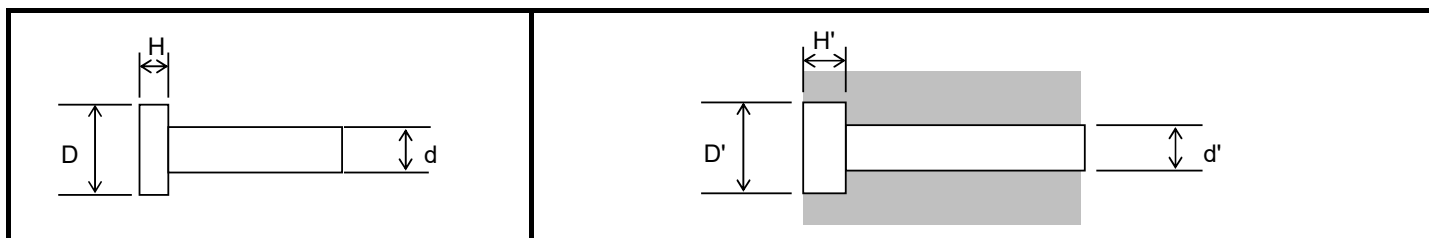


INCH STANDARD COUNTERBORE

REV. F 06/02/2005



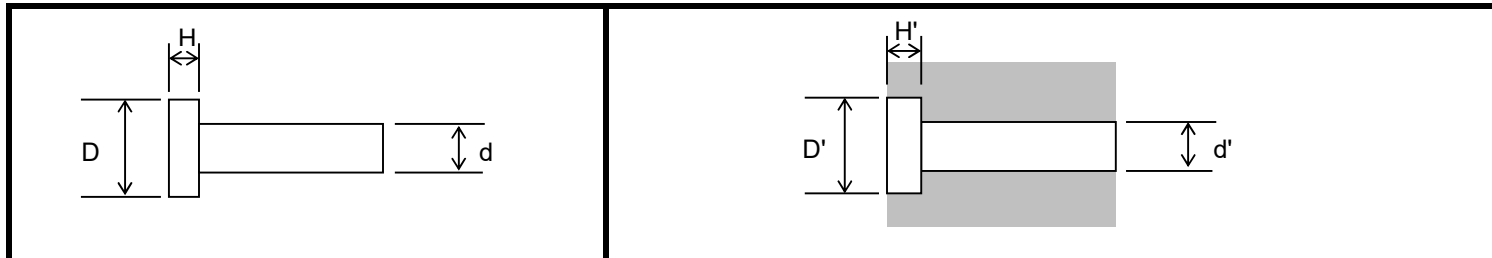
SCREW SIZE	SCREW DIA. d	CAP HEAD DIA. (MAX) D	CAP HEAD HEIGHT (MAX) H	SOCKET SIZE	CLEARANCE DIA. (CLOSE) d'		C'BORE DIA. (CLOSE) D'	CLEARANCE DIA. (FREE) d'		C'BORE DIA. (FREE) D'	C'BORE DEPTH H'	SCREW SIZE
# 2	0.086	0.140	0.086	5/64	3/32	0.094	0.156	#36	0.107	0.161	0.105	# 2
# 4	0.112	0.183	0.112	3/32	1/8	0.125	0.204	#27	0.144	0.220	0.135	# 4
# 6	0.138	0.226	0.138	7/64	#23	0.154	0.246	#18	0.170	0.262	0.165	# 6
# 8	0.164	0.270	0.164	9/64	#15	0.180	0.290	#10	0.194	0.306	0.190	# 8
# 10	0.190	0.313	0.190	5/32	#5	0.206	0.332	#2	0.221	0.348	0.215	# 10
1/4	0.250	0.375	0.250	3/16	17/64	0.266	0.400	9/32	0.281	0.416	0.275	1/4
5/16	0.313	0.469	0.313	1/4	21/64	0.328	0.493	11/32	0.344	0.509	0.340	5/16
3/8	0.375	0.563	0.375	5/16	25/64	0.391	0.590	13/32	0.406	0.606	0.405	3/8
7/16	0.438	0.656	0.438	3/8	29/64	0.453	0.681	15/32	0.469	0.697	0.470	7/16
1/2	0.500	0.750	0.500	3/8	33/64	0.516	0.775	17/32	0.531	0.791	0.535	1/2
5/8	0.625	0.938	0.625	1/2	41/64	0.641	0.963	21/32	0.656	1.000	0.665	5/8
3/4	0.750	1.125	0.750	5/8	49/64	0.766	1.151	25/32	0.781	1.171	0.790	3/4
7/8	0.875	1.313	0.875	3/4	57/64	0.891	1.340	29/32	0.906	1.359	0.915	7/8
1	1.000	1.500	1.000	3/4	1-1/64	1.016	1.528	1-1/32	1.031	1.546	1.045	1

