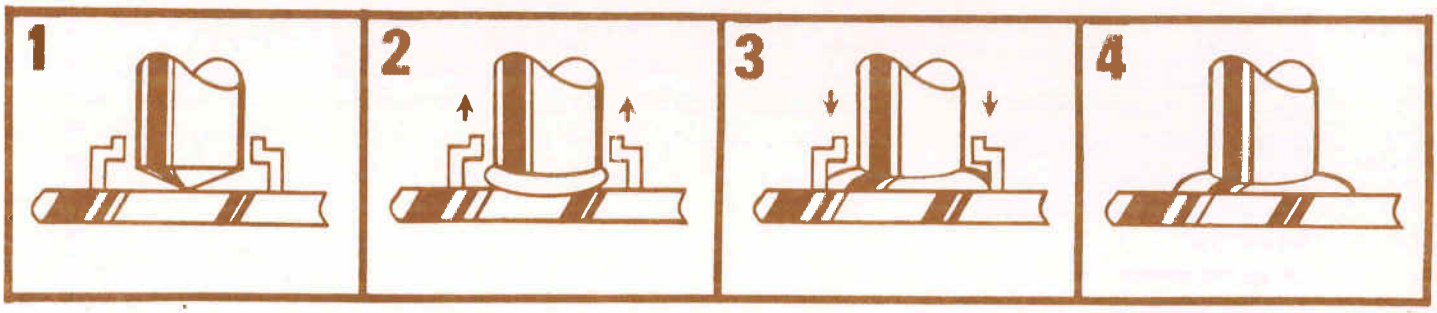
THE PROCESSES

Arc Stud Welding

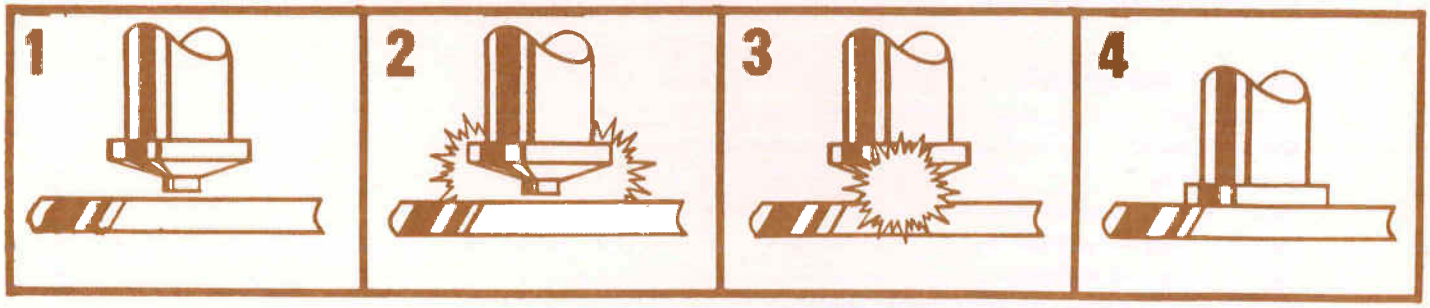


1) stud and ceramic ferrule against the work plate 2) stud lifts and arc is drawn 3) control times out and stud plunges into molten steel 4) metal solidifies and weld is completed in a split second

Arc Stud Welding involves the same basic principles and metallurgical aspects as any other arc welding procedure, in that a controlled electric arc is used to melt the end of the stud or electrode and a portion of the base metal. The stud is thrust automatically into the molten metal and a high quality fusion weld is accomplished where the weld is stronger than the stud itself. Stud Welding is applicable to mild steel, stainless steel and aluminum.

Welded fasteners or studs may be almost any size, shape, or type and there are literally hundreds, however, they must be made of weldable materials and one end of the fastener must be designed for welding. Conventional DC welding machines of all types may be used, but special power units designed specifically for stud welding are also available.

Capacitor Discharge Stud Welding



1) stud against work 2) stored energy discharged through special weld "timing" tip and stud starts downward 3) stud forced into molten metal 4) metal solidifies and weld is completed in a split second

Capacitor Discharge (CD) Stud Welding is also a semi-automatic arc welding process. However, with CD welding small diameter fasteners (1/4" and under) are end welded to extremely thin gauge parent metal. The CD process operates on the principle of capacitor stored energy which is instantaneously discharged by the equipment system through a special weld "timing" tip. Since the entire weld cycle is completed in several milliseconds, welds can be made to thin sheet without pronounced distortion, burn-through or discoloration. CD welding permits stud welding of dissimilar metals.

