

TABLE A2
Materials and Allowable Stresses

ASTM Spec	Grade	Material Composition	Condition	Minimum Tensile (KSI)	Minimum Yield (KSI)	Maximum Allowable Stress in Tension (ksi) for Metal Temperatures Not Exceeding Degrees F												
						-20 to 450	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
STRUCTURAL STEEL																		
A36	-	Carbon Steel	HR	58	36	16.6	16.6	15.6	13.0	-	-	-	-	-	-	-	-	-
(a) A500	B	Carbon Steel	CF	58	46	16.6	16.6	15.6	13.0	-	-	-	-	-	-	-	-	-
(a) A500	C	Carbon Steel	CF	62	50	17.1	15.8	15.3	13.0	-	-	-	-	-	-	-	-	-
(a) A501	-	Carbon Steel	HR	58	36	16.6	16.6	15.6	13.0	-	-	-	-	-	-	-	-	-
A572	50	Low Alloy	-	65	50	18.6	18.6	18.6	-	-	-	-	-	-	-	-	-	-
A992	-	Carbon Steel	-	65	50	18.6	18.6	18.6	-	-	-	-	-	-	-	-	-	-
RODS & BARS																		
A36	-	Carbon Steel	HR	58	36	16.6	16.6	15.6	13.0	-	-	-	-	-	-	-	-	-
(a) A108	1018	Carbon Steel	CF	60	40	17.1	17.1	-	-	-	-	-	-	-	-	-	-	-
(a) A108	1141	Carbon Steel	CF	90	80	23.1	23.1	-	-	-	-	-	-	-	-	-	-	-
(a) A108	12L14	Carbon Steel	CF	78	60	20.0	20.0	-	-	-	-	-	-	-	-	-	-	-
A276	304	18 CR - 8 Ni	-	75	30	13.3	12	11.7	11.5	11.2	11	10.8	10.6	10.4	-	-	-	-
A276	316	16 CR - 12 Ni - 2 Mo	-	75	30	13.8	12.3	12.1	11.9	11.7	11.6	11.5	11.4	11.3	-	-	-	-
A276	321	18 CR - 10 Ni - Ti	-	75	30	14.8	13.2	13	12.7	12.6	12.4	12.3	12.1	12	-	-	-	-
A276	347	18 CR - 10 Ni - Cb	-	75	30	15.5	14	13.8	13.7	13.6	13.5	13.4	13.4	13.4	-	-	-	-
A322	4130	1 CR - 1/5 Mo	A	81	52	20.8	20.8	-	-	-	-	-	-	-	-	-	-	-
A322	4140	1 CR - 1/5 Mo	A	95	70	24.4	24.4	-	-	-	-	-	-	-	-	-	-	-
A331	41L40	1 CR - 1/5 Mo	A	95	70	24.4	24.4	-	-	-	-	-	-	-	-	-	-	-
(b) A479	304	18 CR - 8 Ni	-	75	30	13.3	12	11.7	11.5	11.2	11	10.8	10.6	10.4	10.1	9.8	7.7	6.1
(b) A479	316	16 CR - 12 Ni - 2 Mo	-	75	30	13.8	12.3	12.1	11.9	11.7	11.6	11.5	11.4	11.3	11.2	11	9.8	7.4
(b) A479	321	18 CR - 10 Ni - Ti	-	75	30	14.8	13.2	13	12.7	12.6	12.4	12.3	12.1	12	9.6	6.9	5	3.6
(b) A479	347	18 CR - 10 Ni - Cb	-	75	30	15.5	14	13.8	13.7	13.6	13.5	13.4	13.4	13.4	12.1	9.1	6.1	4.4
(f) A564	630	17-4PH	AH	145	125	34.8	33.7	-	-	-	-	-	-	-	-	-	-	-
(a) A575	M1010	Carbon Steel	HR	47	26	12.1	12.1	-	-	-	-	-	-	-	-	-	-	-
(a) A575	M1015	Carbon Steel	HR	50	27	12.9	12.9	-	-	-	-	-	-	-	-	-	-	-
(a) A575	M1020	Carbon Steel	HR	55	30	14.1	14.1	-	-	-	-	-	-	-	-	-	-	-
(a) A575	M1025	Carbon Steel	HR	58	32	14.9	14.9	-	-	-	-	-	-	-	-	-	-	-
(a) A576	1010	Carbon Steel	HR	47	26	12.1	12.1	-	-	-	-	-	-	-	-	-	-	-
(a) A576	1015	Carbon Steel	HR	50	25	13.9	12.4	-	-	-	-	-	-	-	-	-	-	-
(a) A576	1020	Carbon Steel	HR	55	27.5	15.3	13.6	-	-	-	-	-	-	-	-	-	-	-
(a) A576	1025	Carbon Steel	HR	60	30	16.7	14.8	-	-	-	-	-	-	-	-	-	-	-
A675	60	Carbon Steel	HR	60	30	16.7	14.8	14.3	13.0	-	-	-	-	-	-	-	-	-
A675	65	Carbon Steel	HR	65	32.5	18.1	16.1	15.5	13.9	-	-	-	-	-	-	-	-	-
A675	70	Carbon Steel	HR	70	35	19.4	17.3	16.7	14.8	-	-	-	-	-	-	-	-	-

Conditions: A = Annealed, AH = Age Hardened, CF = Cold Finished, DNT = Double Normalized and Tempered, HR = Hot Rolled, HT = Heat Treated, QT = Quenched and Tempered, N = Normalized, NT = Normalized and Tempered