TOLERANCES +/-		
	FREE	CLOSE
CLEARANCE DIAMETER	0.005	0.005
COUNTERBORE DIAMETER	0.010	0.005
COUNTERBORE DEPTH	0.010	0.010

FREE SHOULD BE USED UNLESS CLOSE IS REQUIRED

METRIC COUNTERBORE

REV. H 06/02/2005



SCREW SIZE	SCREW DIA. d	CAP HEAD DIA. (MAX) D		CAP HEAD HEIGHT (MAX) H		SOCKET SIZE	CLEARANCE DIA. (CLOSE) d'		C'BORE DIA. (CLOSE) D'		CLEARANCE DIA. (FREE) d'		C'BORE DIA. (FREE) D'		C'BORE DEPTH H'		SCREW SIZE
	in	mm	in	mm	in		mm	in	mm	in	mm	in	mm	in	mm	in	
M 2	0.079	3.8	0.150	2.0	0.079	1.5 mm	2.2	0.087	4.0	0.157	2.50	0.098	4.30	0.169	2.5	0.098	M 2
M 2.5	0.098	4.5	0.177	2.5	0.098	2.0 mm	2.7	0.106	4.7	0.185	3.00	0.118	5.00	0.197	3.0	0.118	M 2.5
M 3	0.118	5.5	0.217	3.0	0.118	2.5 mm	3.5	0.138	6.0	0.236	3.75	0.148	6.25	0.246	3.5	0.138	M 3
M 4	0.157	7.0	0.276	4.0	0.157	3.0 mm	4.5	0.177	7.5	0.295	4.90	0.193	7.90	0.311	4.5	0.177	M 4
M 5	0.197	8.5	0.335	5.0	0.197	4.0 mm	5.5	0.217	9.0	0.354	5.90	0.232	9.40	0.370	5.5	0.217	M 5
M 6	0.236	10.0	0.394	6.0	0.236	5.0 mm	6.5	0.256	10.5	0.413	7.00	0.276	11.00	0.433	7.0	0.276	M 6
M 8	0.315	13.0	0.512	8.0	0.315	6.0 mm	8.5	0.335	13.5	0.531	9.20	0.362	14.20	0.559	9.0	0.354	M 8
M 10	0.394	16.0	0.630	10.0	0.394	8.0 mm	10.5	0.413	16.5	0.650	11.40	0.449	17.40	0.685	11.0	0.433	M 10
M 12	0.472	18.0	0.709	12.0	0.472	10.0 mm	12.5	0.492	18.5	0.728	13.50	0.531	19.50	0.768	13.0	0.512	M 12
M 14	0.551	21.0	0.827	14.0	0.551	7.000	14.5	0.571	21.5	0.846	15.70	0.618	22.70	0.894	15.0	0.591	M 14
M 16	0.630	24.0	0.945	16.0	0.630	14.0 mm	17.0	0.669	25.0	0.984	18.00	0.709	26.00	1.024	18.0	0.709	M 16
M 20	0.787	30.0	1.181	20.0	0.787	17.0 mm	21.0	0.827	31.0	1.220	22.50	0.886	32.50	1.280	22.0	0.866	M 20
M 24	0.945	36.0	1.417	24.0	0.945	19.0 mm	25.0	0.984	37.0	1.457	26.70	1.051	38.70	1.524	26.0	1.024	M 24
M 30	1.181	45.0	1.772	30.0	1.181	22.0 mm	31.0	1.220	46.0	1.811	33.00	1.299	48.00	1.890	32.0	1.260	M 30