GENERAL INFORMATION

Basic engineering specifications which cover all of the studs listed in this publication regardless of size or shape are detailed below.

STUD DIMENSIONS (After Weld Length)

The length dimension (L) carried throughout the specifications is the overall length of the stud Before Weld. The After Weld length will be shorter dependent upon the size of the stud as shown in the following table.

Stud Diameter	Length Reduction
3/16" Dia. Through 1/2" Dia.	1/8"
5/8" Dia. Through 7/8" Dia.	3/16"
1" Dia. and Over	3/16" - 1/4"

MATERIALS

All of the studs shown are available in mild or stainless steel. When a stud is stocked, the steel grade it is stocked in is indicated.

The low carbon steel or mild steel studs conform with reasonable limits to the analysis shown.

C - 0.23% Max.	P - 0.040% Max.
Mn - 0.90% Max.	S - 0.050% Max.

Stainless Steels: Stainless steels most commonly used are types 304 or 305. Other grades of 300 series stainless steels are available (except SS-303) when required.

Aluminum: In aluminum, alloy 5356 is most commonly used for stud welding.

THREADS

The standard threads on studs are UNC-2A. Other threads are available on request. Standard maximum thread length is 3".

FLUX

All Studs 1/4" diameter and over are solid fluxed. Below 1/4" diameter solid flux or non fluxed studs are available upon request. The rectangular studs shown in this publication are not fluxed.

MECHANICAL PROPERTIES

(as cold drawn)

Stud Type	Material	Tensile (ultimate)	Reduction In Area
PT, FT, FB, RB TF, CK, SB, NT R6, R7, R2	C-1010/C-1020 ASTM-A108	55,000 psi Min.	50% Min.
HA, SC	C-1010/C-1020 AWSD1.1 & ASTM-A108	60,000 psi Min.	50% Min.
DA	Low Carbon/ASTM 496	80,000 psi Min.	—
CD	C-1010/C-1020 ASTM-A108	50,000 psi Min.	—

ANNEALING

S.W.A. Studs can be annealed to a maximum of 75 Rockwell B for low carbon steel and 85 Rockwell B for Stainless Steel. An extra charge is applicable for annealing and will be quoted if desired.

ORDERING

Each stud ordered should be listed separately along with the appropriate ferrule. The stud style should be specified as well as the length, diameter, material, and quantity required.

Your SWA representative will be happy to advise you on the aces-sories required for welding the stud ordered. He is also available to aid in determining the proper anchor type and placement.

DELIVERIES

Delivery on stock items will be made within 3 days following date of receipt of an order. Non-stock items or special items which require manufacturing will be acknowledged in writing with a delivery promise.

EXTRA CHARGES

A non-stock or special stud that requires manufacturing may be subect to a set-up charge for setting dies onto the machines and changing production processes.

With approval by SWA, a non-stock item may be given production priority if required before the acknowledged delivery date. Should such service be required and approved the customer will be charged an extra "break-in" fee for this service.

Stock items are not subject to additional charges.