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TABLE A2
Materials and Allowable Stresses (continued)

ASTM Spec	Grade	Material Composition	Condition	Minimum Tensile (KSI)	Minimum Yield (KSI)	Maximum Allowable Stress in Tension (ksi) for Metal Temperatures Not Exceeding Degrees F												
						-20 to 450	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
						PLATE												
A36	-	Carbon Steel	HR	58	36	16.6	16.6	15.6	13.0									
(b,c) A240	304	18 CR - 8 Ni	-	75	30	13.3	12.0	11.7	11.5	11.2	11.0	10.8	10.6	10.4	10.1	9.8	7.7	6.1
(b,c) A240	316	16 CR - 12 Ni - 2 Mo	-	75	30	13.8	12.3	12.1	11.9	11.7	11.6	11.5	11.4	11.3	11.2	11.0	9.8	7.4
(b,c) A240	321	18 CR - 10 Ni - Ti	-	75	30	14.8	13.2	13.0	12.7	12.6	12.4	12.3	12.1	12.0	9.6	6.9	5.0	3.6
(b,c) A240	347	18 CR - 10 Ni - Cb	-	75	30	15.5	14.0	13.8	13.7	13.6	13.5	13.4	13.4	13.4	12.1	9.1	6.1	4.4
A285	A	Carbon Steel	HR	45	24	12.9	11.9	11.5	10.7	-	-	-	-	-	-	-	-	-
A285	B	Carbon Steel	HR	50	27	14.3	13.3	12.5	11.2	-	-	-	-	-	-	-	-	-
A285	C	Carbon Steel	HR	55	30	15.7	14.8	14.3	13.0	-	-	-	-	-	-	-	-	-
(g) A387	22	2 1/4 CR - 1 Mo	-	60	30	16.6	16.6	16.6	16.6	16.6	16.6	13.6	10.8	8.0	5.7	3.8	2.4	1.4
(n) A387	91	9 CR - 1 Mo - V	-	85	60	24.1	23.4	22.9	22.2	21.3	20.3	19.1	17.8	16.3	14.0	10.3	7.0	4.3
(o) A387	91	9 CR - 1 Mo - V	-	85	60	24.1	23.4	22.9	22.2	21.3	20.3	19.1	17.8	16.3	12.9	9.6	7.0	4.3
A514	t ≤ 2.5in	Alloy Steel	QT	110	100	31.4	31.3	30.7	-	-	-	-	-	-	-	-	-	-
A514	t > 2.5in	Alloy Steel	QT	100	90	28.5	28.4	28.0	-	-	-	-	-	-	-	-	-	-
A515	60	Carbon Steel	HR	60	32	17.1	15.8	15.3	13.0	-	-	-	-	-	-	-	-	-
A515	65	Carbon Steel	HR	65	35	18.6	17.3	16.7	13.9	-	-	-	-	-	-	-	-	-
A515	70	Carbon Steel	HR	70	38	20.0	18.8	18.1	14.8	-	-	-	-	-	-	-	-	-
A516	60	Carbon Steel	HR	60	32	17.1	15.8	15.3	13.0	-	-	-	-	-	-	-	-	-
A516	65	Carbon Steel	HR	65	35	18.6	17.3	16.7	13.9	-	-	-	-	-	-	-	-	-
A516	70	Carbon Steel	HR	70	38	20.0	18.8	18.1	14.8	-	-	-	-	-	-	-	-	-
A517	t ≤ 2.5in	Alloy Steel	QT	115	100	32.8	32.7	32.2	-	-	-	-	-	-	-	-	-	-
A517	t > 2.5in	Alloy Steel	QT	105	90	30.0	29.9	29.3	-	-	-	-	-	-	-	-	-	-
SHEET & STRIP																		
A109	#4	Carbon Steel	CF	48	--	12.3	12.3											
(b,c) A240	304	18 CR - 8 Ni	-	75	30	13.3	12	11.7	11.5	11.2	11	10.8	10.6	10.4	10.1	9.8	7.7	6.1
(b,c) A240	316	16 CR - 12 Ni - 2 Mo	-	75	30	13.8	12.3	12.1	11.9	11.7	11.6	11.5	11.4	11.3	11.2	11	9.8	7.4
(b,c) A240	321	18 CR - 10 Ni - Ti	-	75	30	14.8	13.2	13	12.7	12.6	12.4	12.3	12.1	12	9.6	6.9	5	3.6
(b,c) A240	347	18 CR - 10 Ni - Cb	-	75	30	15.5	14	13.8	13.7	13.6	13.5	13.4	13.4	13.4	12.1	9.1	6.1	4.4
(a) A446	A	Carbon Steel	HR	45	24	12.9	11.9	-	-	-	-	-	-	-	-	-	-	-
(a) A526	-	Carbon Steel	HR	45	24	12.9	11.9	-	-	-	-	-	-	-	-	-	-	-
(a) A569	(superseded by A1011 CS)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(a) A570	(superseded by A1011 SS)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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ASTM Spec	Grade	Material Composition	Condition	Minimum Tensile (KSI)	Minimum Yield (KSI)	Maximum Allowable Stress in Tension (ksi) for Metal Temperatures Not Exceeding Degrees F												
						-20 to 450	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
SHEET & STRIP																		
(a) A635	1010	Carbon Steel	HR	47	26	12.1	12.1	-	-	-	-	-	-	-	-	-	-	-
A653 SS	33	Pregalv. Steel	-	45	33	12.9	12.9	-	-	-	-	-	-	-	-	-	-	-
(a,e) A653 CS	-	Pregalv. Steel	-	-	30	11.7	11.7	-	-	-	-	-	-	-	-	-	-	-
(a) A659	1020	Carbon Steel	HR	50	27	14.3	13.3	-	-	-	-	-	-	-	-	-	-	-
(f) A693	630	17-4PH	AH	145	125	39.8	38.5	-	-	-	-	-	-	-	-	-	-	-
(a) A1011 SS	33	Carbon Steel	HR	52	33	14.9	14.9	-	-	-	-	-	-	-	-	-	-	-
(a) A1011 SS	40	Carbon Steel	HR	55	40	15.7	15.7	-	-	-	-	-	-	-	-	-	-	-
(a) A1011 CS	-	Carbon Steel	HR	-	30	13.5	13.5	-	-	-	-	-	-	-	-	-	-	-
PIPE & TUBING																		
A53	A	Carbon Steel	HR	48	30	13.7	13.7	12.5	10.7	-	-	-	-	-	-	-	-	-
A53	B	Carbon Steel	HR	60	35	17.1	17.1	15.6	13.0	-	-	-	-	-	-	-	-	-
A106	A	Carbon Steel	HR	48	30	13.7	13.7	12.5	10.7	-	-	-	-	-	-	-	-	-
A106	B	Carbon Steel	HR	60	35	17.1	17.1	15.6	13.0	-	-	-	-	-	-	-	-	-
A106	C	Carbon Steel	HR	70	40	20.0	19.8	18.3	14.8	-	-	-	-	-	-	-	-	-
(b) A312	304	18 CR - 8 Ni	-	75	30	11.3	10.2	10	9.8	9.6	9.4	9.2	9	8.8	8.6	8.3	6.6	5.2
(b) A312	316	16 CR - 12 Ni - 2 Mo	-	75	30	11.7	10.5	10.3	10.1	10	9.9	9.8	9.7	9.6	9.5	9.4	8.3	6.3
(b) A312	321	18 CR - 10 Ni - Ti	-	75	30	12.6	11.2	11	10.8	10.7	10.5	10.4	10.3	10.2	8.2	5.9	4.3	3.1
(b) A312	347	18 CR - 10 Ni - Cb	-	75	30	13.2	11.9	11.8	11.6	11.5	11.5	11.4	11.4	11.4	10.3	7.8	5.2	3.8
A335	P11	1 1/4 CR - 1/2 Mo	HR	60	30	16.5	15.4	15.1	14.8	14.4	14.0	13.6	9.3	6.3	4.2	2.8	1.9	1.2
A335	P22	2 1/4 CR - 1 Mo	HR	60	30	16.6	16.6	16.6	16.6	16.6	16.6	13.6	10.8	8.0	5.7	3.8	2.4	1.4
A335	P91	9 CR - 1 Mo - V	-	85	60	24.1	23.4	22.9	22.2	21.3	20.3	19.1	17.8	16.3	14.0	10.3	7.0	4.3
A513	1015	Carbon Steel	HR	50	32	14.3	14.3	-	-	-	-	-	-	-	-	-	-	-
A513	1020	Carbon Steel	HR	50	32	14.3	14.3	-	-	-	-	-	-	-	-	-	-	-
A513	1025	Carbon Steel	HR	55	35	15.7	15.7	-	-	-	-	-	-	-	-	-	-	-
A519	1018	Carbon Steel	HR	50	32	14.3	14.3	-	-	-	-	-	-	-	-	-	-	-