NOTE: " FREE SIZES " AND M2.0 AND M2.5
ARE NOT McMASTER CARR STANDARD CUTTING TOOLS
 FREE SHOULD BE USED UNLESS CLOSE IS REQUIRED

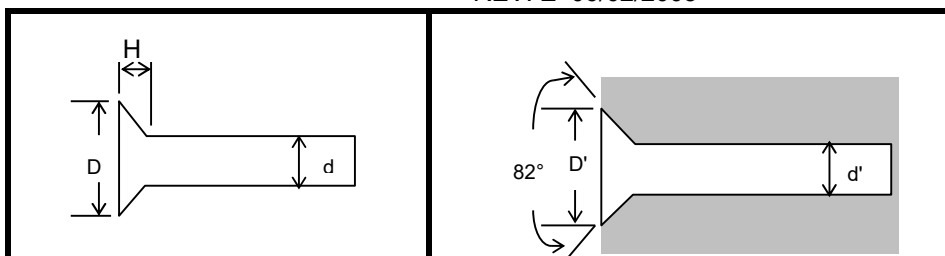
THREAD PITCHES SHOULD ALWAYS BE SPECIFIED,
 BUT WHEN METRIC THREADS ARE SPECIFIED WITHOUT A PITCH,
 THE FOLLOWING PITCHES ARE TO BE USED:

TOLERANCES +/-		
	FREE	CLOSE
CLEARANCE DIAMETER	0.005	0.005
COUNTERBORE DIAMETER	0.010	0.005
COUNTERBORE DEPTH	0.010	0.010

M 2	X .40		M 6	X 1.0		M 16	X 2.0
M 2.5	X .45		M 8	X 1.25		M 20	X 2.5
M 3	X .50		M 10	X 1.5		M 24	X 3.0
M 4	X .70		M 12	X 1.75		M 30	X 3.5
M 5	X .80		M 14	X 2.0			

INCH STANDARD COUNTERSINK

REV. E 06/02/2005

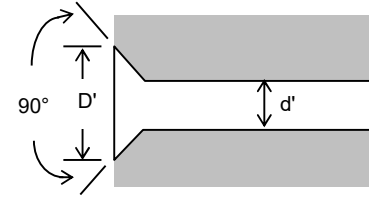
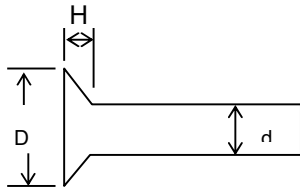


SCREW SIZE	SCREW DIA. d	FLAT HEAD DIA. D (max)	FLAT HEAD HEIGHT H (max)	SOCKET SIZE	C'SINK DIA. D'	CLEARANCE DIA. d' CLOSE		SCREW SIZE
# 2	0.086	0.197	0.064	0.050	0.214	3/32	0.094	# 2
# 4	0.112	0.255	0.083	1/16	0.272	1/8	0.125	# 4
# 6	0.138	0.307	0.097	5/64	0.324	#23	0.154	# 6
# 8	0.164	0.359	0.112	3/32	0.376	#15	0.180	# 8
# 10	0.190	0.411	0.127	1/8	0.428	#5	0.206	# 10
1/4	0.250	0.531	0.161	5/32	0.548	17/64	0.266	1/4
5/16	0.313	0.656	0.198	3/16	0.673	21/64	0.328	5/16
3/8	0.375	0.781	0.234	7/32	0.798	25/64	0.391	3/8
7/16	0.438	0.844	0.234	1/4	0.861	29/64	0.453	7/16
1/2	0.500	0.938	0.251	5/16	0.955	33/64	0.516	1/2
5/8	0.625	1.188	0.324	3/8	1.205	41/64	0.641	5/8
3/4	0.750	1.438	0.396	1/2	1.455	49/64	0.766	3/4
7/8	0.875	1.688	0.468	9/16	1.705	57/64	0.891	7/8
1	1.000	1.938	0.540	5/8	1.955	1-1/64	1.016	1

