.120				1460	1598	2645				1348	1427	1752	.120
.128					1665	2877					1527	1885	.128
.130					1680	2935					1552	1920	.130
.140					1762	3220					1675	2087	.140
.150					1845	3505					1802	2252	.150
5/32					1898	3700					1880	2362	5/32
.160					1930	3790					1925	2420	.160
.170					2015						2015	2585	.170
.180					2095						2095	2750	.180
3/16					2160						2160	2875	3/16
.20					2265						2265	3080	.20
.25					2680								.25

Table B 1.1.3.5 Shear Strengths of Protruding and Flush-Head Aluminum-Alloy Rivets

Diameter of rivet, (in.)	Mat. Code	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
Shear strength, lb:									
5056, F_{su}=28 ksi	B	99	203	363	556	802	1,450	2,290	3,280
2117-T3, F_{su}=30 ksi	AD	106	217	388	596	862	1,550	2,460	3,510
2017-T31, F_{su}=34 ksi	D	120	247	442	675	977	1,760	2,790	3,970
2017-T3, F_{su}=38 ksi	D	135	275	494	755	1,090	1,970	3,110	4,450
2024-T31, F_{su}=41 ksi	DD	145	296	531	815	1,180	2.120	3,360	4,800
Single-shear rivet strength factors									
Sheet thickness, in.:									
0.016		0.964							
0.018		.984							
0.020		.996							
0.025		1.000	0.972						
0.032			1.000	0.964					
0.036				.980					
0.040				.996	0.964				
0.045				1.000	.980				
0.050					.996	0.972			
0.063					1.000	1.000	0.964		
0.071							.980	0.964	
0.080							.996	.974	
0.090							1.000	.984	
0.100								.996	0.972
0.125								1.000	1.000
0.160									
0.190									
0.250									

Table B 1.1.3.5 Shear Strengths of Protruding and Flush-Head Aluminum-Alloy Rivets **(Cont'd)**

Diameter of rivet, (in.)	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
Double-shear rivet strength factors								
Sheet thickness, in.:								
0.016	0.688							
0.018	.753							
0.020	.792							
0.025	.870	0.714						
0.032	.935	.818	0.688					
0.036	.974	.857	.740					
0.040	.987	.896	.792	0.688				
0.045	1.000	.922	.831	.740				
0.050		.961	.870	.792	0.714			
0.063		1.000	.935	.883	.818	0.688		
0.071			.974	.919	.857	.740		
0.080			1.000	.948	.896	.792	0.688	
0.090				.974	.922	.831	.753	
0.100				1.000	.961	.870	.792	0.714
0.125					1.000	.935	.883	.818
0.160						.987	.935	.883
0.190						1.000	.974	.935
0.250							1.000	1.000

Note: Values of shear strength should be multiplied by the factors given herein whenever the D/t ratio is large enough to require such a correction.

Shear values are based on areas corresponding to the nominal hole diameters specified in table 4.12.0.9, note e.

Shear stresses in table 4.12.0.9 corresponding to 90 percent probability data are used wherever available.

Sheet thickness is that of the thinnest sheet in single-shear joints and the middle sheet in double-shear joints.

Table B 1.1.3.6 Ultimate Shear Strength for Aluminum Alloy Rivets

Type	Protruding-head rivets[a]									
Alloy	2117		2017				2024		5056	
Specification	MIL-R-5674									
Condition	-T3		-T31[b]		-T3[c]		-T31		-H321	
Basis[d]	A	B	A	B	A	B	A	B	A	B
Ultimate Shear Strength, ksi:										
F_{su}[e] (for driven rivets)	28	30	33	34	35	38	37	41	27	28
F_{su} (for undriven rivets and rivet wire)	26	29			33	37	37	38	24	27

a The driven head diameter shall be at least 1.3 times the nominal shank diameter of the rivet.

b The 2017-T31 designation refers to rivets that have been heat treated and then maintained in the heat-treated condition until driving.

c The 2017-T3 designation refers to 2017 rivets which are fully aged at room temperature for at least 4 days after quenching, and then driven. (The higher strength properties of the 2017-T3 rivets result from the cold-working effects obtained when the rivets are driven in the aged condition.)

d A is the mechanical-property column based upon the minimum guaranteed tensile properties; B is the mechanical-property column based upon probability data.

e Shear and bearing strength values for driven rivets may be based on areas corresponding to the nominal hole diameter, provided that the nominal hole diameter is not larger than the values listed below. If the nominal hole diameter is larger than the listed values, the listed value shall be used.

Standard Rivet-Hole Drill Sizes and Nominal Hole Diameters

Rivet size, in.	1/16	3/32	1/8	5/32	3/16	1/4	5/16	3/8
Drill No.	51	41	30	21	11	F	P	W
Nominal hole diameter, (in.)	0.067	0.096	0.1285	0.159	0.191	0.257	0.323	0.386

B 1.1.3 Protruding-Head Rivets and Bolts (Cont'd)

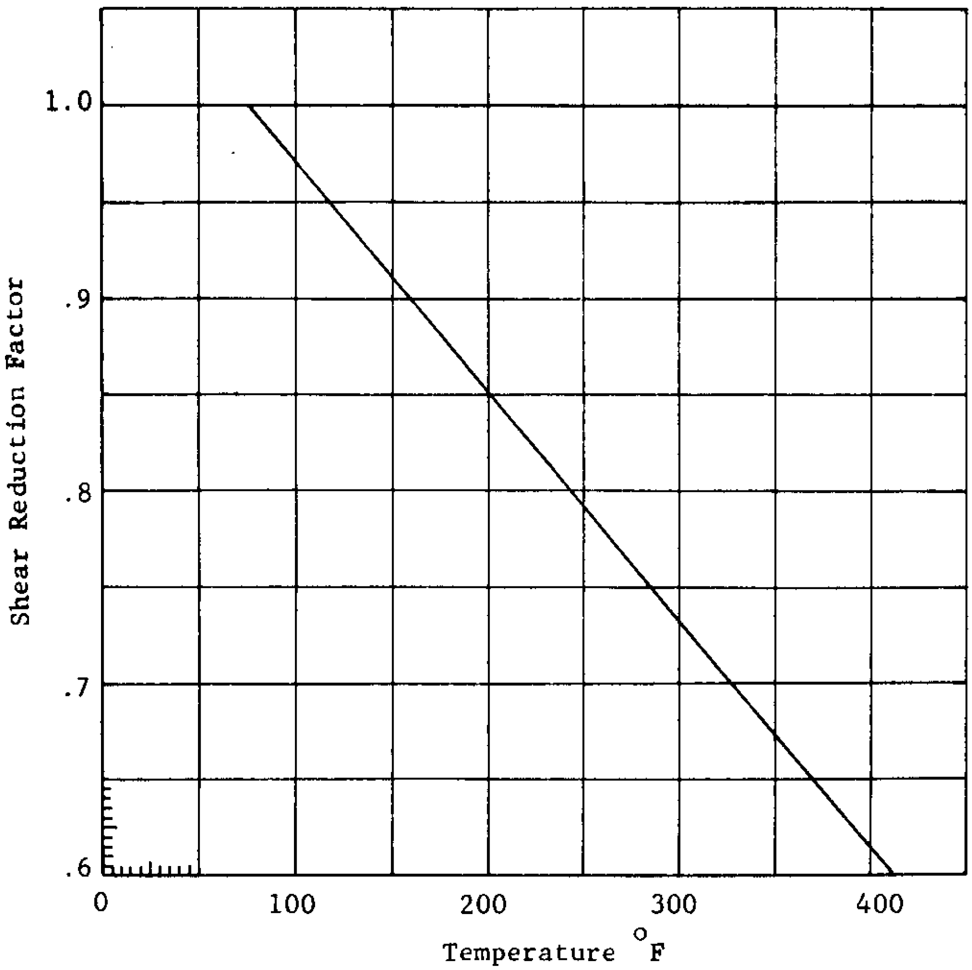


Fig. B 1 1.3-2 Reduction Factor for Allowables of Protruding Head, AN470-AD (2117-T3), Rivets at Elevated Temperature for Five Minutes

B 1.1.3 Protruding-Head Rivets and Bolts (Cont'd)