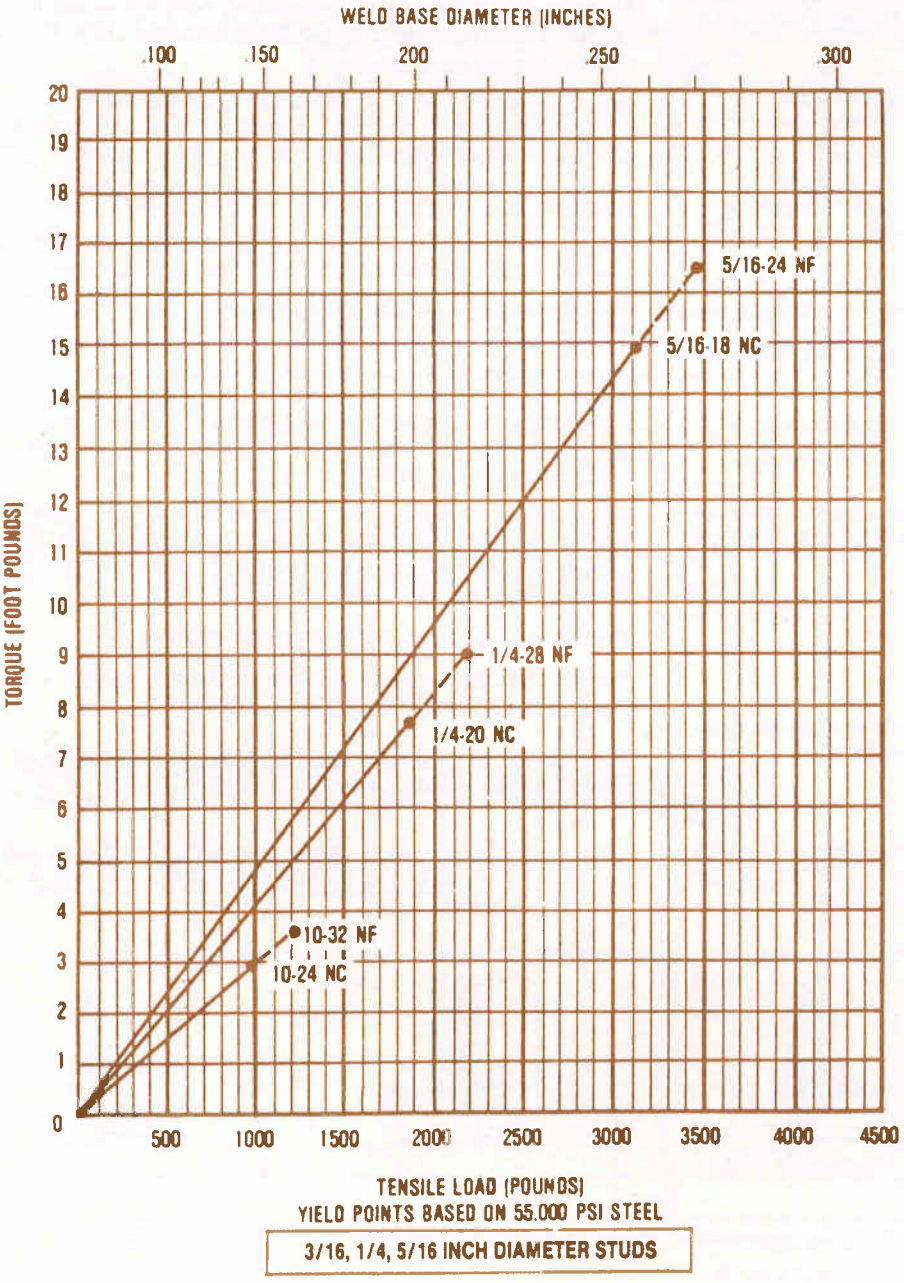
Packing other than standard and export packing is subject to extra charge and quotation will be made on request.

For stud dimaters, lengths and materials other than shown — Consult your SWA Field Sales Representative.

STUD TENSILE-TORQUE STRENGTHS

The graphs shown here and on the following page provide a simple method for obtaining wrench torque and tensile strength data for various thread and weld bases. From these graphs you are able to find the yield strength of all weld base diameters, the yield strength of the various threaded sections, and the torque-tension relation at loads varying from minimum to maximum. Information gathered for these graphs was obtained from the result of a leading torque wrench manufacturer's tests, recommendations of several nut and bolt manufacturers and generally accepted formulas.