COUNTERSINK DIAMETERS ARE BASED ON THE THEORETICAL MAXIMUM HEAD DIAMETER AT A DEPTH OF .005 TO .015 AND AN ANGLE OF 82 DEGREES. ACTUAL DEPTH MAY VARY DEPENDING ON ACTUAL HEAD DIAMETER AND ANGLE
 COUNTERSINK DIAMETER TOLERANCES ARE +/- .010
 COUNTERSINK ANGLE TOLERANCES ARE +/- 2 DEGREES
 FREE SHOULD BE USED UNLESS CLOSE IS REQUIRED

METRIC COUNTERSINK

REV. H 06/02/2005



SCREW SIZE	SCREW DIA. d	FLAT HEAD DIA. D (max)		FLAT HEAD HEIGHT H (max)		SOCKET SIZE	COUNTERSINK DIAMETER D'		CLEARANCE DIA. d' CLOSE		SCREW SIZE
	in	mm	in	mm	in		mm	in	mm	in	
M 2	0.079	4.2	0.165	1.1	0.043	1.3 mm	4.7	0.185	2.2	0.087	M 2
M 2.5	0.098	5.2	0.207	1.4	0.054	1.5 mm	5.8	0.227	2.7	0.106	M 2.5
M 3	0.118	6.4	0.252	1.7	0.067	2 mm	6.9	0.272	3.5	0.138	M 3
M 4	0.157	8.6	0.339	2.3	0.091	2.5 mm	9.4	0.369	4.5	0.177	M 4
M 5	0.197	10.6	0.417	2.8	0.110	3 mm	11.6	0.457	5.5	0.217	M 5
M 6	0.236	12.6	0.496	3.3	0.130	4 mm	13.9	0.546	6.50	0.256	M 6
M 8	0.315	16.8	0.661	4.4	0.173	5 mm	18.3	0.721	8.5	0.335	M 8
M 10	0.394	21.0	0.827	5.5	0.217	6 mm	22.8	0.897	10.5	0.413	M 10
M 12	0.472	25.0	0.984	6.5	0.256	8 mm	27.0	1.064	12.5	0.492	M 12
M 14	0.551	28.0	1.102	7.0	0.276	10 mm	30.4	1.197	14.5	0.571	M 14

COUNTERSINK DIAMETERS ARE BASED ON THE THEORETICAL MAXIMUM HEAD DIAMETER AT A DEPTH OF .005 TO .015 AND AN ANGLE OF 90 DEGREES. ACTUAL DEPTH MAY VARY DEPENDING ON ACTUAL HEAD DIAMETER AND ANGLE
COUNTERSINK DIAMETER TOLERANCES ARE +/- .010
COUNTERSINK ANGLE TOLERANCES ARE +/- 2 DEGREES

THREAD PITCHES SHOULD ALWAYS BE SPECIFIED, BUT WHEN METRIC THREADS ARE SPECIFIED WITHOUT A PITCH, THE FOLLOWING PITCHES ARE TO BE USED:

M 2	X .40		M 5	X .80		M 12	X 1.75			M 24	X 3.0
M 2.5	X .45		M 6	X 1.0		M 14	X 2.0			M 30	X 3.5
M 3	X .50		M 8	X 1.25		M 16	X 2.0				
M 4	X .70		M 10	X 1.5		M 20	X 2.5				

Printed copies of Electroimpact standards are for reference only and are not subject to revision control.

Printed copies of Electroimpact standards are for reference only and are not subject to revision control.

WRENCH FLATS

REV. D 11/1/15



SAE

NOMINAL	MAX.	MIN.
3/8	0.378	0.372
7/16	0.440	0.434
1/2	0.504	0.498
9/16	0.566	0.559
5/8	0.629	0.621
11/16	0.692	0.684
3/4	0.755	0.745
13/16	0.818	0.808
7/8	0.880	0.870
15/16	0.944	0.932
1	1.006	0.992