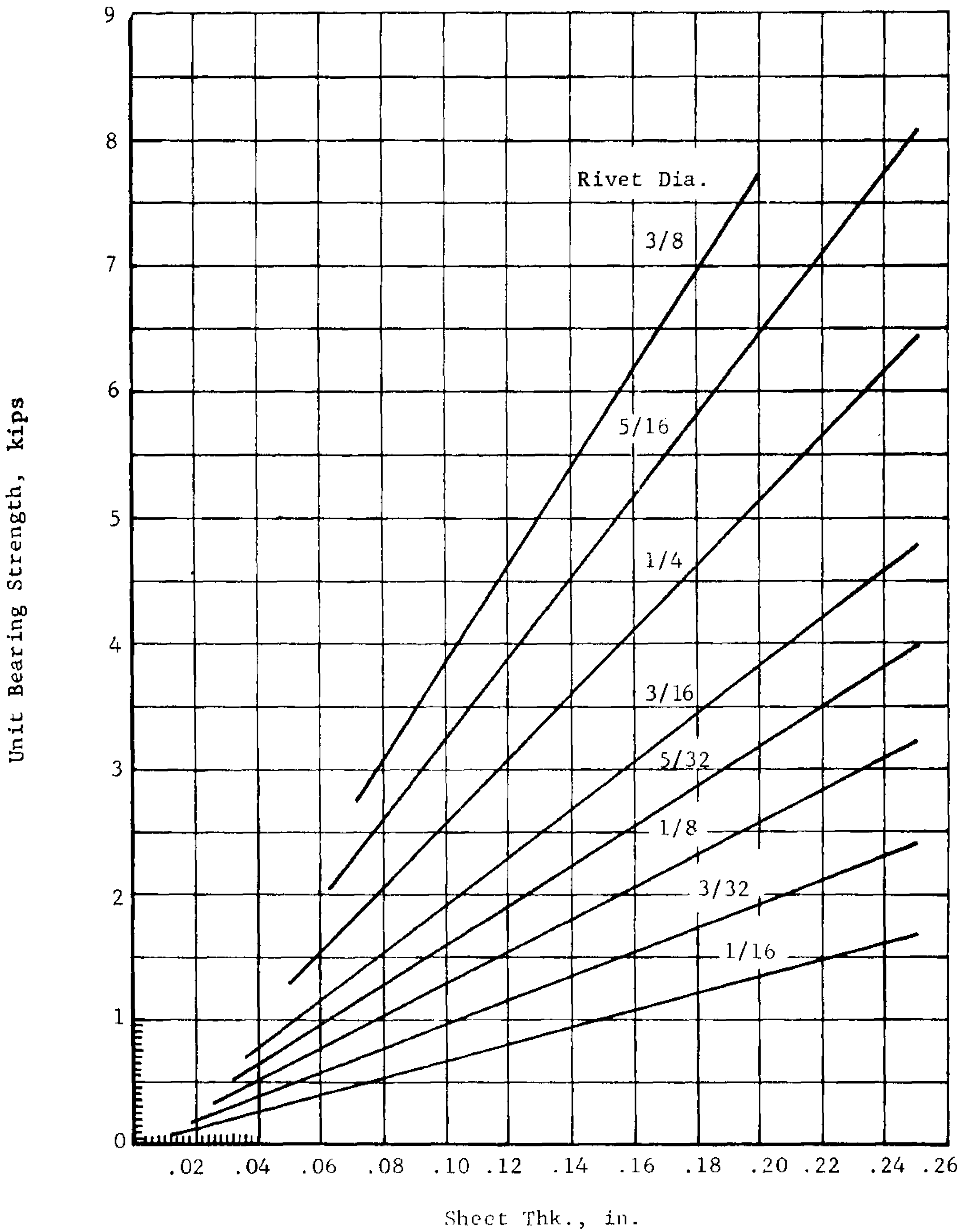


Fig. B 1.1.3-3 Unit Bearing Strengths of Sheets on Rivets

F_{br} = 100 ksi

Table B 1.1.3.7 Unit Bearing Strength of Sheet on Rivets, F_{br} = 100 ksi

Sheet thickness (in.)	Unit bearing strength for rivet diameter indicated, lb[a]							
	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	1/4 in.	5/16 in.	3/8 in.
0.012	80							
0.016	107							
0.018	121	173						
0.020	134	192						
0.025	168	240	321					
0.032	214	307	411	509				
0.036	241	346	463	572	688			
0.040	268	384	514	636	764			
0.045	302	432	578	716	860			
0.050	335	480	643	795	955	1285		
0.063	422	605	810	1002	1203	1619	2035	
0.071	476	682	912	1129	1356	1825	2293	2741
0.080	536	768	1028	1272	1528	2056	2584	3088
0.090	603	864	1157	1431	1719	2313	2907	3474
0.100	670	960	1285	1590	1910	2570	3230	3860
0.125	838	1200	1606	1988	2388	3213	4038	4825
0.160	1072	1536	2056	2544	3056	4112	5168	6176
0.200	1340	1920	2570	3180	3820	5140	6460	7720
0.250	1670	2400	3210	3970	4770	6420	8070	......

a Bearing values are based on areas computed using the nominal hole diameters specified in table B 1.1.3.6

Table B 1.1.3.8 Aluminum-Alloy Sheet and Plate Bearing Factors[a]
(K = ratio of actual bearing strength to 100 ksi)

Material	Thickness, in.	A values				B values			
		K (Ultimate)		K (Yield)		K (Ultimate)		K (Yield)	
		e/D=2.0	e/D=1.5	e/D=2.0	e/D=1.5	e/D=2.0	e/D=1.5	e/D=2.0	e/D=1.5
2024-T42 (heat treated by user)	<.250	1.18	0.93	0.64	0.56				
	.250- .500	1.22	.96	.61	.53				
	.501-1.000	1.18	.93	.61	.53				
2024-T3	<.250	1.24	.98	.79	.69	1.29	1.02	0.82	0.71
	.250- .500	1.24	.98	.74	.64	1.27	1.01	.78	.69
2024-T4	.501-1.000	1.20	.95	.70	.62	1.29	1.02	.77	.67
2024-T36	≤.500	1.33	1.05	.96	.84	1.37	1.08	1.00	.88
2024-T4 (coiled)	<.250	1.18	.93	.64	.56	1.26	.99	.66	.57
Clad 2024-T42 (heat treated by user)	<.063	1.06	.84	.54	.48	1.10	.87	.56	.49
	.064- .249	1.12	.89	.58	.50	1.16	.92	.68	.53
	.250- .499	1.18	.93	.61	.53				
	.500-1.000	1.14	.90	.58	.50				
Clad 2024-T3	.010- .063	1.14	.90	.73	.64	1.18	.93	.76	.67
	.064- .249	1.20	.95	.74	.64	1.24	.98	.78	.69
Clad 2024-T4	.250- .499	1.20	.95	.74	.64	1.24	.98	.78	.69
	.500-1.000	1.16	.92	.67	.59	1.24	.98	.74	.64
Clad 2024-T36	.019- .063	1.20	.95	.88	.77	1.25	.99	.93	.81
	.064- .500	1.27	1.01	.93	.81	1.31	1.04	.96	.84
Clad 2024-T4 (coiled)	.012- .062	1.10	.87	.59	.52	1.16	.92	.61	.53
	.063	1.16	.92	.61	.53	1.20	.95	.64	.56
Clad 2024-T6	<.063	1.14	.90	.75	.66				
	≥.063	1.18	.93	.78	.69				
Clad 2024-T81	<.063	1.22	.96	.90	.78				
	≥.063	1.27	1.00	.94	.83				
Clad 2024-T86	<.063	1.33	1.05	1.04	.91				
	≥.063	1.35	1.06	1.09	.95				
7075-T6	.016- .039	1.44	1.14	1.06	.92	1.48	1.17	1.10	.97
	.040- .249	1.49	1.16	1.07	.94	1.50	1.19	1.12	.98
	.250- .500	1.39	1.08	1.00	.87	1.42	1.10	1.04	.90
	.501-1.000	1.42	1.10	1.04	.90	1.47	1.15	1.08	.94

Table B 1.1.3.8 Aluminum-Alloy Sheet and Plate Bearing Factors[a]
(K = ratio of actual bearing strength to 100 ksi) Cont'd

Material	Thickness, in.	A values				B values			
		K (Ultimate)		K (Yield)		K (Ulitmate)		K (Yield)	
		e/d=2.0	e/D=1.5	e/D-2.0	e/D=1.5	e/D=2.0	e/D=1.5	e/D=2.0	e/D=1.5
Clad 7075-T6	.016- .039	1.33	1.05	.98	.85	1.39	1.10	1.02	.90
	.040- .249	1.37	1.08	1.01	.88	1.41	1.11	1.04	.91
	.250- .499	1.30	1.01	.94	.84	1.33	1.04	.98	.82
	.500-1.000	1.33	1.04	.96	.83	1.37	1.06	1.00	.87
Clad 2014-T6	≤.039	1.22	.96	.90	.78	1.22	.96	.90	.78
	.040-1.000	1.24	.98	.93	.81	1.27	1.01	.96	.84
2014-T6	.040-1.000	1.29	1.02	.96	.84	1.33	1.05	.99	.87
5052-H32 (1/4H)		.65	.50	.34	.29				
5052-H32 (1/2H)		.71	.54	.38	.34				
5052-H36 (3/4H)		.78	.59	.46	.41				
5052-H38 (H)		.82	.62	.53	.46				
6061-T4		.63	.48	.26	.22				
6061-T6		.88	.67	.58	.50				

[a] For e/D values between 1.5 and 2.0 bearing factors may be obtained by linear interpolation. (e = edge distance, D = hole diameter).

B 1.1.3 Protruding-Head Rivets and Bolts (Cont'd)

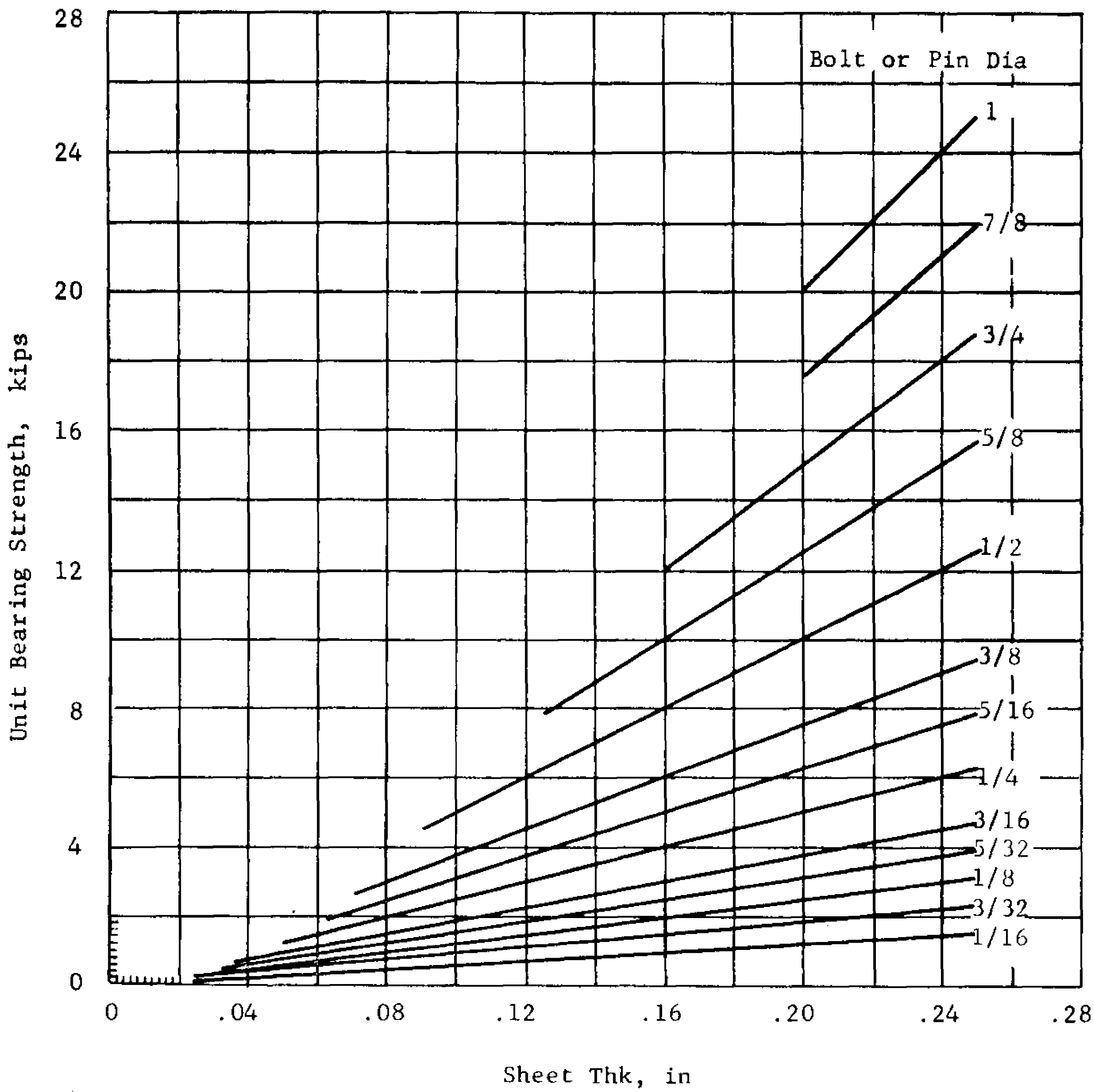


Fig. B 1.1.3-4 Unit Bearing Strengths of Sheets on Bolts and Pins
F_{br} = 100 ksi