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						-20 to 450	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
CASTINGS																		
A47	32510	Malleable Iron	A	50	32.5	11.4	—	—	—	—	—	—	—	—	—	—	—	—
A47	35018	Malleable Iron	A	53	35	12.1	—	—	—	—	—	—	—	—	—	—	—	—
A48	20	Gray Iron	—	20	—	2	(limited to 400 °F)											
A48	25	Gray Iron	—	25	—	2.5	(limited to 400 °F)											
A48	30	Gray Iron	—	30	—	3	(limited to 400 °F)											
A126	A	Gray Iron	—	21	—	2	(limited to 400 °F)											
A126	B	Gray Iron	—	31	—	3	(limited to 400 °F)											
A126	C	Gray Iron	—	41	—	4	(limited to 400 °F)											
A197	—	Malleable Iron	A	40	30	9.1	—	—	—	—	—	—	—	—	—	—	—	—
A216	WCA	Carbon Steel	N	60	30	16.7	14.8	14.3	—	—	—	—	—	—	—	—	—	—
A216	WCB	Carbon Steel	N	70	36	19.8	17.8	17.2	—	—	—	—	—	—	—	—	—	—
A217	WC6	1 1/4 CR - 1/2 Mo	NT	70	40	20	20	20	—	—	—	—	—	—	—	—	—	—
A217	WC9	2 1/4 CR - 1 Mo	NT	70	40	19.3	19.1	18.8	—	—	—	—	—	—	—	—	—	—
A351	CF8	18 CR - 8 Ni	—	70	30	10.64	9.6	9.36	9.2	8.96	—	—	—	—	—	—	—	—
A351	CF8C	18 CR - 10 Ni - Cb	—	70	30	12.4	11.2	11.04	10.96	10.88	—	—	—	—	—	—	—	—
A351	CF8M	16 CR - 12 Ni - 2 Mo	—	70	30	10.96	9.84	9.68	9.52	9.36	—	—	—	—	—	—	—	—
A395	—	Ductile Iron	—	60	40	13.7	13.7	—	—	—	—	—	—	—	—	—	—	—
A536	65-45-12	Ductile Iron	—	65	45	14.9	14.9	—	—	—	—	—	—	—	—	—	—	—
B86	AC43A (ZA2)	ZnAl4Cu3	Aged	48	41	9.6	(limited to 230°F)											
B86	AG40A (ZA3)	ZnAl4	Aged	34.9	32	6.98	(limited to 230°F)											
B86	AC41A (ZA5)	ZnAl4Cu1	Aged	39	32	7.8	(limited to 230°F)											
B86	(ZA8)	ZnAl8Cu1	Aged	43	32.6	8.6	(limited to 230°F)											