METRIC

NOMINAL	MAX.	MIN.	Width	MAX.	MIN.	Width
MM	MM	MM	IN	IN	IN	IN
4	4.00	3.82	5.000	0.157	0.150	0.197
5	5.00	4.78	5.000	0.197	0.188	0.197
5.5	5.50	5.32	5.000	0.217	0.209	0.197
6	6.00	5.78	5.000	0.236	0.228	0.197
7	7.00	6.78	5.500	0.276	0.267	0.217
8	8.00	7.78	5.900	0.315	0.306	0.232
9	9.00	8.78	6.400	0.354	0.346	0.252
10	10.00	9.78	6.900	0.394	0.385	0.272
11	11.00	10.73	7.400	0.433	0.422	0.291
12	12.00	11.73	7.900	0.472	0.462	0.311
13	13.00	12.73	8.400	0.512	0.501	0.331
14	14.00	13.73	8.900	0.551	0.541	0.350
15	15.00	14.73	9.300	0.591	0.580	0.366
16	16.00	15.73	9.800	0.630	0.619	0.386
17	17.00	16.73	10.300	0.669	0.659	0.406
18	18.00	17.73	10.800	0.709	0.698	0.425
19	19.00	18.67	11.100	0.748	0.735	0.437
20	20.00	19.67	11.400	0.787	0.774	0.449
21	21.00	20.67	11.700	0.827	0.814	0.461
22	22.00	21.67	12.000	0.866	0.853	0.472
24	24.00	23.67	12.700	0.945	0.932	0.500
27	27.00	26.67	13.600	1.063	1.050	0.535
30	30.00	29.67	14.600	1.181	1.168	0.575

Flat should be .866x round size to make flat the same length as on a hex head

BOLT INSTALLATION GUIDELINES

Rev C 6/4/2025

Size	Torque (Class 12.9)		Torque (Class 10.9) & Low Head		Torque (Class 8.8), Flathead, ButtonHead		Minimum Engagement
3	2.3 Nm	20 in-lbs	2.0 Nm	17 in-lbs	1.3 Nm	12 in-lbs	5 mm
4	5.1 Nm	45 in-lbs	4.3 Nm	38 in-lbs	3.0 Nm	26 in-lbs	6 mm
5	10 Nm	89 in-lbs	8.5 Nm	75 in-lbs	5.8 Nm	51 in-lbs	8 mm
6	17.4 Nm	154 in-lbs	14.8 Nm	131 in-lbs	10.1 Nm	89 in-lbs	10 mm
8	42 Nm	31 ft-lbs	36 Nm	26 ft-lbs	24 Nm	18 ft-lbs	13 mm
10	83 Nm	61 ft-lbs	71 Nm	52 ft-lbs	48 Nm	36 ft-lbs	16 mm
12	126 Nm	93 ft-lbs	107 Nm	79 ft-lbs	73 Nm	54 ft-lbs	19 mm
14	201 Nm	148 ft-lbs	171 Nm	126 ft-lbs	117 Nm	86 ft-lbs	22 mm
16	309 Nm	228 ft-lbs	263 Nm	194 ft-lbs	179 Nm	132 ft-lbs	26 mm
20	605 Nm	446 ft-lbs	514 Nm	379 ft-lbs	351 Nm	259 ft-lbs	32 mm
24	1041 Nm	768 ft-lbs	885 Nm	653 ft-lbs	604 Nm	445 ft-lbs	38 mm
30	2077 Nm	1532 ft-lbs	1765 Nm	1302 ft-lbs	1205 Nm	889 ft-lbs	48 mm
36	3607 Nm	2661 ft-lbs	3066 Nm	2261 ft-lbs	2092 Nm	1543 ft-lbs	58 mm

Notes:

1. M5 and under bolts apply purple Loctite 222 or equivalent - [per EI-0014](#) , except flat heads and button heads anti-seize only.
2. M6 - M10 bolts apply blue Loctite 243 or equivalent, except flat heads and button heads anti-seize only.
3. M12 and over bolts apply copper anti-seize or equivalent.
4. Minimum thread engagement shown should be checked prior to installing bolt. Values shown are for ASTM A36 steel tapped holes with Class 12.9 bolts. If minimum engagement cannot be obtained contact the engineer responsible for the assembly about using a reduced torque value.
5. removed 6/4/25
6. Plated class 12.9 fasteners need to be re-torqued after a minimum of 24hrs from initial torquing to check for hydrogen embrittlement.
7. Closely spaced patterns of bolts attaching a single component, such as slewing rings, should be torqued in an alternating sequence and in steps up to the final torque.
8. Critical bolts that have been fully torqued should not be reused.
9. Values shown are calculated according to VDI2230:2003 using a friction factor of .12 for Loctited bolts and .10 for anti-seize coated bolts to stress the bolt to 90% of yield while tightening. This results in a tensile residual stress of approximately 80% of yield.
10. Torque values for purchased components or specified on Electroimpact assembly drawings supersede the values shown in the table.