Table B 1.1.3.9 Unit Bearing Strengths of Sheets on Bolts and Pins; F_{br} = 100 ksi

Plate sizes, in.	Bearing strength of plate for rivet size indicated, lb												
	1/16 in.	3/32 in.	1/8 in.	5/32 in.	3/16 in.	1/4 in.	5/16 in.	3/8 in.	1/2 in.	5/8 in.	3/4 in.	7/8 in.	1 in.
0.025	156	234	313										
0.032	200	300	400	500									
0.036	225	338	450	563	675								
0.040	250	375	500	625	750								
0.045	281	422	563	704	845								
0.050	313	469	625	781	940	1,250							
0.063	394	590	788	985	1,180	1,575	1,969						
0.071	444	665	888	1,110	1,330	1,775	2,219	2,663					
0.080	500	750	1,000	1,250	1,500	2,000	2,500	3,000					
0.090	563	845	1,125	1,407	1,690	2,250	2,813	3,375	4,500				
0.100	625	938	1,250	1,562	1,875	2,500	3,125	3,750	5,000				
0.125	781	1,170	1,563	1,953	2,340	3,125	3,906	4,688	6,250	7,812			
0.160	1,000	1,500	2,000	2,500	3,000	4,000	5,000	6,000	8,000	10,000	12,000		
0.200	1,250	1,875	2,500	3,125	3,750	5,000	6,250	7,500	10,000	12,500	15,000	17,500	20,000
0.250	1,563	2,344	3,125	3,916	4,688	6,250	7,813	9,375	12,500	15,625	18,750	21,875	25,000

Note: For intermediate values see Fig. B 1.1.3-4

B 1.1.4 Flush Rivets

Table B 1.1.4.1 through B 1.1.4.3 contain ultimate and yield allowable single-shear strength values for both machine-countersunk and dimpled flush riveted joints employing solid rivets with a head angle of 100°. These strength values are applicable when the edge distance is equal to or greater than two times the nominal rivet diameter. Other strength values and edge distances may be used if substantiated by tests.

The allowable ultimate loads were established from test data using the average failing load divided by a factor of 1.15. The yield loads were established from test data wherein the yield load was defined as the average test load at which the following permanent set across the joint is developed:

(1) 0.005 inch, up to and including 3/16 inch diameter rivets.

(2) 2.5 percent of the rivet diameter for rivet sizes larger than 3/16 inch diameter.

Table B 1.1.4.1 Ultimate and Yield Strengths of Solid 100° Machine-Countersunk Rivets

Rivet material	Strength, lb 2117-T3				2017-T3			2024-T31	
Clad sheet material	2024-T3, 2024-T4, 2024-T6, 2024-T81, 2024-T86, and 7075-T6								
Rivet diameter, (in.)	3/32	1/8	5/32	3/16	5/32	3/16	1/4	3/16	1/4
Ultimate strength									
Sheet thickness (in.):[ab]									
0.020	132	163							
0.025	156	221	[c]250						
0.032	178	272	[c]348	...	...	...	...	[c]324	
0.040	193	309	[c]418	[c]525	[c]476	...	...	[c]555	
0.050	206	340	[c]479	[c]628	[c]580	[c]726	...	758	[c]975
0.063	216	363	523	705	[c]657	[c]859	[c]1,200	886	[c]1,290
0.071	...	373	542	739	690	[c]917	[c]1,338	942	[c]1,424
0.080	...	...	560	769	720	[c]969	[c]1,452	992	[c]1,543
0.090	...	...	575	795	746	1,015	[c]1,552	1,035	[c]1,647
0.100	...	...	...	818	...	1,054	[c]1,640	1,073	[c]1,738
0.125	...	...	...	853	...	1,090	1,773	1,131	1,877
0.160	...	...	...	...	...	...	1,891	...	2,000
0.190	...	...	...	...	...	...	1,970	...	2,084
Shear	217	388	596	862	755	1,090	1,970	1,180	2,120

Table B 1.1.4.1 Ultimate and Yield Strengths of Solid 100° Machine-Countersunk Rivets (Cont'd)

	Strength, lb								
Rivet material	2117-T3				2017-T3			2024-T31	
Clad sheet material	2024-T3, 2024-T4, 2024-T6, 2024-T81, 2024-T86, and 7075-T6								
Rivet diameter, (in.):[ab]	3/32	1/8	5/32	3/16	5/32	3/16	1/4	3/16	1/4
Yield strength									
0.020	91	98							
0.025	113	150	110						
0.032	132	198	200	...	...	...	...	204	
0.040	153	231	265	273	270	...	...	362	
0.050	188	261	321	389	345	419	...	538	594
0.063	213	321	402	471	401	515	610	614	811
0.071	...	348	453	538	481	557	706	669	902
0.080	...	...	498	616	562	623	788	761	982
0.090	...	...	537	685	633	746	861	842	1,053
0.100	...	...	...	745		854	1,017	913	1,115
0.125	...	...	...	836	...	1,018	1,313	1,021	1,357
0.160	...	...	...	...	...	...	1,574	...	1,694
0.190	...	...	...	...	...	...	1,753	...	1,925

Note: The values in this table are based on "good" manufacturing practice, and any deviation from this will produce significantly reduced values.

[a] Sheet gage is that of the countersunk sheet. In cases where the lower sheet is thinner than the upper, the shear-bearing allowable for the lower sheet-rivet combination should be computed.

[b] Increased attention should be paid to detail design in cases where $D/t > 4.0$ because of possibly greater incidence of difficulty in service.

[c] Yield values of the sheet-rivet combinations are less than 2/3 of the indicated ultimate values.

Table B 1.1.4.2 Ultimate Strength of Solid 100° Dimpled Rivets

Rivet Material	Ultimate strength, lb																
	2117-T3							2017-T3						2024-T31			
Clad sheet material	2024-T3, 2024-T4, 2024-T6, and 2024-T81		2024-T86	2024-T3, and 2024-T4		2024-T6, 2024-T81, 2024-T86, 7075-T6		2024-T3, 2024-T4, 2024-T6, and 2024-T81		2024-T86 and 7075-T6		2024-T3 and 2024-T4	2024-T6 2024-T81, 2024-T86, and 7075-T6	2024-T3, and 2024-T4		2024-T6, 2024-T81, 2024-T86, and 7075-T6	
Rivet diameter (in.)	3/32	1/8	1/8	5/32	3/16	5/32	3/16	5/32	3/16	5/32	3/16	1/4	1/4	3/16	1/4	3/16	1/4
Sheet thickness, (in.):[a]																	
0.016 ...	177																
0.020 ...	209	299	302														
0.025 ...	235	360	383	474	...	462	...	419	...	530							
0.032 ...	257	413	454	568	722	599	725	600	681	672	822	...	...	744	...	786	
0.040 ...	273	451	505	635	839	695	891	728	905	775	1,000	845	1,108	941	879	982	1,300
0.050 ...	...	484	548	693	940	778	1,036	840	1,097	864	1,153	1,332	1,508	1,110	1,359	1,152	1,705
0.063 ...	...	...	...	736	1,012	840	1,142	922	1,240	930	1,267	1,695	1,803	1,236	1,727	1,277	2,010
0.071 ...	...	...	...	755	1,045	867	1,190	958	1,301	957	1,315	1,853	1,930	1,291	1,883	1,332	2,150
0.081 ...	...	...	...	...	1,074	...	1,230	...	1,357	...	1,358	1,995	2,044	1,340	2,025	1,380	2,260
0.090 ...	...	...	...	...	1,098	...	1,267	...	1,405	...	1,398	2,115	2,145	1,382	2,150	1,424	2,365
0.100 ...	...	...	...	...	...	...	...	...	...	...	...	2,220	2,232	...	2,255	...	2,455

Note: The values in this table are based on "good" manufacturing practice and any deviation from this will produce significantly reduced values.

[a] The values apply to double dimpled sheets and to the upper sheet dimpled into a machine-countersunk lower sheet. Sheet gage is that of the thinnest sheet for double dimpled joints and of the upper dimple sheet for dimpled, machine-countersunk joints. The thickness of the machine-countersunk sheet must be at least 1 tabulated gage thicker than the upper sheet. In no case shall allowables be obtained by extrapolation for skin gages other than those shown.

Table B 1.1.4.3 Yield Strength of Solid 100° Dimpled Rivets

Rivet material	Yield strength, lb																	
	2117-T3						2017-T3						2024-T31					
Clad sheet material	2024-T3, 2024-T4, 2024-T6, and 2024-T81	2024-T3, 2024-T4, 2024-T6, 2024-T81, and 2024-T86	2024-T3, 2024-T4, 2024-T6, and 2024-T81		2024-T86 and 7075-T6		2024-T3, 2024-T4, 2024-T6, and 2024-T81			2024-T86 and 7075-T6			2024-T3, and 2024-T4		2024-T6 and 2024-T81		2024-T86 and 7075-T6	
Rivet diameter (in.)	3/32	1/8	5/32	3/16	5/32	3/16	5/32	3/16	1/4	5/32	3/16	1/4	3/16	1/4	3/16	1/4	3/16	1/4
Sheet thickness, in.:[a]																		
0.016...	154																	
0.020...	184	257																
0.025...	209	315	324	...	410	...	336	...	...	450								
0.032...	231	367	430	512	525	640	483	546	...	581	705	...	582	...	649	...	786	
0.040...	246	404	506	644	606	782	589	730	845	675	867	978	666	879	816	962	982	978
0.050...	...	436	571	757	677	905	681	888	1,187	756	1,007	1,508	738	1,308	961	1,308	1,152	1,543
0.063...	...	...	619	841	729	995	748	1,006	1,415	816	1,111	1,803	925	1,564	1,068	1,564	1,277	1,958
0.071...	...	...	641	878	752	1,034	778	1,056	1,656	842	1,156	1,930	1,045	1,711	1,115	1,711	1,332	2,140
0.080...	...	...	...	910	...	1,070	...	1,102	1,870	...	1,196	2,044	1,152	1,928	1,177	1,928	1,380	2,260
0.090...	...	...	...	939	...	1,100	...	1,142	2,057	...	1,231	2,145	1,246	2,121	1,324	2,121	1,424	2,365
0.100...	...	...	...	...	...	...	...	...	2,220	...	...	2,232	...	2,255	...	2,268	...	2,455

Note: The values in this table are based on "good" manufacturing practice and any deviation from this will produce significantly reduced values.