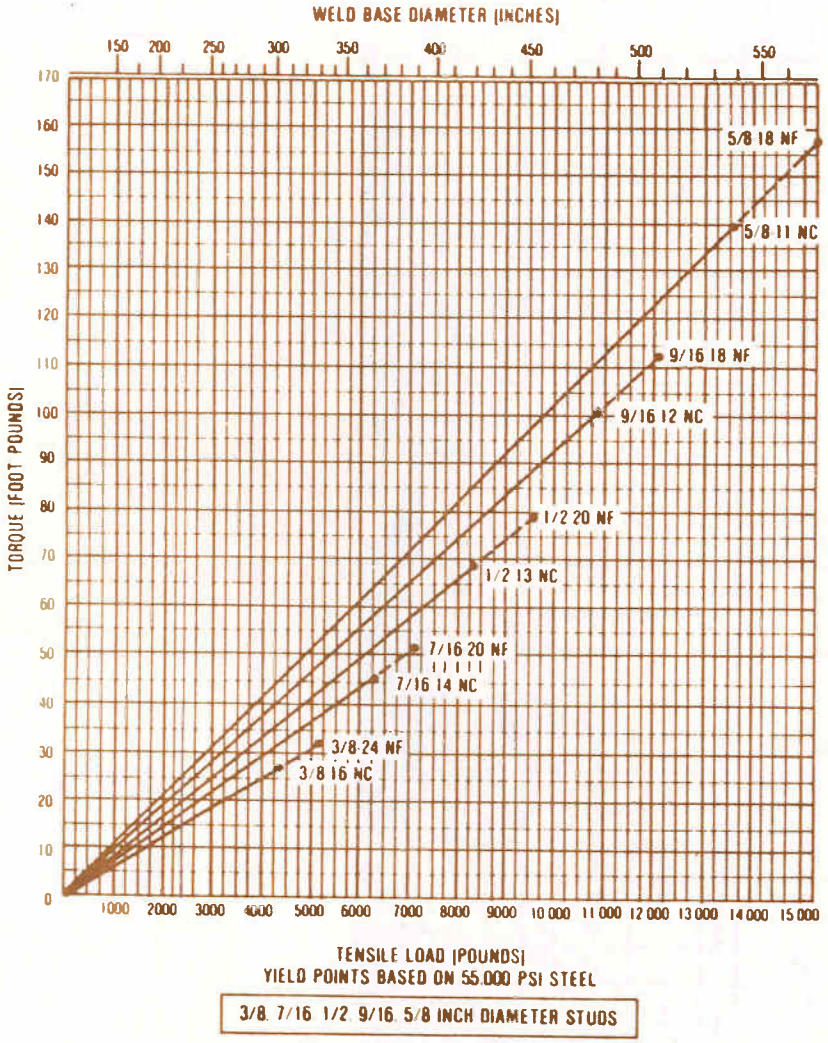
The graphs are reasonably accurate. However, because of the variable affecting the torque-tension relation, they should be used only as a guide. Steel strength, thread finish, lubrication, washer type, hardness and many other factors can cause variations.