BOLT INSTALLATION GUIDELINES(UNC)

Scott Smith 8/26/2016 Rev A

Size	Torque (A574 SHCS)			Torque (Gr8, A490 & Low Head)			Torque (Gr5, A325, Flathead, ButtonHead)			Minimum Engagement	
#5	2.4	Nm	21 in-lbs	2.1	Nm	18 in-lbs	1.5	Nm	13 in-lbs	0.20	in
#6	3.0	Nm	27 in-lbs	2.6	Nm	23 in-lbs	1.8	Nm	16 in-lbs	0.22	in
#8	5.5	Nm	49 in-lbs	4.7	Nm	42 in-lbs	3.3	Nm	29 in-lbs	0.26	in
#10	8	Nm	71 in-lbs	7	Nm	60 in-lbs	5	Nm	43 in-lbs	0.3	in
1/4	19	Nm	14 ft-lbs	16	Nm	12 ft-lbs	11	Nm	8 ft-lbs	0.4	in
5/16	38	Nm	28 ft-lbs	32	Nm	24 ft-lbs	23	Nm	17 ft-lbs	0.5	in
3/8	67	Nm	49 ft-lbs	57	Nm	42 ft-lbs	40	Nm	30 ft-lbs	0.6	in
7/16	106	Nm	78 ft-lbs	90	Nm	67 ft-lbs	64	Nm	47 ft-lbs	0.7	in
1/2	144	Nm	106 ft-lbs	122	Nm	90 ft-lbs	87	Nm	64 ft-lbs	0.8	in
9/16	206	Nm	152 ft-lbs	175	Nm	129 ft-lbs	124	Nm	91 ft-lbs	0.9	in
5/8	285	Nm	210 ft-lbs	242	Nm	178 ft-lbs	171	Nm	126 ft-lbs	1.0	in
3/4	501	Nm	369 ft-lbs	426	Nm	314 ft-lbs	301	Nm	222 ft-lbs	1.2	in
7/8	802	Nm	592 ft-lbs	682	Nm	503 ft-lbs	482	Nm	356 ft-lbs	1.4	in
1	1206	Nm	890 ft-lbs	1025	Nm	756 ft-lbs	638	Nm	471 ft-lbs	1.6	in
1 1/8	1709	Nm	1260 ft-lbs	1453	Nm	1071 ft-lbs	904	Nm	667 ft-lbs	1.8	in
1 1/4	2390	Nm	1763 ft-lbs	2032	Nm	1499 ft-lbs	1264	Nm	933 ft-lbs	2.0	in
1 3/8	3155	Nm	2327 ft-lbs	2682	Nm	1978 ft-lbs	1669	Nm	1231 ft-lbs	2.2	in
1 1/2	4158	Nm	3067 ft-lbs	3534	Nm	2607 ft-lbs	2200	Nm	1622 ft-lbs	2.4	in

Notes:

- #10 and under bolts apply purple Loctite 222 or equivalent, except flat heads and button heads anti-seize only.
- 1/4-7/16 bolts apply blue Loctite 243 or equivalent, except flat heads and button heads anti-seize only.
- 1/2 and over bolts apply copper anti-seize or equivalent.
- Minimum thread engagement shown should be checked prior to installing bolt. Values shown are for ASTM A36 steel tapped holes with A574 SHCS bolts. If minimum engagement cannot be obtained contact the engineer responsible for the assembly about using a reduced torque value.
- Loctite or anti-seize should be applied to thread and underside of bolt head or nut.
- Plated Gr8 and above fasteners need to be re-torqued after a minimum of 24hrs from initial torqueing.
- Closely spaced patterns of bolts attaching a single component, such as slewing rings, should be torqued in an alternating sequence and in steps up to the final torque.
- Critical bolts that have been fully torqued should not be reused.
- Values shown are calculated according to VDI2230:2003 using a friction factor of .12 for Loctited bolts and .10 for anti-seize coated bolts to stress the bolt to 90% of yield while tightening. This results in a tensile residual stress of approximately 80% of yield.
- Torque values for purchased components or specified on Electroimpact assembly drawings supersede the values shown in the table.

