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Agilent Technologies

FABRICATION STANDARDS PROCEDURE 8000

INSTRUCTION MANUAL

Part No. QA8000
Revision F
March 2005

FABRICATION STANDARDS PROCEDURE 8000

ATTENTION

UNLESS OTHERWISE SPECIFIED ON THE PURCHASE ORDER OR VACUUM TECHNOLOGIES INTERNAL SHOP WORK ORDER, ALL REQUIREMENTS OF THE DRAWING OR SPECIFICATION MUST BE MET.

Approved:



Quality Assurance Manager



General Manager

Objective

The objective of this Fabrication Standards Manual (Procedure 8000) is to supplement design information on Vacuum Technologies drawings.

All vendors and Vacuum Technologies manufacturing departments will be responsible for the implementation of the contents of this Standard in the performance of work for Vacuum Technologies as covered by Vacuum Technologies Purchase Orders and by shop work orders.

Failure to comply with the requirements contained in this Fabrication Standards manual may result in the rejection of the material produced or procured.

In the event of a conflict between these Standards, the drawing, and/or the Purchase Order, the Purchase Order shall take precedence, the drawing next, and then these Standards.

All questions from vendors concerning the interpretation of these Standards shall be directed to the Vacuum Technologies Purchasing Department.

Additional information or revisions will be supplied to vendors and Vacuum Technologies departments. It shall be the vendors responsibility and the responsibility of all Vacuum Technologies departments engaged in fabrication of piece parts, subassemblies, and finished products to keep these Standards up to date.

Revision Page

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1 Burrs, Sharp Edges, and Fillets

1.1 Burrs

1.1.1

A burr is defined as an objectionable, loose, hanging particle or fragment which interrupts the normal symmetry of a plane or surface.

1.1.2

It shall be standard practice to remove burrs from the edges of all surfaces, even if this requirement is not noted on the drawing. Burrs shall be removed to the extent that they are not visible without magnification.

1.1.3

The method of deburring must not introduce any contamination; all loose particles must be removed.

1.1.4

In no case shall the dimensional tolerance be exceeded as a result of a burr or removal of a burr.

1.2 Sharp Edges

1.2.1

A sharp edge is defined as the theoretical apex of the angle formed by the intersection of two planes at less than 180°.



1.2.2

It shall be standard practice to remove all sharp edges unless otherwise specified. Edges shall be broken by either a 45° chamfer or radius. If limits are not specified on the drawing, a 0.005 minimum chamfer or radius is acceptable.

1.2.3

A *sharp edge* callout on a drawing shall be interpreted as being a sharp edge limited to a 0.005 maximum chamfer, or radius.

1.3 Corners & Fillets

1.3.1

A corner or fillet shall be defined as the theoretical apex of an angle formed by the intersection of two planes at greater than 180° .

1.3.2

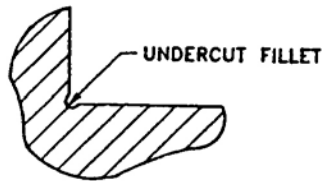
Unless otherwise specified on the drawing, all corners shall be limited to a 0.010 maximum radius or 1/32 fillet for machined parts.

1.3.3

A *sharp corner* callout on a drawing shall be interpreted as being a sharp corner up to a 0.005 maximum radius or fillet.

1.3.4

Undercuts shall be subject to rejection unless otherwise specified on the drawing.

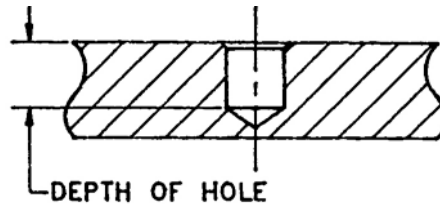


2 Holes

2.1 Drilled Holes

2.1.1

A drilled hole shall be measured for depth as the distance from the surface of entry to the limit of depth of the full diameter (thus excluding the drill point unless otherwise specified).



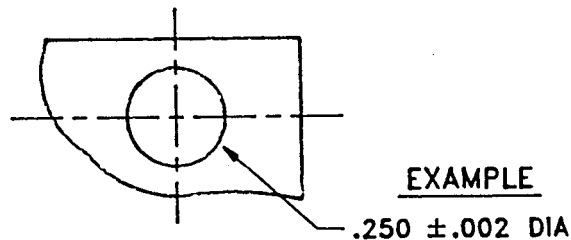
2.1.2

The tolerance of the depth of the hole shall be defined on the drawing.