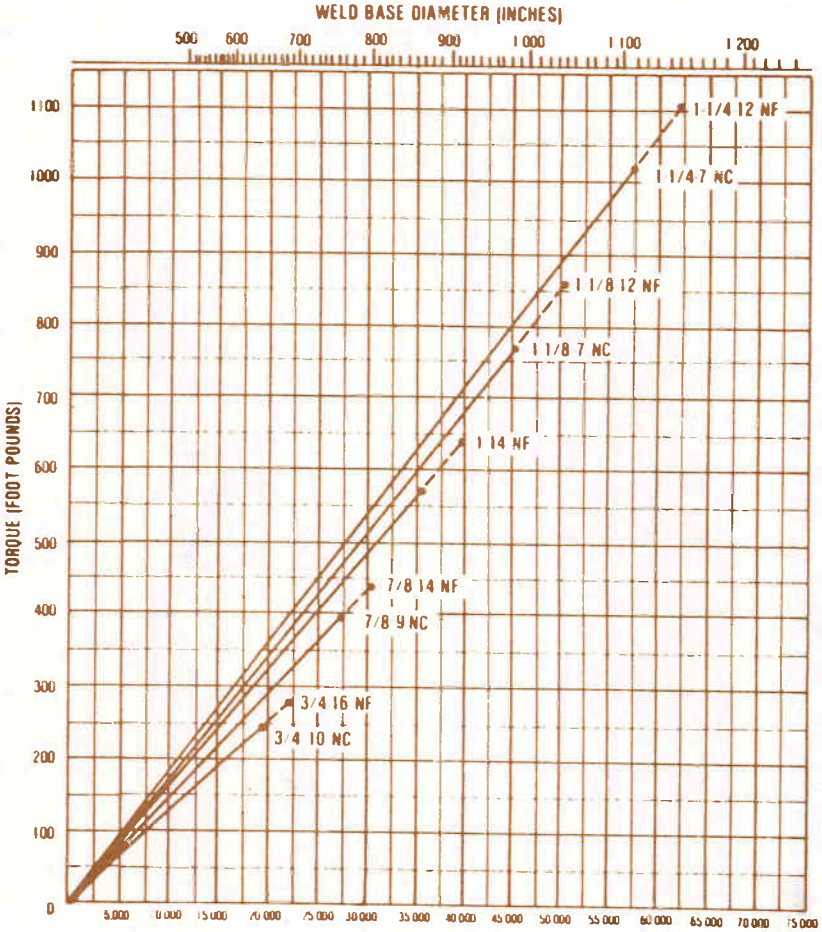
HOW TO USE THE GRAPHS

Scale along the top of each graph represents weld base diameter in inches, while the one at the graph's bottom edge shows tensile load in pounds. A separate line is plotted for each thread diameter. The solid portion of each line terminates at a small dot which represents the tensile yield of the national coarse thread. A dashed line is then extended to a second dot at the tensile yield load of the national fine thread.

Graphs are based on 55,000 psi strength steel. Of course, in actual practice, a stud should never be used at its yield load. A factor of safety must be applied. It is generally recommended that studs be used at no more than 60% of yield. However, the factor of safety may vary up or down, depending on the particular application. The user will make this determination.



3/8, 7/16, 1/2, 9/16, 5/8 INCH DIAMETER STUDS



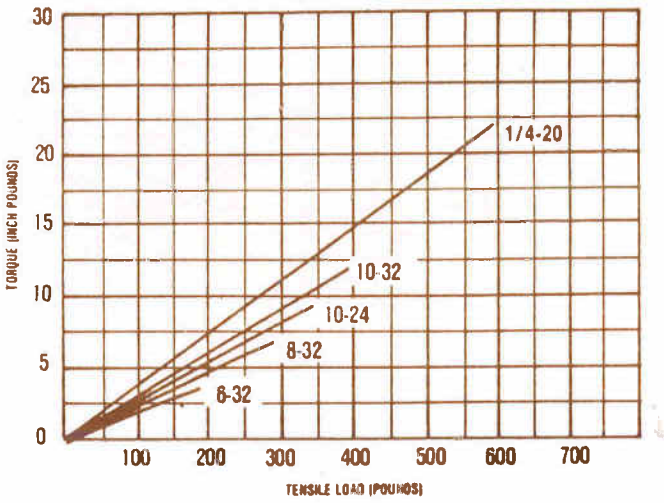
3/4, 7/8, 1, 1-1/8, 1-1/4 INCH DIAMETER STUDS

STUD TENSILE-TORQUE STRENGTHS

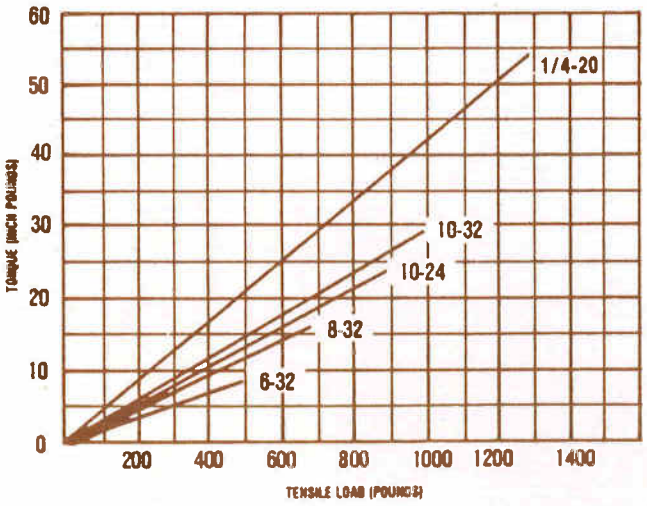
Standard threaded CD studs are available from stock in mild steel and stainless steel in sizes from 6-32 x 1/4 to 1/4-20 x 1-1/2.

Strengths shown are average and a safety factor should be used in designing for a given diameter and material. In testing, all welds were made to plate heavy enough to insure that no failure would occur in the base material.