Internal Thread Minor Diameter Limits

Rev A 6/24/04

Inch

Metric

Class 2B

Class 6H

Thread	Min	Max
4-40	0.094	0.085
4-48	0.089	0.097
6-32	0.104	0.114
8-32	0.130	0.139
10-24	0.145	0.156
10-32	0.156	0.164
1/4-20	0.196	0.207
1/4-28	0.211	0.220
5/16-18	0.252	0.265
5/16-24	0.267	0.277
3/8-16	0.307	0.321
3/8-24	0.330	0.340
7/16-14	0.360	0.376
7/16-20	0.383	0.395
1/2-13	0.417	0.434
1/2-20	0.446	0.457
5/8-11	0.527	0.546
5/8-18	0.565	0.578
3/4-10	0.642	0.663
3/4-16	0.682	0.696
1-8	0.865	0.890
1-12	0.910	0.928

Thread	Metric		Inch	
	Min	Max	Min	Max
M 2 X .40	1.57	1.68	0.062	0.066
M 2.5 X .45	2.01	2.14	0.079	0.084
M 3 X .50	2.46	2.64	0.097	0.104
M 4 X .70	3.24	3.47	0.128	0.136
M 5 X .80	4.13	4.38	0.163	0.173
M 6 X 1.0	4.92	5.15	0.194	0.203
M 8 X 1.25	6.65	6.91	0.262	0.272
M 10 X 1.5	8.38	8.68	0.330	0.342
M 12 X 1.75	10.11	10.44	0.398	0.411
M 14 X 2.0	11.84	12.21	0.466	0.481
M 16 X 2.0	13.84	14.21	0.545	0.559
M 20 X 2.5	17.29	17.74	0.681	0.699
M 24 X 3.0	20.75	21.25	0.817	0.837
M 30 X 3.5	26.21	26.77	1.032	1.054

Other metric threads start
on page 1645 in Machinery's Handbook

Other unified threads start
on page 1544 in Machinery's Handbook

Copied from Machinery's Handbook and is for reference only

For metric threads where the pitch is not called out on the drawing,
see the countersink/counterbore standards

Mild or Low Carbon Steel Definition -

Rev. A 3/28/13

Chemistry

.05-.29% Carbon

1.65% max manganese

.6% max silicon

.6% max copper

No other significant alloying elements allowed

Material Properties

Easily weldable, formable and machineable

Typical .2% yield point 15-50ksi

Examples

AISI 1018, 1020

ASTM A36, A500

Recommended Drawing Note:

“Mild steel – vendor to confirm suitability of specific material used with Electroimpact engineer prior to manufacture.”

Electroimpact Weld Stress Relief Guidelines
6/7/13 Rev. A

Stress relieve ?		Reasons
Yes	Welded steel lifting beams should be stress relieved	A
Yes	Welded steel tooling that has machining operations	B, C
Yes	Welded steel tooling that has no machining operations	C
Yes	When required by customer or Government codes	E
Yes	When required by material, such as some higher strength materials	
No	Welded steel carts, tables, handrails, staircases etc.	
No	Welded steel Flooring	
No	All thin walled welded steel items with $T < ?$	D

A	To make sure the calculated safety margin to failure is valid i.e. stresses caused by external loading are not superimposed on top of internal stresses present from manufacture.
B	To prevent the residual stresses from welding causing pinging and shifting during machining
C	To prevent the residual stresses from welding causing movements over the lifetime of the tooling
D	Material is not thick enough to have internal stress gradients because rate of cooling is approximately the same through a thin thickness
E	Legal or Contract requirements

References:

<http://www.jlff.org/pdfs/papers/keyconcepts4.pdf>

<http://www.aws.org/wj/sept01/cullison.html>

http://www.usace-isc.org/presentation/Structural%20-%20Hydraulic%20Steel%20Structures/Stress%20Relieving%20Welds_Wessel_Tim.pdf