2.2 Hole Diameter Tolerances

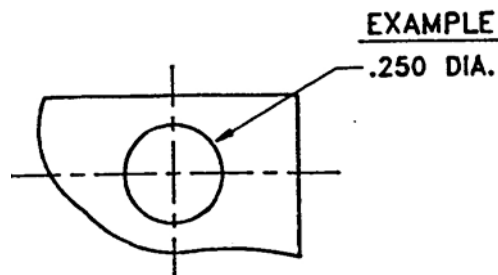
2.2.1

When a drawing calls for a hole and specifies the hole diameter and tolerance, the drawing tolerance shall take precedence.



2.2.1

When the drawing calls for a hole without tolerance on the hole dimension, the tolerance block shall apply.



3 Threads and Heli-Coils

3.1 General

3.1.1

All threads, unless otherwise specified on the drawing, shall conform to the unified tabulations and formulations as noted in the current edition of Machinery's Handbook.

3.1.2

The class of fit for external threads shall be defined as Class 2A, and for internal threads shall be defined as Class 2B unless otherwise specified on the drawing.

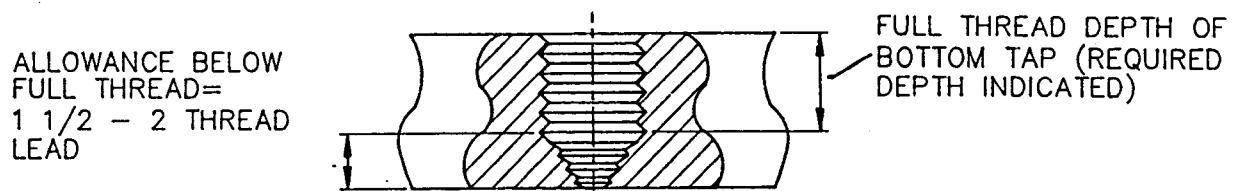
3.2 Threaded Holes

3.2.1

All threaded holes shall be countersunk $82^{\circ} \pm 5^{\circ}$ to a diameter of 0.030 larger than the major diameter of the specified thread. In the case of through holes, this requirement shall apply to both ends. A countersink shall not damage the threads.

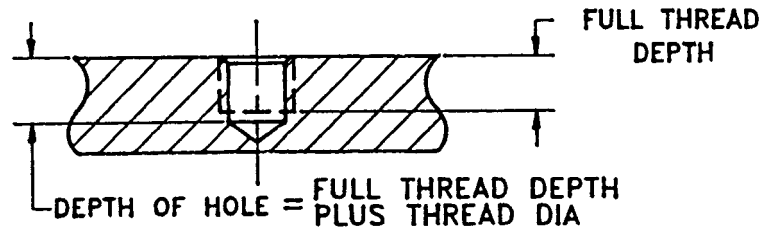
3.2.2

The specified depth of a threaded hole shall mean there will be full threads to that depth. When a bottom thread is specified, a 1-1/2 to 2 thread lead shall be acceptable below the thread.



3.2.3

The depth of the tap drill will not be specified unless critical. If the depth of a tap/twist drill hole is not specified, the depth of the hole shall not exceed the full thread depth plus a dimensional allowance equal to the nominal thread diameter.



3.2.4

In gauging a threaded hole, the NO-GO (Hi) gauge shall not penetrate more than three turns. The GO gauge shall freely enter the full length of the thread.

3.3 Threaded Parts

3.3.1

The end of all external threads shall be chamfered to an included angle of $90^\circ \pm 5^\circ$ to the minor diameter.

3.3.2

All screws (except standard purchased hardware) under the head protrusions may be necked or undercut to the root diameter of the thread, unless otherwise specified. The length of such undercut shall not exceed 3 full threads.

3.4 Metric Threads

Unless otherwise specified on the drawing, metric threads shall conform to the standards as noted in the current edition of Machinery's Handbook.

3.4.1 Basic Designations

I.S.O. metric threads are designated by the letter *M* followed by the nominal size in millimeters and the pitch in millimeters separated by the letter *x* (example: M16 x 1.5).

3.5 Heli-Coils

When heli-coil inserts are to be used on Vacuum Technologies parts, the following should be adhered to.