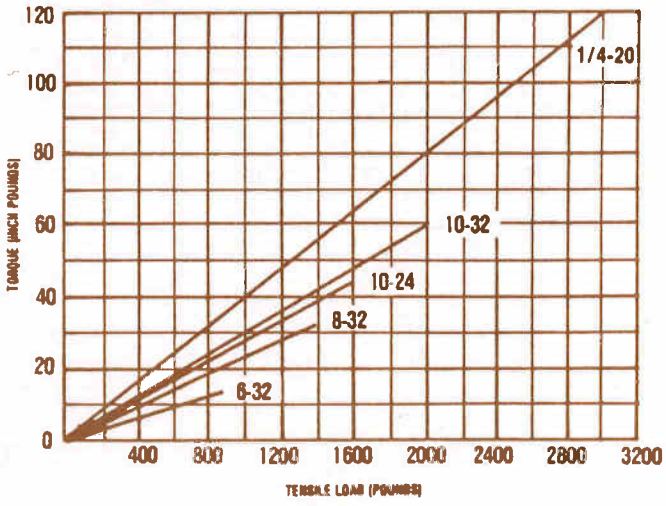
ALUMINUM



MILD STEEL ANNEALED



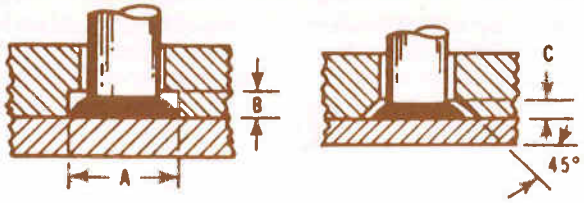
STAINLESS STEEL



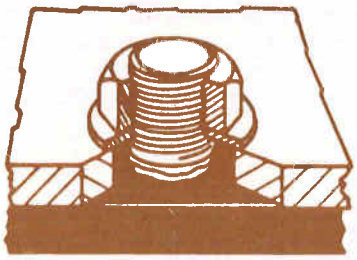
ACCOMMODATING THE FILLET

When a stud is end-welded, a fillet forms around its base with the fillet dimensions being closely controlled by the design of the ferrule used. Since the diameter of the fillet is generally larger than the diameter of the stud, some consideration is required in the design of mating parts. Counter bore and counter sink methods are commonly used. Dimensions will vary with studs and ferrules. Additional methods of accommodating fillet include over sized clearance holes, use of a gasket material around the fillet or use of a dog type construction.

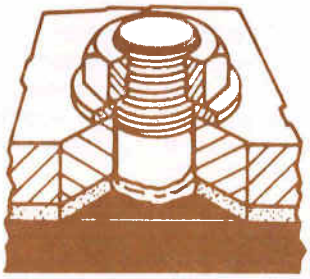
FILLET CLEARANCE FOR ELECTRIC-ARC WELDED FULL BASE STUDS



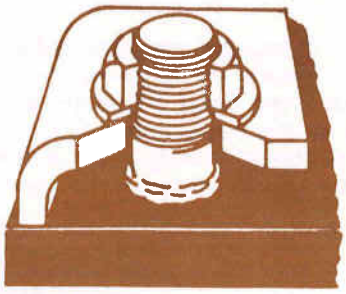
STUD SIZE (in.)	COUNTERBORE (in.)		90° COUNTERSINK (in.)
	A	B	C
1/4	0.437	0.125	0.125
5/16	0.500	0.125	0.125
3/8	0.593	0.125	0.125
7/16	0.656	0.187	0.125
1/2	0.750	0.187	0.187
5/8	0.875	0.218	0.187
3/4	1.125	0.312	0.187