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						-20 to 450	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	
FORGINGS																			
A105	-	Carbon Steel	HT	70	36	19.8	17.8	17.2	-	-	-	-	-	-	-	-	-	-	
A181	70	Carbon Steel	-	70	36	19.8	17.8	17.2	-	-	-	-	-	-	-	-	-	-	
A182	F11	1 1/4 CR - 1/2 Mo - Si	A	70	40	20.0	20.0	20.0	19.7	19.2	18.7	13.7	9.3	6.3	4.2	2.8	1.9	1.2	
A182	F22	2 1/4 CR - 1 Mo	A	75	45	20.5	20.2	20.0	19.7	19.3	18.7	15.8	11.4	7.8	5.1	3.2	2.0	1.2	
(b) A182	F304	18 CR - 8 Ni	HT	75	30	13.3	12.0	11.7	11.5	11.2	11.0	10.8	10.6	10.4	10.1	9.8	7.7	6.1	
(b) A182	F316	16 CR - 12 Ni - 2 Mo	HT	75	30	13.8	12.3	12.1	11.9	11.8	11.6	11.5	11.4	11.3	11.2	11.0	9.8	7.4	
(b) A182	F321	18 CR - 10 Ni - Ti	HT	75	30	14.8	13.2	13.0	12.7	12.6	12.4	12.3	12.1	12.0	9.6	6.9	5.0	3.6	
(b) A182	F347	18 CR - 10 Ni - Cb	HT	75	30	15.5	14.0	13.8	13.7	13.6	13.5	13.4	13.4	13.4	12.1	9.1	6.1	4.4	
A668	A	Carbon Steel	-	47	-	13.4	13.4	-	-	-	-	-	-	-	-	-	-	-	
A668	B	Carbon Steel	A	60	30	17.1	17.1	-	-	-	-	-	-	-	-	-	-	-	
A668	C	Carbon Steel	A	66	33	18.8	18.8	-	-	-	-	-	-	-	-	-	-	-	
A668	D	Carbon Steel	N	75	37.5	21.4	21.4	-	-	-	-	-	-	-	-	-	-	-	
A668	E	Carbon Steel	DNT	83	43	23.7	23.7	-	-	-	-	-	-	-	-	-	-	-	
(p) A668	F	Carbon Steel	QT	90	55	25.7	25.7	-	-	-	-	-	-	-	-	-	-	-	
BOLTING																			
(j) A193	B7	1 CR - 1/5 Mo	HT	125	105	25	25	25	23.6	21	17	12.5	8.5	4.5	-	-	-	-	
(k) A193	B7	1 CR - 1/5 Mo	HT	115	95	23	23	23	22.5	20	16.3	12.5	8.5	4.5	-	-	-	-	
(l) A193	B7	1 CR - 1/5 Mo	HT	100	75	18.8	18.8	18.8	18.8	18	16.3	12.5	8.5	4.5	-	-	-	-	
(b,c,d) A193	B8	18 CR - 8 Ni	-	75	30	13.3	12	11.8	11.5	11.2	11	10.8	10.6	10.4	10.1	9.8	7.7	6	
(b,c,d) A193	B8M	16 CR - 12 Ni - 2 Mo	-	75	30	13.8	12.3	12.1	11.9	11.7	11.6	11.5	11.4	11.3	11.2	11	9.8	7.4	
(b,c,d) A193	B8C	18 CR - 10 Ni - Cb	-	75	30	15.2	14.1	13.8	13.7	13.6	13.5	13.5	13.4	13.4	12.1	9.1	6.1	4.4	
(b,c,d) A193	B8T	18 CR - 10 Ni - Ti	-	75	30	14.8	13.3	12.9	12.7	12.5	12.4	12.3	12.1	12	9.6	6.9	5	3.6	
A307	A	Carbon Steel	-	60	-	17.1	17.1	-	-	-	-	-	-	-	-	-	-	-	
A307	B	Carbon Steel	-	60	-	17.1	17.1	-	-	-	-	-	-	-	-	-	-	-	
(h) A325	TYPE 2	Carbon Steel	HT	120	-	34.3	34.3	-	-	-	-	-	-	-	-	-	-	-	
(i) A325	TYPE 2	Carbon Steel	HT	105	-	30.0	30.0	-	-	-	-	-	-	-	-	-	-	-	
(h) A449	-	Carbon Steel	QT	120	-	26.2	26.2	-	-	-	-	-	-	-	-	-	-	-	
(i) A449	-	Carbon Steel	QT	105	-	22.8	22.8	-	-	-	-	-	-	-	-	-	-	-	
(m) A449	-	Carbon Steel	QT	90	-	16.5	16.5	-	-	-	-	-	-	-	-	-	-	-	
A490	-	Alloy Steel	QT	150	130	42.9	42.9	-	-	-	-	-	-	-	-	-	-	-	
RIVETS & NUTS																			
A194	ALL	-	-	Product Specification		-	-	-	-	-	-	-	-	-	-	-	-	-	
A502	-	Carbon Steel	-	52	28	14.9	14.9	-	-	-	-	-	-	-	-	-	-	-	
A563	ALL	Carbon Steel	-	Product Specification		-	-	-	-	-	-	-	-	-	-	-	-	-	
SPRINGS See Figures 1 and 2 for Materials and Stresses																			