[a]These values apply to double dimpled sheets and to the upper sheet dimpled into a machine-countersunk lower sheet. Sheet gage is that of the thinnest sheet for double dimpled joints and of the upper dimple sheet for dimpled, machine-countersunk joints. The thickness of the machine-countersunk sheet must be at least 1 tabulated gage thicker than the upper sheet. In no case shall values be obtained by extrapolation for skin gages other than those shown.

B 1.1.5 Flush Screws

Table B 1.1.5.1 contains ultimate and yield allowable strength values for 100° flush-head screws with recessed heads installed in machine-countersunk clad 2024 and 7075 sheet. These strength values are applicable when the edge distance is equal to or greater than two times the nominal screw diameter. Other strength values and edge distances may be used if substantiated by tests.

These strength values may be used for the design of dimpled joints. Higher values may be used for dimpled joints if based on test results.

The allowable ultimate loads were established from test data using the average failing load divided by a factor of 1.15. The yield loads were established from test data, wherein the yield load was defined as the average test load at which the following permanent set across the joint is developed:

(1) 0.012 inch, up to and including 1/4 inch diameter screws.

(2) 4.0 percent of the screw diameter for screw sizes larger than 1/4 inch diameter.

The test specimens used were made up of two equal-gage sheets lap jointed and machine countersunk with washers to build up thickness to minimum grip. All joints had 2D nominal edge distance in the direction of the load and were either of the three-screws-across or the two-screws-in-tandem type. For the latter type, the flush heads were placed on opposite sides of the joint to assure 2D edge distances.

Table B 1.1.5.1 Ultimate and Yield Strengths of 100° Machine-Countersunk Screw Joints[ab]

Type fastener / Sheet material / Screw diameter (in.)	Strength, lb									
Type fastener	AN 509 steel screw with MS20365 steel nut									
Sheet material	Clad 2024-T3					Clad 7075-T6				
Screw diameter (in.)	3/16	1/4	5/16	3/8	1/2	3/16	1/4	5/16	3/8	1/2
Ultimate strength										
Sheet thickness, in.[c]										
0.032	493					569				
0.040	657	761				791	905			
0.050	903	1,074	1,244			[d]1,080	1,277	1,454		
0.063	[d]1,211	1,439	1,690	1,887		[d]1,365	1,748	1,995	2,211	
0.071	[d]1,392	[d]1,693	1,955	2,235		[d]1,501	[d]2,006	[d]2,386	2,608	
0.080	[d]1,567	[d]1,965	[d]2,288	2,600		[d]1,632	[d]2,252	[d]2,777	[d]3,105	
0.090	[d]1,726	[d]2,263	[d]2,679	3,022	3,690	[d]1,762	[d]2,488	[d]3,162	[d]3,693	4.263
0.100	[d]1,877	[d]2,576	[d]3,105	[d]3,519	4,292	[d]1,892	[d]2,723	[d]3,536	[d]4,222	5,100
0.125	[d]2,126	[d]3,054	[d]3,922	[d]4,579	5,586	2,126	[d]3,109	[d]4,180	[d]5,216	6,791
0.160	2,126	[d]3,536	[d]4,772	[d]5,878	7,482	2,126	[d]3,551	[d]4,858	[d]6,193	8,673
0.190		3,680	[d]5,405	[d]6,872	[d]9,408		3,680	[d]5,433	[d]6,996	10,202
0.250			[d]5,750	[d]8,280	[d]12,201			5,750	[d]8,280	[d]12,421
0.312				[d]8,280	[d]14,141				8,280	14,185
0.375					14,700					14,700

Table B 1.1.5.1 Ultimate and Yield Strengths of 100° Machine-Countersunk Screw Joints[ab] (Cont'd)

Type fastener Sheet material Screw diameter (in.)	Strength, lb AN 509 steel screw with MS20365 steel nut Clad 2024-T3 3/16	 1/4	 5/16	 3/8	 1/2	 Clad 7075-T6 3/16	 1/4	 5/16	 3/8	 1/2
	Yield strength									
0.032	436	...	...	...	...	559				
0.040	508	732	...	...	...	616	931			
0.050	617	854	1,035	...	...	710	1,041	1,156		
0.063	744	1,012	1,248	1,531	...	819	1,181	1,374	1,722	
0.071	818	1,122	1,380	1,697	...	884	1,269	1,495	1,887	
0.080	903	1,232	1,512	1,871	...	965	1,369	1,610	2,045	
0.090	989	1,354	1,633	2,070	3,395	1,063	1,479	1,731	2,219	3,925
0.100	1,084	1,490	1,765	2,244	3,719	1,179	1,600	1,857	2,401	4,292
0.125	1,296	1,748	2,001	2,559	4,336	1,462	1,895	2,098	2,699	5,145
0.160	1,615	2,116	2,334	2,939	5,189	1,913	2,363	2,501	3,088	6,085
0.190	...	2,484	2,702	3,361	6,012	...	2,926	3,018	3,601	6,835
0.250	...	...	3,404	4,197	7,306	...	...	4,312	4,868	8,041
0.312	...	...	...	5,092	8,452	...	...	...	6,624	9,437
0.375	...	...	...	...	9,996	...	...	...	...	11,686

NOTE: The values in this table are based on "good" manufacturing practice, and any deviation from this will produce significantly reduced values.

[a] This table refers to recessed-head screws only. Values for sheet thicknesses above or below the range for which values are indicated shall not be determined by extrapolation.

[b] Values for alloys in other physical conditions, for joint configurations other than that indicated in section B 1.1.5 or for section thicknesses outside the range for which values are indicated shall be substantiated by test data.

[c] Sheet thickness of countersunk sheet.

[d] The yield values of the sheet screw combinations are less than 2/3 of the indicated ultimate values.

B 1.1.6 Blind Rivets

Tables B 1.1.6.1 through B 1.1.6.6 contain ultimate and yield allowable single-shear strengths for protruding and flush-head blind rivets. These strengths are applicable only when the grip lengths and rivet-hole tolerances are as recommended by the respective manufacturers, and may be substantially reduced if oversize holes or improper grip lengths are used.

The strength values were established from test data obtained from tests of specimens having values of e/D equal to or greater than 2.0. Where e/D values less than 2.0 are used, tests to substantiate yield and ultimate strengths must be made. Ultimate strength values of protruding and flush blind rivets were obtained from the average failing load of test specimens divided by 1.15. Yield strength values were obtained from average yield load test data wherein the yield load is defined as the load at which the following permanent set across the joint is developed:

(1) 0.005 inch, up to and including 3/16 inch diameter rivets.

(2) 2.5 percent of the rivet diameter for rivet sizes larger than 3/16 inch diameter.

For tables B 1.1.6.2 and B 1.1.6.3 the ultimate rivet shear strength was based on the comparable rivet shear strength of 2117 solid rivets, as noted in table B 1.1.6.3. Test data on which the strength values of these tables were based were obtained using standard degreased clad 2024-T4 specimens.

In view of the wide variance in dimpling methods and tolerances for aluminum and magnesium alloys, no standard or uniform load allowables are recommended. Allowables for ultimate and shear strengths of blind rivets in double-dimpled or dimpled, machine-countersunk application should be established on the basis of specific tests. In the absence of such data, allowables for blind rivets in machine-countersunk sheet may be used.

Since blind rivets are primarily shear-type fasteners, they should not be used in applications where appreciable tensile loads on the rivets will exist. Reference should be made to the requirements of the applicable use of blind rivets, such as the limitations of usage on Drawing MS33522.

Table B 1.1.6.1 Ultimate and Yield Strengths for Blind Monel Cherry Rivets in Corrosion-Resistant Sheet

	Strength, lb[a]											
Installation	Protruding heat				100° Doubled dimpled[b]				100° Machine countersunk[c]			
Rivet type	CR 563				CR 562							
Sheet material	18-8 (1/2 hard)											
Diameter of rivet (in.)	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/4
Ultimate strength												
Sheet thickness, in.[d]												
0.008	150	178	....	....	252	327						
0.012	242	286	335	....	302	428	560					
0.020	402	530	620	....	415	542	705	1135				
0.025	456	621	785	....	482	642	808	1230				
0.032	522	712	937	1362	543	750	963	1400				
0.040	580	810	1050	1615	585	833	1110	1660	387			
0.050	635	903	1200	1845	628	910	1240	1940	480	607		
0.063	678	980	1325	2090	....	964	1330	2175	554	744	912	
0.071	701	1013	1385	2220	....	993	1375	2275	585	793	1013	
0.080	717	1050	1438	2340	....	....	1420	2360	612	862	1109	1570
0.090	735	1081	1486	2450	....	....	....	2440	637	910	1196	1743
0.100	747	1100	1540	2540	....	....	....	....	662	952	1270	1915
0.125	772	1147	1605	2710	....	....	....	....	697	1012	1380	2180
Rivet shear strength[e]	775	1190	1720	3110	....	....	....	....	775	1190	1720	3110

Table B 1.1.6.1 Ultimate and Yield Strengths for Blind Monel Cherry Rivets in Corrosion-Resistant Sheet (Cont'd)

Installation	Strength, lb[a]											
	Protruding head				100° Double dimpled[b]				100° Machine countersunk[c]			
Rivet type	CR 563				CR 562							
Sheet material	18-8 (1/2 hard)											
Diameter of rivet (in.)	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/4
	Yield strength											
0.008	150	178	......	......	151	185						
0.012	242	286	335	......	252	291	344					
0.020	402	530	620	......	412	535	653	793				
0.025	456	621	785	......	473	637	800	1072				
0.032	522	712	937	1338	497	743	963	1395				
0.040	580	810	1050	1615	582	827	1090	1650	236			
0.050	635	903	1200	1845	620	900	1220	1930	364	393		
0.063	678	980	1325	2090	......	958	1315	2145	457	572	628	
0.071	701	1013	1385	2220		977	1360	2250	500	643	757	
0.080	717	1050	1438	2340	......	......	1395	2350	534	720	877	995
0.090	735	1081	1486	2450	......	......	......	2425	565	774	972	1242
0.100	747	1100	1540	2540	......	......	......	......	597	834	1075	1460
0.125	772	1147	1605	2710	......	......	......	......	635	917	1212	1800

[a] The strength values listed are based on the results of laboratory tests conducted under optimum conditions and should be used with caution.