3.5.1 Class of Fit

For standard and screw-lock inserts no. 3 through no. 8, use 28; for larger size no. 10 and above, use 28 or 38.

4 Datums and Centering of Features

4.1 Datums

4.1.1

Definition - Datums are points, lines, planes, or surfaces of cylinders assumed to be exact for purposes of computation from which the location or geometric relationship (form) of features of a part may be established.

4.1.2

Dimension Callout - Dimensions on Vacuum Technologies drawings shall be taken from datum surfaces and are not relative to each other or measured from centerlines, unless otherwise specified on the drawing.

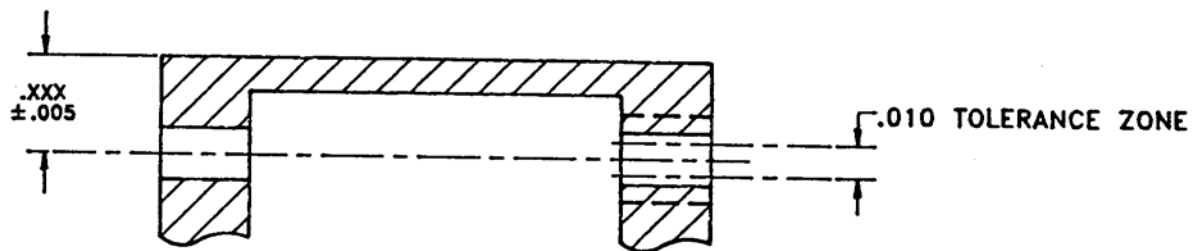
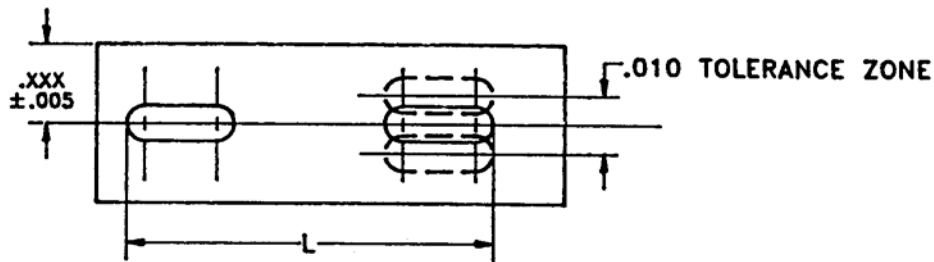
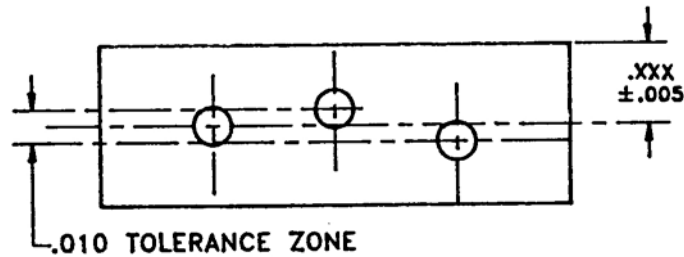
4.1.3

Casting and Forging Datums - Datums for castings and forgings may be temporary datums used only to locate machined surfaces which will subsequently serve as the permanent datum. Such temporary datums may or may not be removed by machining. Machining datums should be surfaces or centers of features which are not changed by subsequent machining.

4.2 Tolerances with Respect to Centerlines


4.2.1

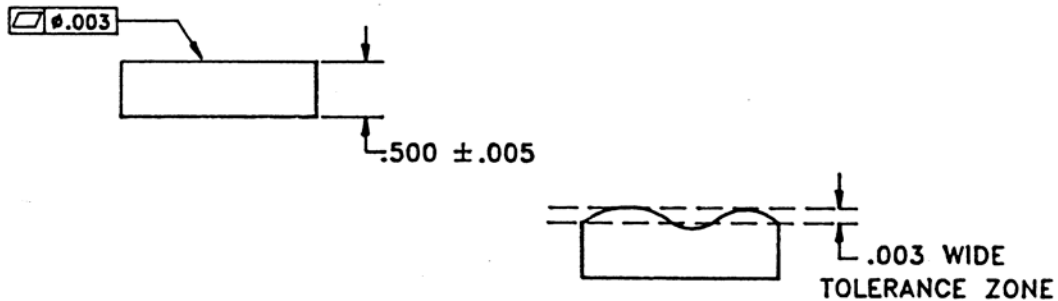
When a centerline common to several features is located from a datum by a tolerated dimension, each element may vary from the nominal centerline within the limits of the given tolerance.