Conditions: A=Annealed, AH=Age Hardened, CF=Cold Finished, DNT=Double Normalized and Tempered, HR=Hot Rolled, HT=Heat Treated, QT=Quenched and Tempered, N=Normalized, NT=Normalized and Tempered

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TABLE A2
Materials and Allowable Stresses (continued)

NOTES:

- (a) Allowable stresses for these materials are based upon those of comparable materials of similar chemical properties.
- (b) For temperatures above 1000 °F, these stress values apply only when the carbon content is 0.04% or higher based on heat analysis.
- (c) For temperatures above 1000 °F, these stress values may be used only if the material is heat treated by treating it to a minimum temperature of 1900 °F and quenching in water or rapidly cooling by other means.
- (d) Derived from Class 1.
- (e) Derived from Type B.
- (f) Age hardened at 1075 °F.
- (g) For temperatures above 850 °F, these stress values apply only when the carbon content is 0.05% or higher based on heat analysis.
- (h) For bolt diameters 1 in. and less.
- (i) For bolt diameters greater than 1 in. through 1 ½ in.
- (j) For bolt diameters 2 ½ in. and less.
- (k) For bolt diameters greater than 2 ½ in. through 4 in.
- (l) For diameters greater than 4 in.
- (m) For bolt diameters greater than 1 ½ in. through 3 in.
- (n) For material thickness 3 in. and less.
- (o) For material thickness greater than 3 in.
- (p) For sizes 4 in. and less.

TABLE A2M
Materials and Allowable Stresses SI (Metric) Units

ASTM Spec	Grade	Material Composition	Condition	Minimum Tensile (MPa)	Minimum Yield (MPa)	Maximum Allowable Stress in Tension (MPa) for Metal Temperatures Not Exceeding Degrees C												
						-29 to 232	343	371	399	427	454	482	510	538	566	593	621	649
PLATE																		
A36	—	Carbon Steel	HR	400	248	114.5	114.5	107.6	89.6									
(b,c) A240	304	18 CR - 8 Ni	—	517	207	91.7	82.7	80.7	79.3	77.2	75.8	74.5	73.1	71.7	69.6	67.6		
(b,c) A240	316	16 CR - 12 Ni - 2 Mo	—	517	207	95.1	84.8	83.4	82.0	80.7	80.0	79.3	78.6	77.9	77.2	75.8		
(b,c) A240	321	18 CR - 10 Ni - Ti	—	517	207	102.0	91.0	89.6	87.6	86.9	85.5	84.8	83.4	82.7	82.0	80.7		
(b,c) A240	347	18 CR - 10 Ni - Cb	—	517	207	106.9	96.5	95.1	94.5	93.8	93.1	92.4	92.4	92.4	92.4	92.4		
A285	A	Carbon Steel	HR	310	165	88.9	82.0	79.3	73.8	—	—	—	—	—	—	—		
A285	B	Carbon Steel	HR	345	186	98.6	91.7	86.2	77.2	—	—	—	—	—	—	—		
A285	C	Carbon Steel	HR	379	207	108.2	102.0	98.6	89.6	—	—	—	—	—	—	—		
(g) A387	22	2¼ CR - 1 Mo	—	414	207	114.5	114.5	114.5	114.5	114.5	114.5	93.8	74.5	55.2	39.3	26.2		
(n) A387	91	9 CR - 1 Mo - V	—	586	414	166.2	161.3	157.9	153.1	146.9	140.0	131.7	122.7	112.4	96.5	71.0		
(o) A387	91	9 CR - 1 Mo - V	—	586	414	166.2	161.3	157.9	153.1	146.9	140.0	131.7	122.7	112.4	88.9	66.2		
A514	t ≤ 6.35cm	Alloy Steel	QT	758	689	216.5	215.8	211.7	—	—	—	—	—	—	—	—		
A514	t > 6.35cm	Alloy Steel	QT	689	621	196.5	195.8	193.1	—	—	—	—	—	—	—	—		
A515	60	Carbon Steel	HR	414	221	117.9	108.9	105.5	89.6	—	—	—	—	—	—	—		
A515	65	Carbon Steel	HR	448	241	128.2	119.3	115.1	95.8	—	—	—	—	—	—	—		
A515	70	Carbon Steel	HR	483	262	137.9	129.6	124.8	102.0	—	—	—	—	—	—	—		
A516	60	Carbon Steel	HR	414	221	117.9	108.9	105.5	89.6	—	—	—	—	—	—	—		
A516	65	Carbon Steel	HR	448	241	128.2	119.3	115.1	95.8	—	—	—	—	—	—	—		
A516	70	Carbon Steel	HR	483	262	137.9	129.6	124.8	102.0	—	—	—	—	—	—	—		
A517	t ≤ 6.35cm	Alloy Steel	QT	793	689	226.1	225.5	222.0	—	—	—	—	—	—	—	—		
A517	t > 6.35cm	Alloy Steel	QT	724	621	206.8	206.2	202.0	—	—	—	—	—	—	—	—		
SHEET & STRIP																		
A109	#4	Carbon Steel	CF	331	—	84.8	84.8	—	—	—	—	—	—	—	—	—		
(b,c) A240	304	18 CR - 8 Ni	—	517	207	91.7	82.7	80.7	79.3	77.2	75.8	74.5	73.1	71.7	69.6	67.6		
(b,c) A240	316	16 CR - 12 Ni - 2 Mo	—	517	207	95.1	84.8	83.4	82.0	80.7	80.0	79.3	78.6	77.9	77.2	75.8		
(b,c) A240	321	18 CR - 10 Ni - Ti	—	517	207	102.0	91.0	89.6	87.6	86.9	85.5	84.8	83.4	82.7	82.0	80.7		
(b,c) A240	347	18 CR - 10 Ni - Cb	—	517	207	106.9	96.5	95.1	94.5	93.8	93.1	92.4	92.4	92.4	92.4	92.4		
(a) A446	A	Carbon Steel	HR	310	165	88.9	82.0	—	—	—	—	—	—	—	—	—		
(a) A526	—	Carbon Steel	HR	310	165	88.9	82.0	—	—	—	—	—	—	—	—	—		
(a) A569	(superseded by A1011 CS)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
(a) A570	(superseded by A1011 SS)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—		