(a) Oversize clearance hole

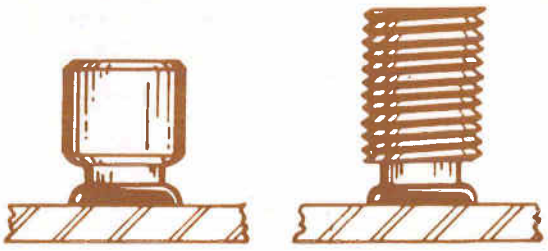


(b) Gasket material

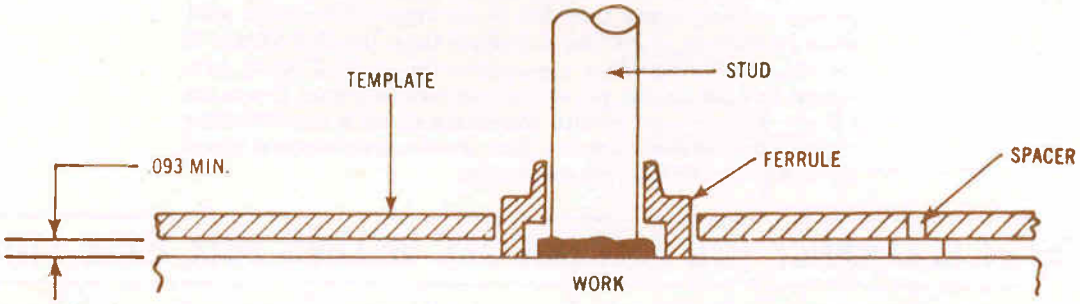


(c) Dog clamp

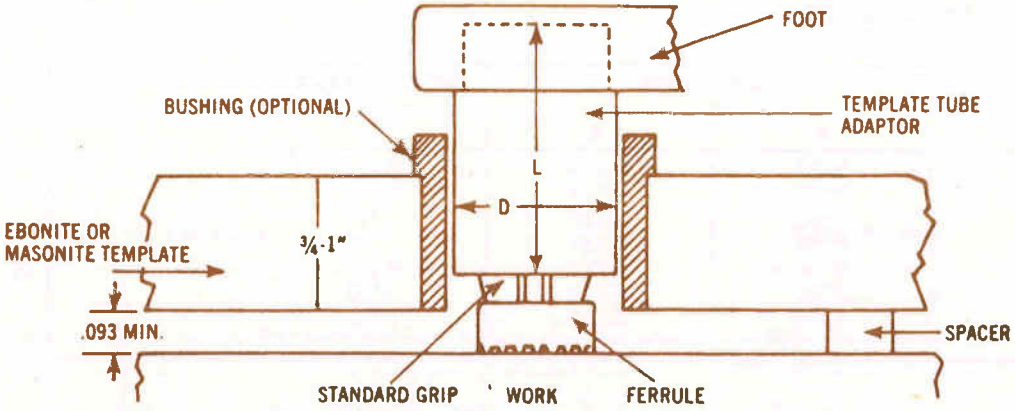
Welded studs designed with reduced weld bases so that weld fillet does not exceed maximum diameter of fastener. This design is not recommended if fastener strength is important.



TEMPLATE DESIGN FOR STUD LOCATING



This method of templating is recommended for use with all ferrules. The template is usually a steel plate $^{3}/_{32}$" to $^{3}/_{16}$" thick. Spacers are required to allow the gases to escape during the welding cycle. The ferrule can be held by a standard ferrule grip or where clearance is prohibitive a tube type set-up can be used. The recommended hole sizes on the template to locate the ferrules should equal the maximum outside diameter of the ferrule plus $^{1}/_{32}$". Holes may be drilled or bored at required locations. See stud specification sheets for ferrule detail.



Stud Size	D	L
½" and under	1.250	2.000
⅝" and ¾"	1.562	2.500
⅞" and larger	2.125	2.500

This method of templating is recommended for use with all stud styles. The design makes it possible to accurately hold angular alignment of the studs as well as stud location. The template should be made of ebonite or masonite of a thickness sufficient to afford good alignment. Bushings may be used to insure greater accuracy and extend the life of the template. Standard copper ferrule grips are used with the tube adaptor. This permits standardization of templates since it is only necessary to change the copper ferrule grip to weld studs of different diameters. The hole diameter of the bushing or template should be approximately .010 larger than the maximum outside diameter of the template tube adaptor.

RECOMMENDED MINIMUM PLATE THICKNESS OF STEEL AND ALUMINUM FOR ELECTRIC-ARC STUD WELDING

BASE DIA. OF STUD (in.)	STEEL		ALUMINUM	
	WITHOUT BACKUP (in.)	(gage)	WITHOUT BACKUP (in.)	WITH BACKUP (in.)
0.187	0.0359	20	0.125	0.125
0.250	0.0478	18	0.125	0.125
0.312	0.0598	16	0.187	0.125
0.375	0.0747	14	0.187	0.187
0.437	0.0897	13	0.250	0.187
0.500	0.1196	11	0.25	0.250
0.625	0.148	9	0.250	
0.750	0.187			
0.875	0.250			
1.000	0.375			