5 Flatness (Reference ANSI-Y-14.5)

5.1 Flatness

When the symbol for flatness  X.XXX appears on a Vacuum Technologies manufacturing drawing, it shall be defined as the condition of a surface having all elements in one plane. The tolerance zone is confined by two parallel planes within which the surface must lie.

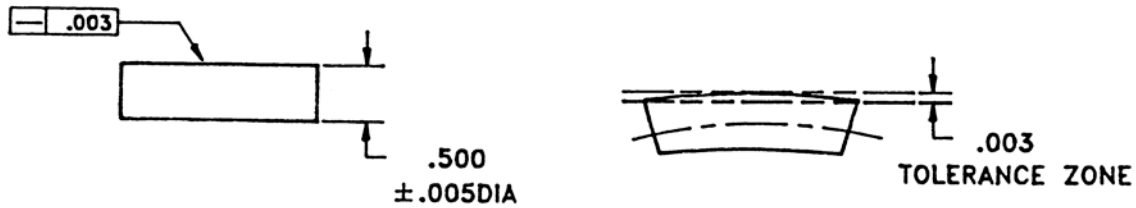


This surface must be within the specified tolerance of size 0.495 to 0.505 and must lie between two parallel planes 0.003 apart.

6 Straightness

6.1 Straightness

When the symbol for straightness $\boxed{\text{—}} \boxed{\text{X.XXX}}$ appears on a Vacuum Technologies manufacturing drawing, it shall be defined as a condition where an element of a surface or an axis is a straight line. The straightness tolerance specifies a tolerance zone within which an axis or all points of the considered element must lie.



The feature must be within the specified 0.495 to 0.505 tolerance of size and any longitudinal element of its surface must be between two parallel lines 0.003 apart where the two lines and the nominal axis of the feature share a common plane.

7 Concentricity (Reference ANSY- Y-14.5)

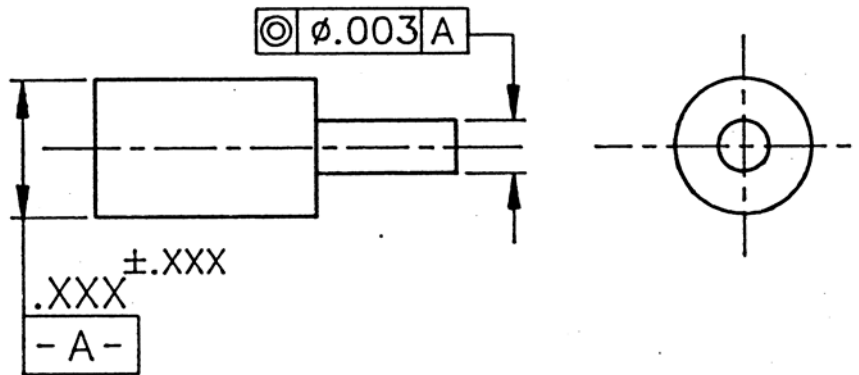
7.1 Concentricity

Concentricity is the condition where the axes of all cross-sectional elements of a feature's surface of revolution are common to the axis of a datum feature.