Conditions: A=Annealed, AH=Age Hardened, CF=Cold Finished, DNT=Double Normalized and Tempered, HR=Hot Rolled, HT=Heat Treated, QT=Quenched and Tempered,

N=Normalized, NT=Normalized and Tempered

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TABLE A2M
Materials and Allowable Stresses SI (Metric) Units (continued)

ASTM Spec	Grade	Material Composition	Condition	Minimum Tensile (MPa)	Minimum Yield (MPa)	Maximum Allowable Stress in Tension (MPa) for Metal Temperatures Not Exceeding Degrees C										
						-29 to 232	343	371	399	427	454	482	510	538	566	593
SHEET & STRIP Cont'd																
(a) A635	1010	Carbon Steel	HR	324	179	83.4	83.4	—	—	—	—	—	—	—	—	—
A653 SS	33	Pregalv. Steel	—	310	228	88.9	88.9	—	—	—	—	—	—	—	—	—
(a,e) A653 CS	—	Pregalv. Steel	—	—	207	80.7	80.7	—	—	—	—	—	—	—	—	—
(a) A659	1020	Carbon Steel	HR	345	186	98.6	91.7	—	—	—	—	—	—	—	—	—
(f) A693	630	17-4PH	AH	1000	862	274.4	265.4	—	—	—	—	—	—	—	—	—
(a) A1011 SS	33	Carbon Steel	HR	359	228	102.7	102.7	—	—	—	—	—	—	—	—	—
(a) A1011 SS	40	Carbon Steel	HR	379	276	108.2	108.2	—	—	—	—	—	—	—	—	—
(a) A1011 CS	—	Carbon Steel	HR	—	207	93.1	93.1	—	—	—	—	—	—	—	—	—
PIPE & TUBING																
A53	A	Carbon Steel	HR	331	207	94.5	94.5	86.2	73.8	—	—	—	—	—	—	—
A53	B	Carbon Steel	HR	414	241	117.9	117.9	107.6	89.6	—	—	—	—	—	—	—
A106	A	Carbon Steel	HR	331	207	94.5	94.5	86.2	73.8	—	—	—	—	—	—	—
A106	B	Carbon Steel	HR	414	241	117.9	117.9	107.6	89.6	—	—	—	—	—	—	—
A106	C	Carbon Steel	HR	483	276	137.9	136.5	126.2	102.0	—	—	—	—	—	—	—
(b) A312	304	18 CR - 8 Ni	-	517	207	77.9	70.3	68.9	67.6	66.2	64.8	63.4	62.1	60.7	59.3	35.9
(b) A312	316	16 CR - 12 Ni - 2 Mo	-	517	207	80.7	72.4	71.0	69.6	68.9	68.3	67.6	66.9	66.2	65.5	43.4
(b) A312	321	18 CR - 10 Ni - Ti	-	517	207	86.9	77.2	75.8	74.5	73.8	72.4	71.7	71.0	70.3	56.5	21.4
(b) A312	347	18 CR - 10 Ni - Cb	-	517	207	91.0	82.0	81.4	80.0	79.3	79.3	78.6	78.6	78.6	71.0	26.2
A335	P11	1¼ CR - 1/2 Mo	HR	414	207	113.8	106.2	104.1	102.0	99.3	96.5	93.8	64.1	43.4	29.0	8.3
A335	P22	2¼ CR - 1 Mo	HR	414	207	114.5	114.5	114.5	114.5	114.5	114.5	93.8	74.5	55.2	39.3	9.7
A335	P91	9 CR - 1 Mo - V	-	586	414	166.2	161.3	157.9	153.1	146.9	140.0	131.7	122.7	112.4	96.5	29.6
A513	1015	Carbon Steel	HR	345	221	98.6	98.6	—	—	—	—	—	—	—	—	—
A513	1020	Carbon Steel	HR	345	221	98.6	98.6	—	—	—	—	—	—	—	—	—
A513	1025	Carbon Steel	HR	379	241	108.2	108.2	—	—	—	—	—	—	—	—	—
A519	1018	Carbon Steel	HR	345	221	98.6	98.6	—	—	—	—	—	—	—	—	—