[b] In dimpled installations, values shall not be obtained by extrapolation for skin gages other than those shown.

[c] In the case of machine-countersunk joints where the lower sheet is thinner than the upper, the bearing allowable for the lower sheet-rivet combination should be computed.

[d] Sheet gage is that of the thinnest sheet for protruding-head and double-dimpled installations. For machine-countersunk installations, sheet gage is that of the upper sheet.

[e] Rivet shear strength computed using nominal hole size and the following values for rivet and pin materials: Rivet - R monel, annealed - F_{su} = 55 ksi, Pin - R monel, cold worked - F_{su} = 65 ksi.

Table B 1.1.6.2 Ultimate and Yield Strengths for Protruding-Head (MS-20600 and MS-20602) Aluminum-Alloy Blind Rivets[ab]

Installation	Strength, lb: Universal		Strength, lb: Brazier head	
Rivet type	MS-20600 AD (2117)	and/or	MS-20602 AD (2017)	
Sheet material	For clad 2024-T4 and higher strength aluminum sheet materials			
Rivet diameter (in.)	1/8	5/32	3/16	1/4
Ultimate strength				
Sheet thickness, in.:[c]				
0.020	186			
0.025	233	286		
0.032	277	368	445	601
0.040	321	425	544	750
0.050	386	506	643	961
0.063	388	596	753	1,110
0.071	388	596	823	1,200
0.080	...	...	862	1,305
0.090	...	...	862	1,415
0.100	...	...	...	1,548
0.125	...	...	...	1,550

Table B 1.1.6.2 Ultimate and Yield Strengths for Protruding-Head (MS-20600 and MS-20602) Aluminum-Alloy Blind Rivets[ab] (Cont'd)

	Strength, lb			
Installation	Universal		Brazier head	
Rivet type	MS-20600 AD (2117) and/or		MS-20602 AD (2017)	
Sheet material	For clad 2024-T4 and higher strength aluminum sheet materials			
Rivet diameter (in.)	1/8	5/32	3/16	1/4
	Yield strength			
0.020	180			
0.025	226	271		
0.032	264	356	431	572
0.040	304	406	523	720
0.050	362	475	610	925
0.063	388	560	709	1,058
0.071	388	596	771	1,135
0.080	...	...	862	1,230
0.090	...	...	862	1,330
0.100	...	...	...	1,450
0.125	...	...	...	1,550

[a]Protruding-head blind-rivet yield values are included for information purposes.

[b]Values for alloys in other physical conditions for joint configurations other than that indicated in section B 1.1.6 or for section thickness outside the range for which values are indicated shall be substantiated by test data.

[c]Thickness of thinnest sheet.

Table B 1.1.6.3 Ultimate and Yield Strengths for 100° Countersunk-Head (MS-20601 and MS-20603) Aluminum-Alloy Blind Rivets[ab]

Installation	Strength, lb 100° Countersunk head			
Rivet type	MS-20601 AD (2117)		MS-20603 AD (2017)	
Sheet material	For clad 2024-T4 and higher strength aluminum sheet materials			
Rivet diameter (in.)	1/8	5/32	3/16	1/4
Ultimate strength				
Sheet thickness, in.[c]				
0.040	159			
0.050	236	258		
0.063	327	369	398	
0.071	360	439	485	
0.080	388	511	577	654
0.090	388	561	684	795
0.100		596	768	945
0.125		596	862	1,270

Table B 1.1.6.3 Ultimate and Yield Strengths for 100° Countersunk-Head (MS-20601 and M -20603) Aluminum-Alloy Blind Rivets[ab] (Cont'd)

	Strength, lb			
Installation	100° Countersunk head			
Rivet type	MS-20601 AD (2117)		MS-20603 AD (2017)	
Sheet material	For clad 2024-T4 and higher strength aluminum sheet materials			
Rivet diameter (in.)	1/8	5/32	3/16	1/4
Yield strength				
0.040	[d]110			
0.050	198	[d]185		
0.063	300	308	[d]296	
0.071	336	384	391	
0.080	377	468	497	[d]456
0.090	338	524	614	621
0.100		592	709	793
0.125		596	862	1,150

a Values for sheet thicknesses above or below the range for which values are indicated shall not be determined by extrapolation.

b Values for alloys in other physical conditions, for joint configurations other than that indicated in section B 1.1.6 or for section thicknesses outside the range for which values are indicated, shall be substantiated by test data.

c Sheet thicknesses of countersunk sheet.

d These yield values of the sheet-rivet combinations are less than 77 percent (i.e., $\frac{\text{Average yield}}{1.5} \times 1.15$) of the indicated ultimate values.

The remaining countersunk-head blind-rivet values are included for information purposes.

Table B 1.1.6.4 Ultimate and Yield Strengths for Blind 5056 Aluminum Rivets in Magnesium Sheet

	Strength, lb													
Installation	Protruding head							Machine countersunk						
Rivet type	MS-20600				MS-20602			MS-20601				MS-20603		
Sheet material	AZ31A-0													
Rivet diameter (in.)	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/8	5/32	3/16	1/4	1/8	5/32	3/16
	Ultimate strength													
Sheet thickness, in.[a]														
0.020	134													
0.025	165	210	...	...	161	186								
0.032	210	260	318	435	220	261	334							
0.040	268	324	391	535	272	354	391	197						
0.050	311	410	494	667	309	440	490	248	310	...	...	290	465	
0.063	363	481	607	837	322	497	633	307	385	470	...	336	503	652
0.071	...	524	665	930	...	521	670	344	427	523	...	...	545	750
0.080	...	556	720	1040	...	...	720	385	482	584	796	...	...	756
0.090	...	...	785	1140	...	...	725	417	537	654	895			
0.100	...	...	802	1240	...	...	...	...	596	723	992			
0.125	...	...	...	1440	...	...	...	...	637	895	1130			

Table B 1.1.6.4 Ultimate and Yield Strength for Blind 5056 Aluminum Rivets in Magnesium Sheet (Cont'd)

Installation	Strength, lb													
	Protruding head							Machine countersunk						
Rivet type	MS-20600				MS-20602			MS-20601				MS-20603		
Sheet material	AZ31A-0													
Rivet diameter (in.)	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/8	5/32	3/16	1/4	1/8	5/32	3/16
	Yield strength													
0.020	100													
0.025	120	157	......	......	116	162								
0.032	150	192	238	336	137	188	[b]237							
0.040	183	233	286	396	161	218	278	[b]76						
0.050	213	290	354	495	194	260	325	[b]117	[b]124	......	......	[b]148		
0.063	241	326	431	600	226	312	382	[b]161	[b]184	[b]197	......	[b]170	[b]236	
0.071	[b]259	350	456	677	229	342	416	[b]197	[b]217	[b]240	......	[b]185	[b]254	[b]320
0.080	[b]259	[b]375	485	746	235	362	457	[b]228	[b]263	[b]288	[b]317	[b]200	[b]275	[b]345
0.090	300	[b]402	519	800	240	372	502	[b]266	[b]306	[b]343	[b]390	[b]216	[b]296	[b]370
0.100	300	432	[b]559	852	[b]248	381	511	298	[b]356	[b]405	[b]470	235	[b]321	[b]400
0.125		460	642	950	[b]263	399	533	340	448	[b]540	[b]640	275	[b]372	[b]457

[a] Sheet gage is that of the thinnest sheet for protruding-head applications, and that of the upper sheet for machine countersunk applications. In the case of machine countersunk joints where the lower sheet is thinnest, bearing allowable for the lower sheet-rivet combinations should be computed.

[b] Yield values of the sheet-rivet combinations are less than 2/3 of the indicated ultimate values.

Table B 1.1.6.5 Ultimate and Yield Strengths for Protruding and Flush Head Blind A-286 Rivets

	Strength, lbs													
Installation	Protruding head				Flush head				Protruding head			Flush head		
Manufacturer	Cherry								Dupont					
Rivet type	CR-6636, soft stem				CR-6626, soft stem									
Sheet material	4130 Steel 41-43Rc								A-286 Age hardened					
Temperature	RT													
Rivet diameter (in.)	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/8	5/32	3/16
	Ultimate strength													
Sheet thickness:														
0.020	530	…	…	…	…	…	…	…	440	617	791			
0.025	675	825	…	…	…	…	…	…	512	712	895			
0.032	800	1060	1285	…	…	…	…	…	562	829	1040			
0.040	890	1220	1570	2125	475	…	…	…	…	910	1203	435		
0.050	960	1360	1820	2700	640	760	…	…	…	…	1265	477	703	
0.063	970	1465	2000	3160	860	1015	1120	…	…	…	…	529	766	999
0.071	…	1490	2080	3340	960	1165	1330	1650	…	…	…	560	808	1049
0.080	…	…	2150	3510	975	1320	1540	1950	…	…	…	562	853	1103
0.090	…	…	…	3650	…	1490	1750	2240	…	…	…	…	904	1157
0.100	…	…	…	3800	…	…	2010	2540	…	…	…	…	910	1224
0.125	…	…	…	3900	…	…	2160	3270	…	…	…	…	…	1265
0.156	…	…	…	…	…	…	…	3900						

Table B 1.1.6.5 Ultimate and Yield Strengths for Protruding and Flush Head Blind A-286 Rivets (Cont'd)

	Strength, lbs														
Installation	Protruding head				Flush head				Protruding head			Flush head		
Manufacturer	Cherry								Dupont					
Rivet type	CR-6636, soft stem				Cr-6626, soft stem									
Sheet material	4130 Steel 41-43Rc								A-286 Age hardened					
Temperature	RT													
Rivet diameter (in.)	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/4	1/8	5/32	3/16	1/8	5/32	3/16
Yield strength														
0.020	...	...	...	...	...	...	...	...	[a]375	[a]537	[a]704			
0.025	...	...	...	...	...	...	...	...	[a]430	[a]606	[a]775			
0.032	...	...	...	...	...	...	...	...	[a]474	[a]696	[a]881			
0.040	...	...	...	...	[b]275	...	...	...	...	[a]767	[a]1005	308		
0.050	...	...	...	...	430	[b]445	...	...	...	...	[a]1067	358	499	
0.063	...	...	...	...	595	[b]670	[b]660	...	...	...	...	417	575	722
0.071	...	...	...	...	700	800	[b]860	[b]925	...	...	...	451	620	775
0.080	...	...	...	...	825	950	1040	[b]1120	...	...	...	474	672	837
0.090	...	...	...	...	950	1120	1240	[b]1410	...	...	...	...	727	899
0.100	...	...	...	...	...	1300	1460	[b]1680	...	...	...	...	767	976
0.125	...	...	...	...	...	1460	1935	2310	...	...	...	...	...	1667
0.156	...	...	...	...	...	...	...	3140						

[a]Yield strength is 80% ultimate or higher.