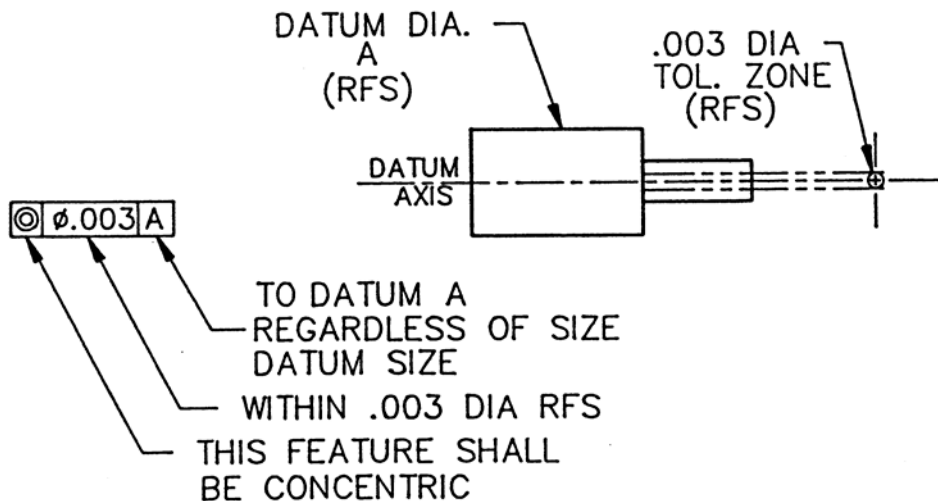
7.2 Concentricity Tolerance

The Concentricity Tolerance is the diameter of the cylindrical tolerance zone within which the axis of the feature(s) must lie; the axis of the tolerance zone must coincide with the axis of the datum feature (s).

EXAMPLE



MEANING



8 Perpendicularity (Squareness, Normality)

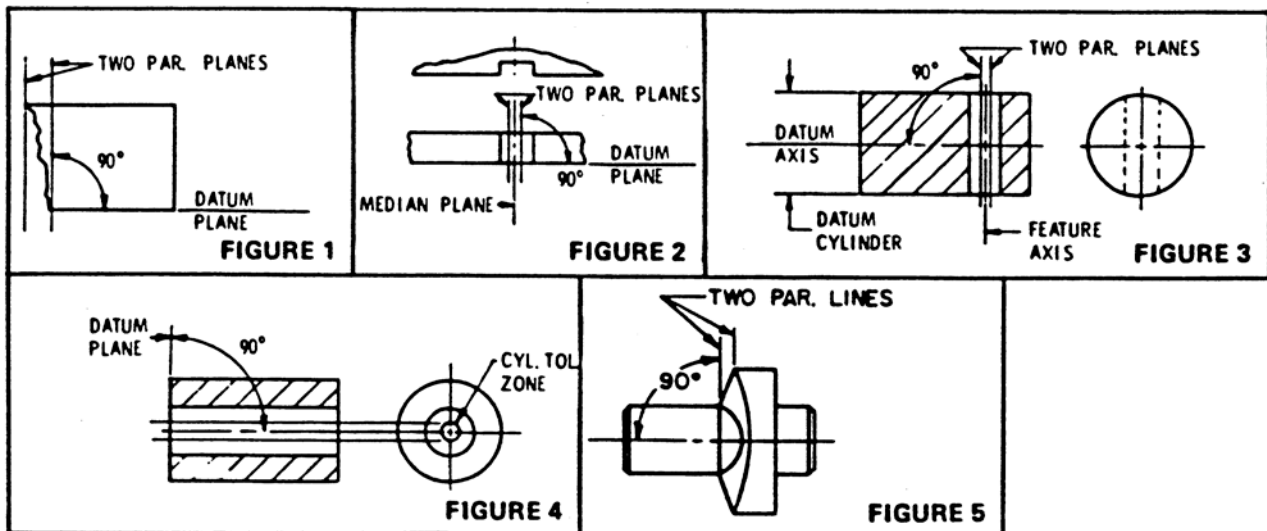
8.1 Perpendicularity

Perpendicularity is the condition of a surface, median plane, or axis which is at exactly 90° to a datum plane or axis.

8.2 Perpendicularity Tolerance

A perpendicularity tolerance specifies:

- 1 a tolerance zone defined by two parallel planes perpendicular to a datum plane within which:
 - ☐ a the surface of a feature must lie (see Figure 1 below);
 - ☐ b the median plane of a feature must lie (see Figure 2 below);
- 2 a tolerance zone defined by two parallel planes perpendicular to a datum axis within which the axis of a feature must lie (see Figure 3 below);
- 3 a cylindrical tolerance zone perpendicular to a datum plane within which the axis of a feature must lie (see Figure 4 below);
- 4 a tolerance zone defined by two parallel, straight lines perpendicular to a datum plane or datum axis within which an element of the surface must lie (see Figure 5 below).



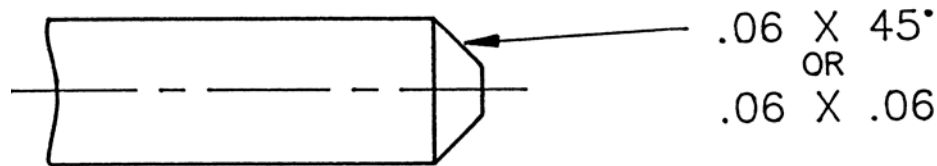
9 Chamfers

9.1 Chamfers Defined

Chamfers shall be indicated by an angle and a length. Chamfers imply that stock is required to be removed from the corner to the point on the surface where the chamfer ends equal to that called out in the note. The dimension is the measurement along the length of the part, and not along the slope of the chamfer.