Conditions: A=Annealed, AH=Age Hardened, CF=Cold Finished, DNT=Double Normalized and Tempered, HR=Hot Rolled, HT=Heat Treated, QT=Quenched and Tempered, N=Normalized, NT=Normalized and Tempered

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TABLE A2M
Materials and Allowable Stresses SI (Metric) Units (continued)

ASTM Spec	Grade	Material Composition	Condition	Minimum Tensile (MPa)	Minimum Yield (MPa)	Maximum Allowable Stress in Tension (MPa) for Metal Temperatures Not Exceeding Degrees C												
						-29 to 232	343	371	399	427	454	482	510	538	566	593	621	649
CASTINGS																		
A47	32510	Malleable Iron	A	345	224	78.6	—	—	—	—	—	—	—	—	—	—	—	—
A47	35018	Malleable Iron	A	365	241	83.4	—	—	—	—	—	—	—	—	—	—	—	—
A48	20	Gray Iron	—	138	—	13.8	(limited to 204°C)											
A48	25	Gray Iron	—	172	—	17.2	(limited to 204°C)											
A48	30	Gray Iron	—	207	—	20.7	(limited to 204°C)											
A126	A	Gray Iron	—	145	—	13.8	(limited to 204°C)											
A126	B	Gray Iron	—	214	—	20.7	(limited to 204°C)											
A126	C	Gray Iron	—	283	—	27.6	(limited to 204°C)											
A197	—	Malleable Iron	A	276	207	62.7	—	—	—	—	—	—	—	—	—	—	—	—
A216	WCA	Carbon Steel	N	414	207	115.1	102.0	98.6	—	—	—	—	—	—	—	—	—	—
A216	WCB	Carbon Steel	N	483	248	136.5	122.7	118.6	—	—	—	—	—	—	—	—	—	—
A217	WC6	1½ CR - 1/2 Mo	NT	483	276	137.9	137.9	137.9	—	—	—	—	—	—	—	—	—	—
A217	WC9	2¼ CR - 1 Mo	NT	483	276	133.1	131.7	129.6	—	—	—	—	—	—	—	—	—	—
A351	CF8	18 CR - 8 Ni	—	483	207	73.4	66.2	64.5	63.4	61.8	—	—	—	—	—	—	—	—
A351	CF8C	18 CR - 10 Ni - Cb	—	483	207	85.5	77.2	76.1	75.6	75.0	—	—	—	—	—	—	—	—
A351	CF8M	16 CR - 12 Ni - 2 Mo	—	483	207	75.6	67.8	66.7	65.6	64.5	—	—	—	—	—	—	—	—
A395	-	Ductile Iron	—	414	276	94.5	94.5	—	—	—	—	—	—	—	—	—	—	—
A536	65-45-12	Ductile Iron	—	448	310	102.7	102.7	—	—	—	—	—	—	—	—	—	—	—
B86	AC43A (ZA2)	ZnAl4Cu3	Aged	331	283	66.2	limited to 110° C											
B86	AG40A (ZA3)	ZnAl4	Aged	241	221	48.2	limited to 110° C											
B86	AC41A (ZA5)	ZnAl4Cu1	Aged	269	221	53.8	limited to 110° C											
B86	(ZA8)	ZnAl8Cu1	Aged	297	225	59.4	limited to 110° C											

Conditions: A=Annealed, AH=Age Hardened, CF=Cold Finished, DNT=Double Normalized and Tempered, HR=Hot Rolled, HT=Heat Treated, QT=Quenched and Tempered,

N=Normalized, NT=Normalized and Tempered

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TABLE A2M
Materials and Allowable Stresses SI (Metric) Units (continued)