WEIGHT CHART

ESTIMATED WEIGHTS OF THREADED STUDS IN POUNDS PER 1000 PIECES								
LENGTH	¼ dia.	5/16 dia.	⅜ dia.	7/16 dia.	½ dia.	⅝ dia.	¾ dia.	⅞ dia.
¾	8.3	12.8	18.8	25.5	34.5			
1	11.0	17.0	25.0	34.0	46.0	70.0		
1¼	13.8	21.3	31.3	42.5	57.5	87.5	133.8	
1½	16.5	25.5	37.5	51.0	69.0	105.0	160.5	243.8
1¾	19.3	29.8	43.8	59.5	80.5	122.5	187.3	284.4
2	22.0	34.0	50.0	68.0	92.0	140.0	214.0	325.0
2¼	24.8	38.3	56.3	76.5	103.5	157.5	240.8	165.6
2½	27.5	42.5	62.5	85.0	115.0	175.0	267.5	406.3
2¾	30.3	46.8	68.8	93.5	126.5	192.5	294.3	446.9
3	33.0	51.0	75.0	102.0	138.0	210.0	321.0	487.5
3¼	35.8	55.3	81.3	110.5	149.5	227.5	347.8	528.1
3½	38.5	59.5	87.5	119.0	161.0	245.0	374.5	568.8
3¾	41.3	63.8	93.8	127.5	172.5	262.5	401.3	609.4
4	44.0	68.0	100.0	136.0	184.0	280.0	428.0	650.0
4¼	46.8	72.3	106.3	144.5	195.5	297.5	454.8	690.6
4½	49.5	76.5	112.5	153.0	207.0	315.0	481.5	731.3
4¾	52.3	80.8	118.8	161.5	218.5	332.5	508.3	771.9
5	55.0	85.0	125.0	170.0	230.0	350.0	535.0	812.5
EACH ADD'L. INCH	11.0	17.0	25.0	34.0	46.0	70.0	107.0	162.5
FERRULE	2.0	2.5	3.0	3.5	4.0	5.0	10.0	12.0

ESTIMATED WEIGHTS OF NO-THREAD STUDS IN POUNDS PER 1000 PIECES									
LENGTH	3/16 dia.	¼ dia.	5/16 dia.	⅜ dia.	7/16 dia.	½ dia.	⅝ dia.	¾ dia.	⅞ dia.
¾	6.0	10.5	16.4	23.5	31.9	41.7			
1	8.0	14.0	21.8	31.3	42.5	55.6	86.6		
1¼	10.0	17.5	27.3	39.1	53.1	69.5	108.3	156.0	
1½	12.0	21.0	32.7	47.0	63.8	83.4	129.9	187.2	225.0
1¾	14.0	24.5	38.2	54.8	74.4	97.3	151.6	218.4	297.5
2	16.0	28.0	43.6	62.6	85.0	111.2	173.2	249.6	340.0
2¼	18.0	31.5	49.1	70.4	95.6	125.1	194.9	280.8	382.5
2½	20.0	35.0	54.5	78.3	106.3	139.0	216.5	312.0	425.0
2¾	22.0	38.5	60.0	86.1	116.9	152.9	238.2	343.2	467.5
3	24.0	42.0	65.4	93.9	127.5	166.8	259.8	374.4	510.0
3¼	26.0	45.5	70.9	101.7	138.1	180.7	281.5	405.6	552.5
3½	28.0	49.0	76.3	117.4	148.8	194.6	303.1	436.8	595.0
3¾	30.0	52.5	81.8	125.2	159.4	208.5	324.8	468.0	637.5
4	32.0	56.0	87.2	125.2	170.0	222.4	346.4	499.2	680.0
4¼	34.0	59.5	92.7	133.0	180.6	236.3	368.1	530.4	722.5
4½	36.0	63.0	98.1	140.9	191.3	250.2	389.7	561.6	765.0
4¾	38.0	66.5	103.6	148.7	201.9	264.1	411.4	592.8	807.5
5	40.0	70.0	109.0	156.5	212.5	278.0	433.0	624.0	850.0
EACH ADD'L. INCH	8.0	14.0	21.8	31.3	42.5	55.6	86.6	124.8	170.0
FERRULE	3.0	3.5	4.0	5.0	6.0	7.5	9.0	27.0	37.0