[b]Yield values of the sheet-rivet combinations are less than 2/3 of the indicated ultimate values.

B 1.1.6 Blind Rivets (Cont'd)

Table B 1.1.6.6 Explosive Rivets, DuPont Extended Cavity

Ultimate Rivet Load, Lb/Rivet							
Rivet Size	Sheet Gauge						
	.025	.032	.040	.051	.064	.072	.081
5/32	320	410	513	610	610	610	--
3/16	--	495	620	796	880	880	880

B 1.1.7 Hollow-End Rivets

If hollow-end rivets with solid cross sections for a portion of the length (AN 450) are used, the strength of these rivets may be taken equal to the strength of solid rivets of the same material, provided that the bottom of the cavity is at least 25 percent of the rivet diameter from the plane of shear, as measured toward the hollow end, and further provided that they are used in locations where they will not be subjected to appreciable tensile stresses.

B 1.1.8 Hi-Shear Rivets

The allowable shear load for "Hi-Shear" rivets is the same as that specified for the standard aircraft bolts heat treated to 125 ksi and given in table B 1.1.3.2.

B 1.1.9 Lockbolts

Lockbolts and lockbolt stumps shall be installed in conformance with the lockbolt manufacturer's recommended practices, and shall be inspected in accordance with procedures recommended by the manufacturer or by an equivalent method. The ultimate allowable shear and tensile strengths for protruding and flush-head Huck lockbolts and lockbolt stumps are contained in table B 1.1.9.1. These strength values were established from test data and are minimum values guaranteed by the manufacturer. Shear and tensile yield strengths and ultimate and yield bearing strengths will be added when available.

For all lockbolts but the BL type (blind) under combined loading of shear and tension installed in material having a thickness large enough to make the shear cutoff strength critical for the shear loading, the following interaction equations are applicable:

Steel lockbolts - $R_t + R_s^{10} = 1.0$, 7075-T6 lockbolts - $R_t + R_s^5 = 1.0$, where R_t and R_s, are the ratios of applied load to allowable load in tension and shear, respectively.

Table B 1.1.9.1 Ultimate Single-Shear and Tensile Strengths of Protruding and Flush-Head Lockbolts[a] and Lockbolt Stumps

Lockbolt diameter, in.	Heat treated alloy steel: Single-shear strength, lb	Heat treated alloy steel: Tensile strength, lb — Standard-type: Stumps	Heat treated alloy steel: Tensile strength, lb — Standard-type: Pull-gun pins	Heat treated alloy steel: Tensile strength, lb — Shear-type: Stumps and pull gun pins	7075-T6 Aluminum alloy: Single-shear strength, lb — Stumps and pull gun pins[b]	7075-T6 Aluminum alloy: Tensile strength, lb — Stumps and pull gun pins[b]
5/32	...	...	...	...	995	850
3/16	2,620	2,210	2,210	1,105	1,330	1,375
1/4	4,650	4,080	4,080	2,040	2,280	2,535
5/16	7,300	6,500	[c]4,225	3,750	3,620	4,025
3/8	10,500	10,100	[d]5,050	5,050	5,270	6,275

[a]Lockbolts are pull-gun driven: lockbolt stumps are hammer or squeeze driven.

[b]Collars are heat-treated 6061S.

[c]Huck designation is R-1028 or R-1029.

[d]Collar material is heat-treated 6061S. All other collars are heat-treated 2024S.

B 1.1.10 Jo-Bolts

The ultimate and yield allowable shear strengths for flush-head steel and aluminum Jo-Bolts in clad aluminum-alloy sheet are given in Tables B 1.1.10.1 and B 1.1.10.2.

Table B 1.1.10.1 Allowable Ultimate and Yield Shear Strengths of Steel Jo-Bolts in Machine-Countersunk Joints in Clad 2024-T3 and Clad 7075-T6 Aluminum Alloys

	Shear strength, lb					
Type	F 200		F 260		F 312	
Sheet	Clad	Clad	Clad	Clad	Clad	Clad
Material	2024-T3	7075-T6	2024-T3	7075-T6	2024-T3	7075-T6
Ultimate strength						
Sheet thickness, in.:						
0.032	420	520				
0.040	445	545	[a]520	580		
0.050	[a]580	[a]700	[a]620	[a]700		
0.063	[a]1000	[a]1200	[a]1040	[a]1230	[a]1540	[a]1720
0.071	[a]1220	[a]1360	[a]1300	[a]1540	[a]1580	[a]1760
0.080	[a]1380	[a]1500	[a]1580	[a]1870	[a]1660	[a]1860
0.090	[a]1520	[a]1620	[a]1900	[a]2260	[a]1780	[a]2130
0.100	[a]1650	[a]1740	[a]2250	[a]2700	[a]2060	[a]2440
0.125	[a]1890	1960	[a]2940	[a]3220	[a]2720	[a]3080
0.160	2160	2200	[a]3390	[a]3570	[a]3600	[a]3940
0.190	2400	2420	[a]3730	[a]3860	[a]4490	[a]4810
0.250	2620	2620	[a]4260	4320	[a]5550	[a]6110
0.312			4650	4650	[a]6020	6500
0.375					6500	6790

Table B 1.1.10.1 Allowable Ultimate and Yield Shear Strengths of Steel Jo-Bolts in Machine-Countersunk Joints in Clad 2024-T3 and Clad 7075-T6 Aluminum Alloys (Cont'd)

	Shear strength, lb					
Type	F 200		F 260		F 312	
Sheet	Clad	Clad	Clad	Clad	Clad	Clad
Material	2024-T3	7075-T6	2024-T3	7075-T6	2024-T3	7075-T6
Yield strength						
Sheet thickness, in.:						
0.032	310	390				
0.040	320	400	320	400		
0.050	340	430	340	430		
0.063	610	770	690	790	870	950
0.071	685	850	780	870	930	1000
0.080	770	930	880	980	1000	1070
0.090	870	1025	990	1110	1090	1160
0.100	980	1130	1120	1280	1200	1280
0.125	1200	1350	1380	1600	1440	1540
0.160	1500	1640	1700	2050	1820	1980
0.190	1800	1960	2010	2470	2200	2520
0.250	2400	2550	2600	3190	2950	3710
0.312			3200	3880	3690	4830
0.375					4450	5790

[a] Yield values are less than 2/3 of the indicated ultimate values.

Table B 1.1.10.2 Allowable Ultimate and Yield Shear Strengths of Aluminum Jo-Bolts in Machine-Countersunk Joints in Clad 2024-T3 and Clad 7075-T6 Aluminum Alloys

	Shear strength, lb			
Type	FA-200		FA-260	
Sheet	Clad	Clad	Clad	Clad
Material	2024-T3	7075-T6	2024-T3	7075-T6
Ultimate strength				
Sheet thickness, in.:				
0.032	390	450		
0.040	420	500	620	740
0.050	500	590	790	940
0.063	640	750	1010	1170
0.071	790	880	1150	1310
0.080	1040	1060	1310	1480
0.090	1270	1270	1480	1650
0.100	1450	1450	1680	1850
0.125	1595	1595	2010	2250
0.160	1595	1595	2300	2650
0.190			2520	2790
0.250			[a]2790	

Table B 1.1.10.2 Allowable Ultimate and Yield Shear Strengths of Aluminum Jo-Bolts in Machine-Countersunk Joints in Clad 2024-T3 and Clad 7075-T6 Aluminum Alloys (Cont'd)

	Shear strength, lb			
Type	FA-200		FA-260	
Sheet	Clad	Clad	Clad	Clad
Material	2024-T3	7075-T6	2024-T3	7075-T6
Yield strength				
Sheet thickness, in.:				
0.032	380	390		
0.040	420	430	450	590
0.050	500	520	520	720
0.063	630	700	705	910
0.071	740	800	820	1020
0.080	860	915	940	1160
0.090	990	1040	1080	1300
0.100	1130	1180	1230	1460
0.125	1340	1420	1550	1790
0.160	1540	1590	1980	2240
0.190			2420	2700
0.250				

[a] Extrapolated value.

B 1.2.0 Welded Joints

Whenever possible, joints to be welded should be so designed that the welds will be loaded in shear.

B 1.2.1 Fusion Welding - Arc and Gas

In the design of welded joints, the strength of both the weld metal and the adjacent parent metal must be considered. The allowable strength for the adjacent parent metal is given in section B 1.2.2 and the allowable strength for the weld metal is given in section B 1.2.3. The weld-metal section will be analyzed on the basis of its loading, allowables, dimensions, and geometry.

B 1.2.2 Effect on Adjacent Parent Metal Due to Fusion Welding

For joints welded after heat treatment, the allowable stresses near the weld are given in Tables B 1.2.2.1 and B 1.2.2.2.

For materials heat treated after welding, the allowable stresses in the parent metal near a welded joint may equal the allowable stress for the material in the heat-treated condition as given in tables of design mechanical properties of the specific alloys.

Table B 1.2.2.1 Allowable Ultimate Tensile Stresses Near Fusion Welds in 4130, 4140, 4340, or 8630 Steels[a]

(Section thickness 1/4 inch or less)	
Type of joint	Ultimate tensile stress, ksi
Tapered joints of 30° or less[b]	90
All others	80

[a] Welded after heat treatment or normalized after weld.
[b] Gussets or plate inserts considered 0° taper with center line.

Table B 1.2.2.2 Allowable Bending Modulus of Rupture Near Fusion Welds in 4130, 4140, 4340, or 8630 Steels[a]

Type of joint	Bending modulus of rupture, ksi
Tapered joints of 30° or less[b]	F_b, figure B 1.2.2-1 for F_{tu} = 90 ksi
All others	0.9 of the values of F_b from figure B 1.2.2-1 for F_{tu} = 90 ksi

[a] Welded after heat treatment or normalized after weld.
[b] Gussets or plate inserts considered 0° taper with center line.