ASTM Spec	Grade	Material Composition	Condition	Minimum Tensile (MPa)	Minimum Yield (MPa)	Maximum Allowable Stress in Tension (MPa) for Metal Temperatures Not Exceeding Degrees C											
						-29 to 232	343	371	399	427	454	482	510	538	566	593	621
FORGINGS																	
A105	—	Carbon Steel	HT	483	248	136.5	122.7	118.6	—	—	—	—	—	—	—	—	—
A181	70	Carbon Steel	—	483	248	136.5	122.7	118.6	—	—	—	—	—	—	—	—	—
A182	F11	1¼ CR - 1/2 Mo - Si	A	483	276	137.9	137.9	137.9	135.8	132.4	128.9	94.5	64.1	43.4	29.0	19.3	8.3
A182	F22	2¼ CR - 1 Mo	A	517	310	141.3	139.3	137.9	135.8	133.1	128.9	108.9	78.6	53.8	35.2	22.1	13.8
(b) A182	F304	18 CR - 8 Ni	HT	517	207	91.7	82.7	80.7	79.3	77.2	75.8	74.5	73.1	71.7	69.6	67.6	53.1
(b) A182	F316	16 CR - 12 Ni - 2 Mo	HT	517	207	95.1	84.8	83.4	82.0	81.4	80.0	79.3	78.6	77.9	77.2	75.8	67.6
(b) A182	F321	18 CR - 10 Ni - Ti	HT	517	207	102.0	91.0	89.6	87.6	86.9	85.5	84.8	83.4	82.7	66.2	47.6	34.5
(b) A182	F347	18 CR - 10 Ni - Cb	HT	517	207	106.9	96.5	95.1	94.5	93.8	93.1	92.4	92.4	92.4	83.4	62.7	42.1
A668	A	Carbon Steel	—	324	—	92.4	92.4	—	—	—	—	—	—	—	—	—	—
A668	B	Carbon Steel	A	414	207	117.9	117.9	—	—	—	—	—	—	—	—	—	—
A668	C	Carbon Steel	A	455	228	129.6	129.6	—	—	—	—	—	—	—	—	—	—
A668	D	Carbon Steel	N	517	259	147.5	147.5	—	—	—	—	—	—	—	—	—	—
A668	E	Carbon Steel	DNT	572	296	163.4	163.4	—	—	—	—	—	—	—	—	—	—
(p) A668	F	Carbon Steel	QT	621	379	177.2	—	—	—	—	—	—	—	—	—	—	—
BOLTING																	
(j) A193	B7	1 CR - 1/5 Mo	HT	862	724	172.4	172.4	172.4	162.7	144.8	117.2	86.2	58.6	31.0	—	—	—
(k) A193	B7	1 CR - 1/5 Mo	HT	793	655	158.6	158.6	158.6	155.1	137.9	112.4	86.2	58.6	31.0	—	—	—
(l) A193	B7	1 CR - 1/5 Mo	HT	689	517	129.6	129.6	129.6	129.6	124.1	112.4	86.2	58.6	31.0	—	—	—
(b,c,d) A193	B8	18 CR - 8 Ni	—	517	207	91.7	82.7	81.4	79.3	77.2	75.8	74.5	73.1	71.7	69.6	67.6	53.1
(b,c,d) A193	B8M	16 CR - 12 Ni - 2 Mo	—	517	207	95.1	84.8	83.4	82.0	80.7	80.0	79.3	78.6	77.9	77.2	75.8	67.6
(b,c,d) A193	B8C	18 CR - 10 Ni - Cb	—	517	207	104.8	97.2	95.1	94.5	93.8	93.1	93.1	92.4	92.4	83.4	62.7	42.1
(b,c,d) A193	B8T	18 CR - 10 Ni - Ti	—	517	207	102.0	91.7	88.9	87.6	86.2	85.5	84.8	83.4	82.7	66.2	47.6	34.5
A307	A	Carbon Steel	—	414	—	117.9	117.9	—	—	—	—	—	—	—	—	—	—
A307	B	Carbon Steel	—	414	—	117.9	117.9	—	—	—	—	—	—	—	—	—	—
(h) A325	TYPE 2	Carbon Steel	HT	827	—	236.5	236.5	—	—	—	—	—	—	—	—	—	—
(i) A325	TYPE 2	Carbon Steel	HT	724	—	206.8	206.8	—	—	—	—	—	—	—	—	—	—
(h) A449	—	Carbon Steel	QT	827	—	180.6	180.6	—	—	—	—	—	—	—	—	—	—
(i) A449	—	Carbon Steel	QT	724	—	157.2	157.2	—	—	—	—	—	—	—	—	—	—
(m) A449	—	Carbon Steel	QT	621	—	113.8	113.8	—	—	—	—	—	—	—	—	—	—
A490	—	Alloy Steel	QT	1034	896	295.8	295.8	—	—	—	—	—	—	—	—	—	—
RIVETS & NUTS																	
A194	ALL	—	—	Product Specification	—	—	—	—	—	—	—	—	—	—	—	—	—
A502	—	Carbon Steel	—	359	193	102.7	102.7	—	—	—	—	—	—	—	—	—	A502
A563	ALL	Carbon Steel	—	Product Specification	—	—	—	—	—	—	—	—	—	—	—	—	—
SPRINGS	See Figures 1 and 2 for Materials and Stresses																

Conditions: A = Annealed, AH = Age Hardened, CF = Cold Finished, DNT = Double Normalized and Tempered, HR = Hot Rolled, HT = Heat Treated, QT = Quenched and Tempered.

N = Normalized, NT = Normalized and Tempered

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TABLE A2M
Materials and Allowable Stresses SI (Metric) Units (continued)

TABLE A2M NOTES:

- (a) Allowable stresses for these materials are based upon those of comparable materials of similar chemical properties.
- (b) For temperatures above 538 °C, these stress values apply only when the carbon content is 0.04% or higher based on heat analysis.
- (c) For temperatures above 538 °C, these stress values may be used only if the material is heat treated by treating it to a minimum temperature of 1038 °C and quenching in water or rapidly cooling by other means.
- (d) Derived from Class 1.
- (e) Derived from Type B.
- (f) Age hardened at 579 °C.
- (g) For temperatures above 454 °C, these stress values apply only when the carbon content is 0.05% or higher based on heat analysis.
- (h) For bolt diameters 25.5 mm and less.
- (i) For bolt diameters greater than 25.5 mm through 38.1 mm.
- (j) For bolt diameters 63.5 mm and less.
- (k) For bolt diameters greater than 63.5 mm through 101.6 mm.
- (l) For diameters greater than 101.6 mm.
- (m) For bolt diameters greater than 38.1 mm through 76.2 mm.
- (n) For material thickness 76.2 mm and less.
- (o) For material thickness greater than 76.2 mm.
- (p) For sizes 101.6 mm and less.