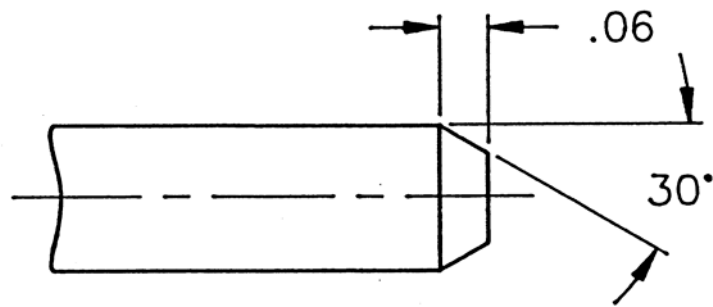
9.1.1 Chamfers 45 °

May be called out on a drawing in either dimensional or note form because the size dimension may apply to either side because of equivalent dimensions.
















9.1.2 Chamfers Other Than 45 °

Chamfers greater or less than 45° - The size of the chamfer will be indicated for the side adjacent to that on which the angle is shown.







10 Symbols (Reference ANSI- Y14.5M)

The following symbols are used on Vacuum Technologies drawings.

ANGULARITY	PARALLELISM
 FLATNESS	 STRAIGHTNESS
 ANGULARITY	 PARALLELISM
 ROUNDNESS (Circularity)	 CYLINDRICITY
 PROFILE OF ANY SURFACE	 PROFILE OF ANY LINE
 RUNOUT	 TRUE POSITION
 CONCENTRICITY	 SYMMETRY
 PERPENDICULARITY (Squareness, Normality)	

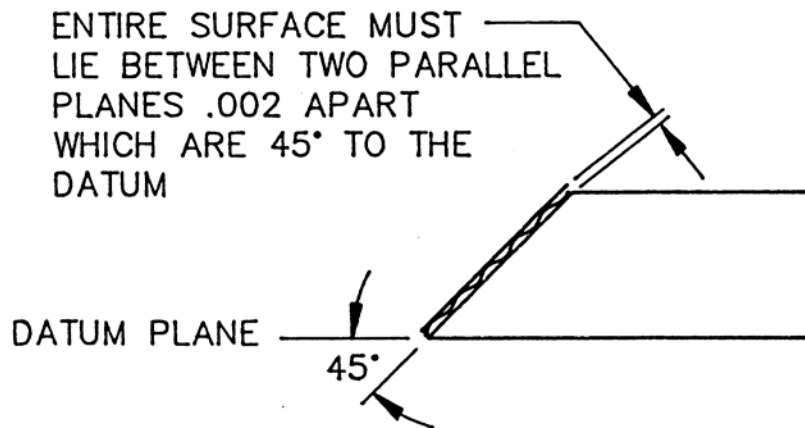
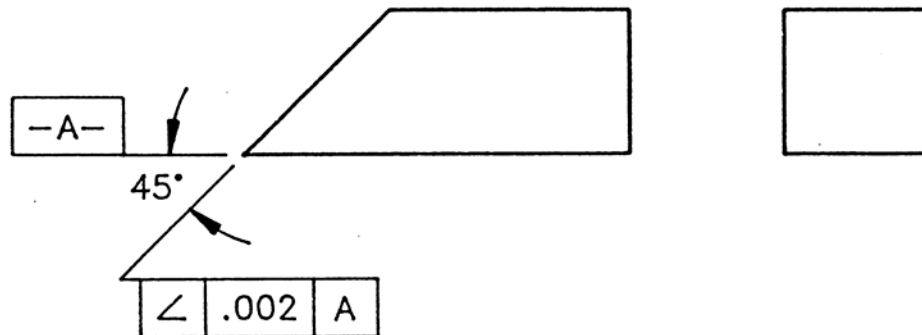
Special Symbols

 Maximum Material Condition	 Projected Tolerance Zone
 Regardless of Feature Size	 Least Material Condition