B 1.2.2 Effect on Adjacent Parent Metal Due to Fusion Welding (Cont'd)

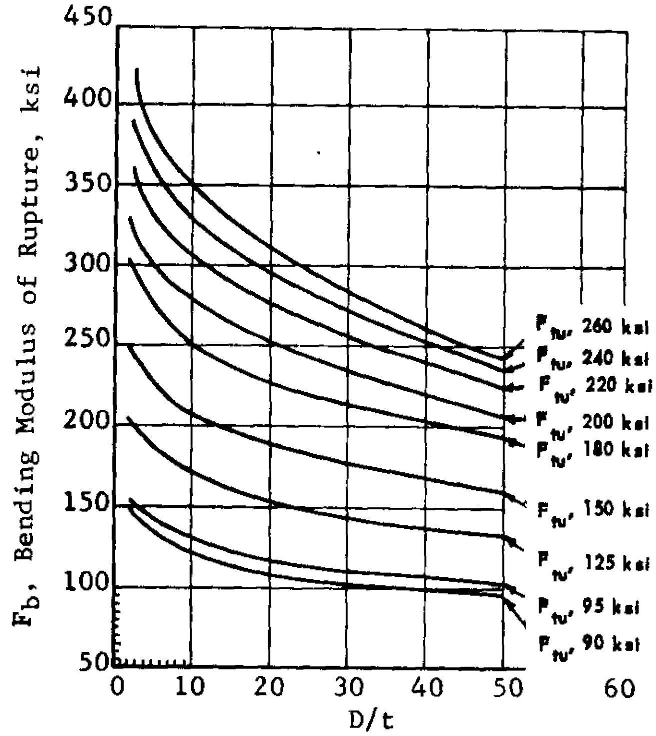


Fig. B 1.2.2-1 Bending Modulus of Rupture for Round Alloy-Steel Tubing.

B 1.2.3 Weld-Metal Allowable Strength

Allowable weld-metal strengths are shown in Table B 1.2.3.1. Design allowable stresses for the weld metal are based on 85 percent of the respective minimum tensile ultimate test values.

Table B 1.2.3.1 Strengths of Welded Joints

Material	Heat treatment subsequent to welding	Welding rod or electrode	F_{su}, ksi	F_{tu}, ksi
Carbon and alloy steels..	None	MIL-R-5632, class 1 MIL-E-15599, classes E-6010 and E-6013	32 32	51 51
Alloy steels	None	MIL-R-5632, class 2	43	72
Alloy steels	Stress relieved	MIL-E-6843, class 10013 MIL-E-18038, classes E-10015 and E-10016	50	85
Alloy steels	Stress relieved	MIL-E-18038, classes E-12015 and E-12016	60	100
Steels	Quench and temper ...			
4130 .... 4140 .... 4340	125 ksi .... 150 ksi .... 180 ksi	MIL-E-8697, classes HT-4130, HT-4140, and HT-4340	63 75 90	105 125 150

B 1.2.4 Welded Cluster

In a welded structure where seven or more members converge, the allowable stress shall be determined by dividing the normal allowable stress by a material factor of 1.5, unless the joint is reinforced. A tube that is continuous through a joint should be assumed as two members.

B 1.2.5 Flash Welding

The tensile ultimate allowable stresses and bending allowable modulus of rupture for flash welds are given in Tables B 1.2.5.1 and B 1.2.5.2.

Table B 1.2.5.1 Allowable Ultimate Tensile Stress for Flash Welds in Steel Tubing

Tubing	Allowable ultimate tensile stress of welds
Normalized tubing - not heat treated (including normalizing) after welding.	1.0 F_{tu} (based on F_{tu} of normalized tubing)
Heat-treated tubing welded after heat treatment.	1.0 F_{tu} (based on F_{tu} of normalized tubing)
Tubing heat treated (including normalizing) after welding. F_{tu} of unwelded material in heat-treated condition:	
$<$100 ksi	0.9 F_{tu}
100 to 150 ksi	0.6 F_{tu} + 30
$>$150 ksi	0.8 F_{tu}

B 1.2.5 Flash Welding (Cont'd)

Table B 1.2.5.2 Allowable Bending Modulus of Rupture for Flash Welds in Steel Tubing

Tubing	Allowable bending modulus of rupture of welds (F_b from Fig. B 1.2.2-1 using values of F_{tu} listed)
Normalized tubing-not heat treated (including normalizing) after welding.	1.0 F_{tu} for normalized tubing
Heat-treated tubing welded after heat treatment.	1.0 F_{tu} for normalized tubing
Tubing heat treated (including normalizing) after welding. F_{tu} of unwelded material in heat-treated condition:	
$<$100 ksi	0.9 F_{tu}
100 to 150 ksi	0.6 F_{tu} + 30
$>$150 ksi	0.8 F_{tu}

B 1.2.6 Spot Welding

Design shear strength allowables for spot welds in various alloys are given in Tables B 1.2.6.1, B 1.2.6.2, and B 1.2.6.3; the thickness ratio of the thickest sheet to the thinnest outer sheet in the combination should not exceed 4:1. Table B 1.2.6.4 gives the minimum allowable edge distance for spot welds, these values may be reduced for non-structural applications, or for applications not depended upon to develop full tabulated weld strength. Combinations of aluminum alloys suitable for spot welding are given in Table B 1.2.6.5.

B 1.2.6 Spot Welding (Cont'd)

Table B 1.2.6.1 Spot-Weld Maximum Design Shear Strengths for Uncoated Steels[a] and Nickel Alloys

Nominal thickness of thinner sheet, in.	Material ultimate tensile strength, lb		
	150 ksi and above	70 ksi to 150 ksi	Below 70 ksi
0.006	70	57	....
0.008	120	85	70
0.010	165	127	92
0.012	220	155	120
0.014	270	198	142
0.016	320	235	170
0.018	390	270	198
0.020	425	310	225
0.025	580	425	320
0.030	750	565	403
0.032	835	623	453
0.040	1,168	850	650
0.042	1,275	920	712
0.050	1,700	1,205	955
0.056	2,039	1,358	1,166
0.060	2,265	1,558	1,310
0.063	2,479	1,685	1,405
0.071	3,012	2,024	1,656
0.080	3,540	2,405	1,960
0.090	4,100	2,810	2,290
0.095	4,336	3,012	2,476
0.100	4,575	3,200	2,645
0.112	5,088	3,633	3,026
0.125	5,665	4,052	3,440

[a]Refers to plain carbon steels containing not more than 0.20 percent carbon and to austenitic steels. The reduction in strength of spot-welds due to the cumulative effects of time-temperature-stress factors is not greater than the reduction in strength of the parent metal.

B 1.2.6 Spot Welding (Cont'd)

Table B 1.2.6.2 Spot-Weld Maximum Design Shear Strength Standards for Bare and Clad Aluminum Alloys[a]

Nominal thickness of thinner sheet, in.	Material ultimate tensile strength, lb			
	Above 56 ksi	28 ksi to 56 ksi	20 ksi to 27.5 ksi	19.5 ksi and below
0.012	60	52	24	16
0.016	86	78	56	40
0.020	112	106	80	62
0.025	148	140	116	88
0.032	208	188	168	132
0.040	276	248	240	180
0.050	374	344	321	234
0.063	539	489	442	314
0.071	662	578	515	358
0.080	824	680	609	417
0.090	1,002	798	695	478
0.100	1,192	933	750	536
0.112	1,426	1,064	796	584
0.125	1,698	1,300	840	629
0.160	2,490			

[a]Spot welding of aluminum-alloy combinations conforming to QQ-A-277, QQ-A-355, and QQ-A-255 may be accomplished. The reduction in strength of spotwelds due to cumulative effects of time-temperature-stress factors is not greater than the reduction in strength of the parent metal.

B 1.2.6 Spot Welding (Cont'd)

Table B 1.2.6.3 Spot-Weld Maximum Design Shear Strength Standards for Magnesium Alloys[a]
Welding Specification MIL-W-6858

Nominal thickness of thinner sheet, in.	Design shear strength, lb
0.020	72
0.022	84
0.025	100
0.028	120
0.032	140
0.036	164
0.040	188
0.045	220
0.050	248
0.056	284
0.063	324
0.071	376
0.080	428
0.090	496
0.100	572
0.112	648
0.125	720

[a]Magnesium alloys AZ31B and HK31A may be spot welded in any combination.

B 1.2.6 Spot Welding (Cont'd)

Table B 1.2.6.4 Minimum Edge Distances for Spot-Welded Joints[ab]

Nominal thickness of thinner sheet, in.	Edge distance, E, in.
0.016	3/16
0.020	3/16
0.025	7/32
0.032	1/4
0.036	1/4
0.040	9/32
0.045	5/16
0.050	5/16
0.063	3/8
0.071	3/8
0.080	13/32
0.090	7/16
0.100	7/16
0.125	9/16
0.160	5/8

[a]Intermediate gages will conform to the requirement for the next thinner gage shown.
[b]For edge distances less than those specified above, appropriate reductions in the spot-weld allowable loads shall be made.

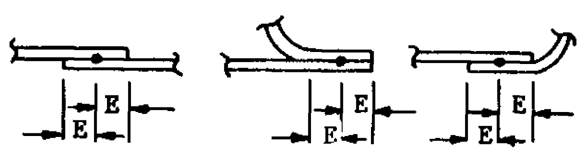


Fig. B 1.2.6-1 Edge Distances for Spot-Welded Joints.

Table B 1.2.6.5 Acceptable Aluminum and Aluminum-Alloy Combinations[a] for Spot Welding

Specification No.	Material	QQ-A-315 (5052)	QQ-A-318 (5052)	QQ-A-327 (6061)	QQ-A-354 (Bare 2024)	QQ-A-355 (Bare 2024)	QQ-A-359 (3003)	QQ-A-362 (Clad 2024)	QQ-A-411 (1100)	QQ-A-561 (1100)	QQ-A-287 (Clad 7075)[b]	QQ-A-277 (Bare 7075)	QQ-A-355 (Bare 2024)	QQ-A-362a (Clad 2024)	QQ-A-255 (Clad 2014)	QQ-A-261 and QQ-A-266 (Bare 2014)
QQ-A-315	(5052)															
QQ-A-318	(52S)(5052)															
QQ-A-327	(61S)(6061)															
QQ-A-354	(Bare 2024)				(*)	(*)						(*)	(*)		(*)	(*)
QQ-A-355	(Bare 2024)				(*)	(*)						(*)	(*)		(*)	(*)
QQ-A-359	(3003)															
QQ-A-362	(Clad 2024)															
QQ-A-411	(1100)															
QQ-A-561	(1100)															
QQ-A-287	(Clad 7075)[b]															
QQ-A-277	(Bare 7075)				(*)	(*)						(*)	(*)		(*)	(*)
QQ-A-355	(Bare 2024)				(*)	(*)						(*)	(*)		(*)	(*)
QQ-A-362a............	(Clad 2024)															
QQ-A-255	(Clad 2014)				(*)	(*)						(*)	(*)			(*)
QQ-A-261 and QQ-A-266	(Bare 2014)				(*)	(*)						(*)	(*)		(*)	(*)

[a]The various aluminum and aluminum-alloy materials referred to in this table may be spot welded in any combinations except the combinations indicated by the asterisk (*) in the table.

[b]Clad heat-treated and aged 7075 material in thicknesses less than 0.020 inch shall not be welded.

B 1.2.7 Reduction in Tensile Strength of Parent Metal Due to Spot Welding

In applications of spot welding where ribs, intercostals, or doublers are attached to sheet, either at splices or at other points on the sheet panels, the allowable ultimate strength of the spot-welded sheet shall be determined by multiplying the ultimate tensile sheet strength ("A" values where available) by the appropriate efficiency factor shown on Figures B 1.2.7-1 through B 1.2.7-4. The minimum values of the basic sheet efficiency in tension should not be considered applicable to cases of seam welds. Allowable ultimate tensile strengths for spot-welded sheet gages of less than 0.012 inch for steel and 0.020 inch for aluminum shall be established on the basis of tests.

B 1.2.7 Reduction in Tensile Strength of Parent Metal Due to Spot Welding (Cont'd)

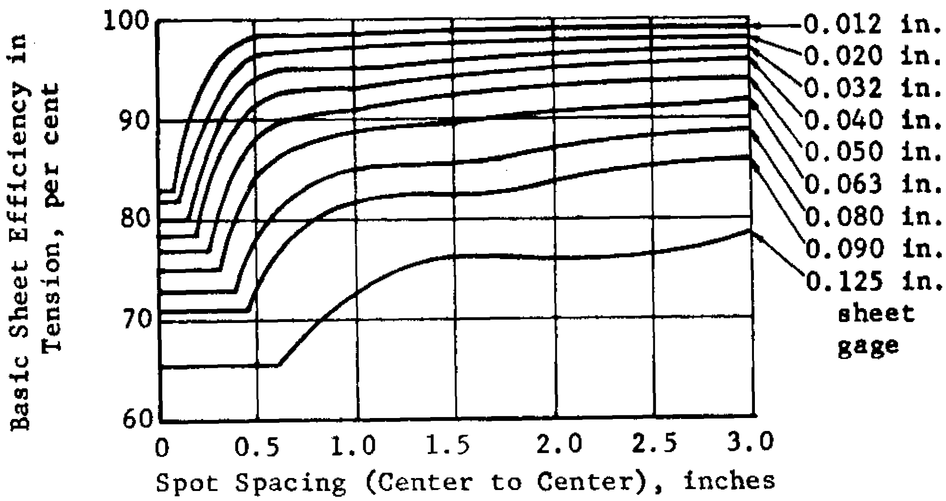


Fig. B 1.2.7-1 Efficiency of the Parent Metal in Tension for Spot-Welded 301-1/2 H Corrosion-Resistant Steel

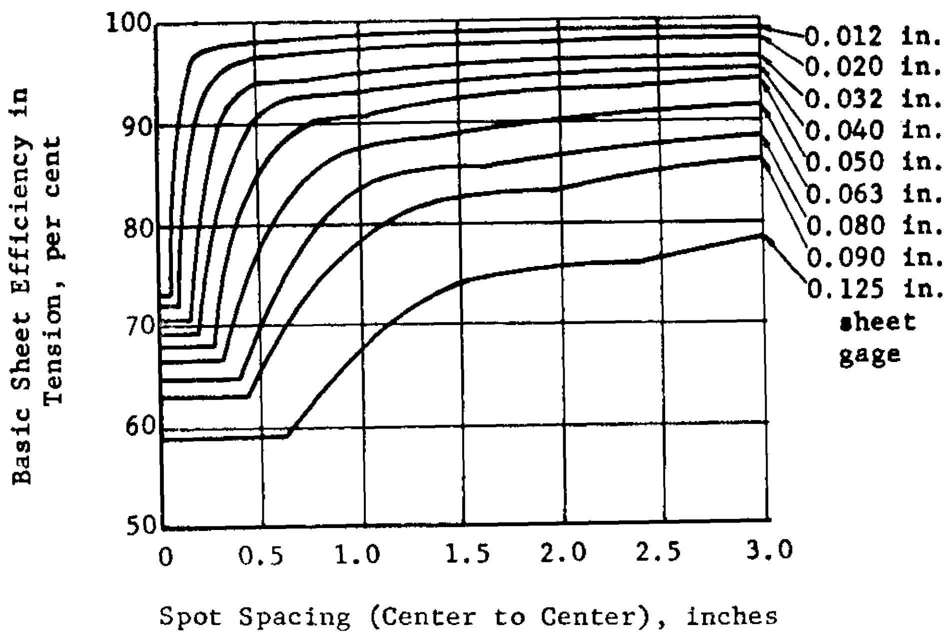


Fig. B 1.2.7-2 Efficiency of the Parent Metal in Tension for Spot-Welded 301-H Corrosion-Resistant Steel

B 1.2.7 Reduction in Tensile Strength of Parent Metal Due to Spot Welding (Cont'd)

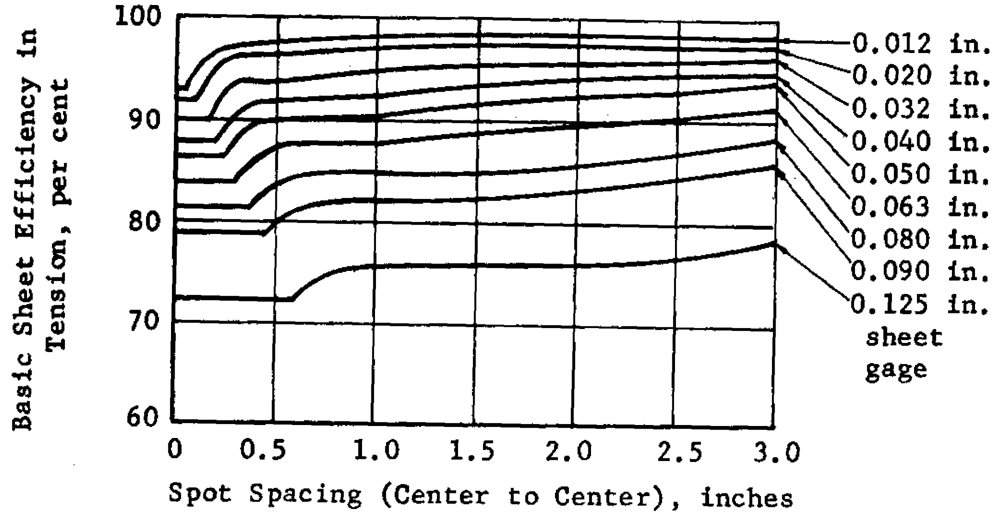


Fig. B 1.2.7-3 Efficiency of the Parent Metal in Tension for Spot-Welded 301-A, 347-A, and 301-1/4 H Corrosion-Resistant Steel

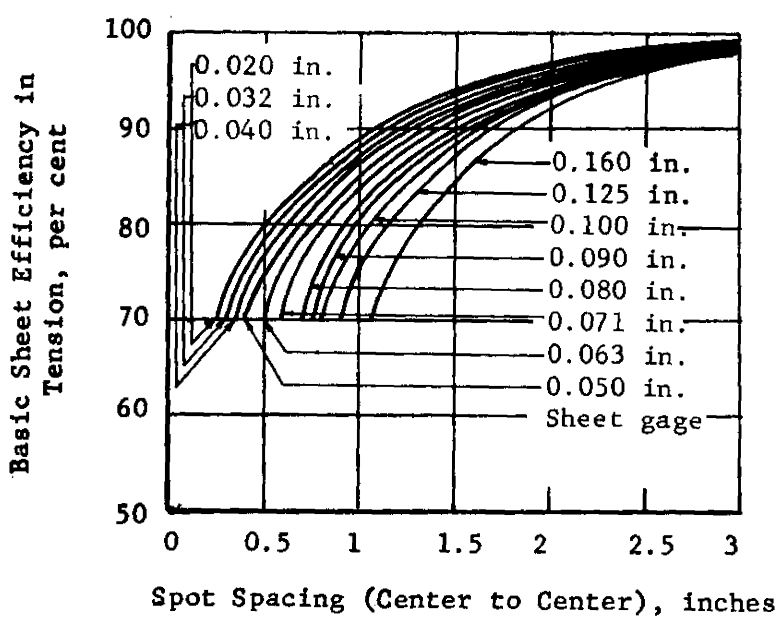


Fig. B 1.2.7-4 Efficiency of the Parent Metal in Tension for Spot-Welded Aluminum Alloys

B 1.3.0 Brazing

Insofar as discussed herein, brazing is applicable only to steel. Brazing is defined as a weld wherein coalescence is produced by heating to suitable temperatures above 800° F and by using a nonferrous filler metal having a melting point below that of the base metal. The filler metal is distributed through the joint by capillarity.

The effect of the brazing process upon the strength of the parent or base metal shall be considered in the structural design. Where copper furnace brazing or silver brazing is employed the calculated allowable strength of the base metal which is subjected to the temperatures of the brazing process shall be in accordance with the following:

Material	Allowable Strength
Heat-treated material (including normalized) used in "as-brazed" condition	Mechanical properties of normalized material
Heat-treated material (including normalized) reheat-treated during or after brazing	Mechanical properties corresponding to heat treatment performed

B 1.3.1 Copper Brazing

The allowable shear stress for design shall be 15 ksi, for all conditions of heat treatment.

B 1.3.2 Silver Brazing

The allowable shear stress for design shall be 15 ksi, provided that clearances or gaps between parts to be brazed do not exceed 0.010 inch. Silver-brazed areas should not be subjected to temperatures exceeding 900° F. Acceptable brazing alloys, with the exception of Class 3, are listed in Federal Specification QQ-S-561d.

Reference:

(1) MIL-HDBK-5, Strength of Metal Aircraft Elements, Armed Forces Supply Support Center, Washington 25, D.C., March 1959.