11 Angularity

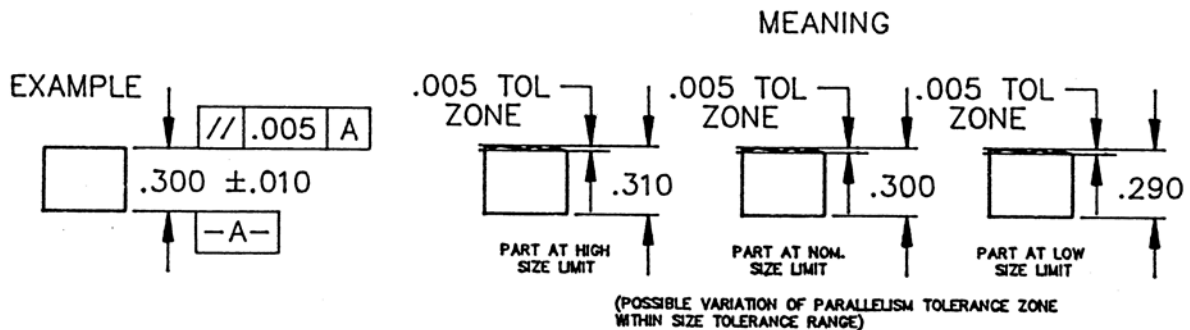
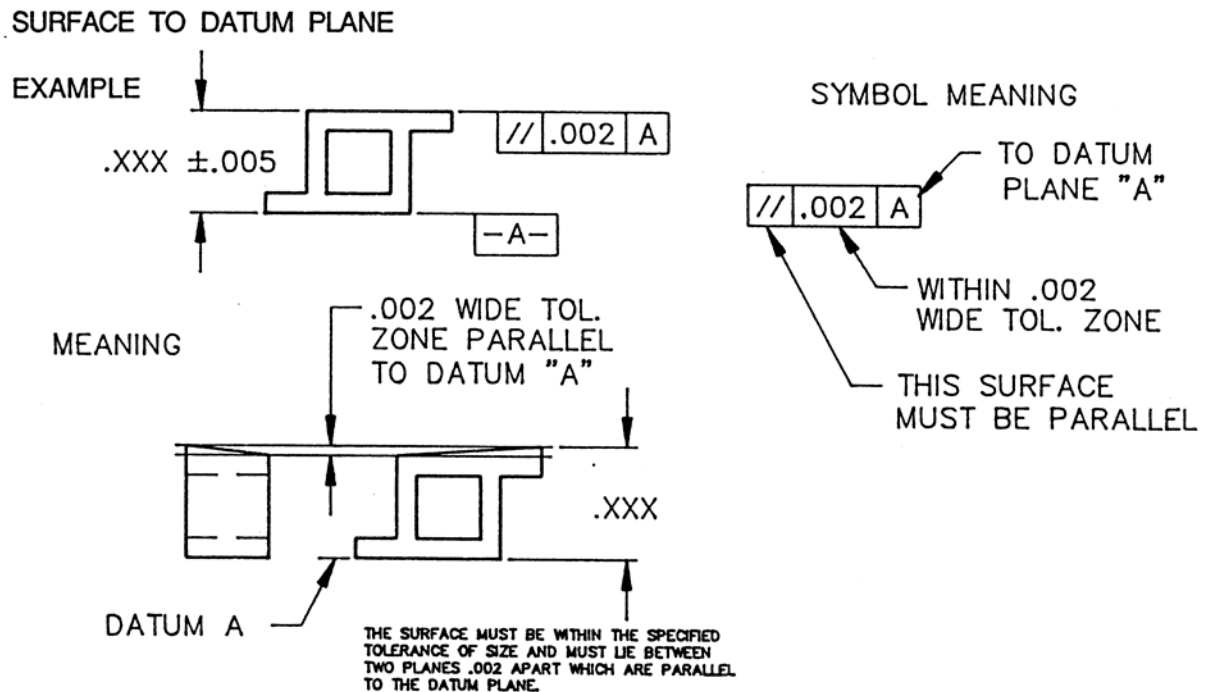
Angularity is the condition of a surface, axis, or median plane which is at a specified angle (other than 90°) from a datum plane or axis.

DRAWING CALLOUT



12 Parallelism (Reference ANSI-Y14.5M)

Parallelism is the condition of a surface, line, or axis which is equidistant at all points from a datum plane or axis.



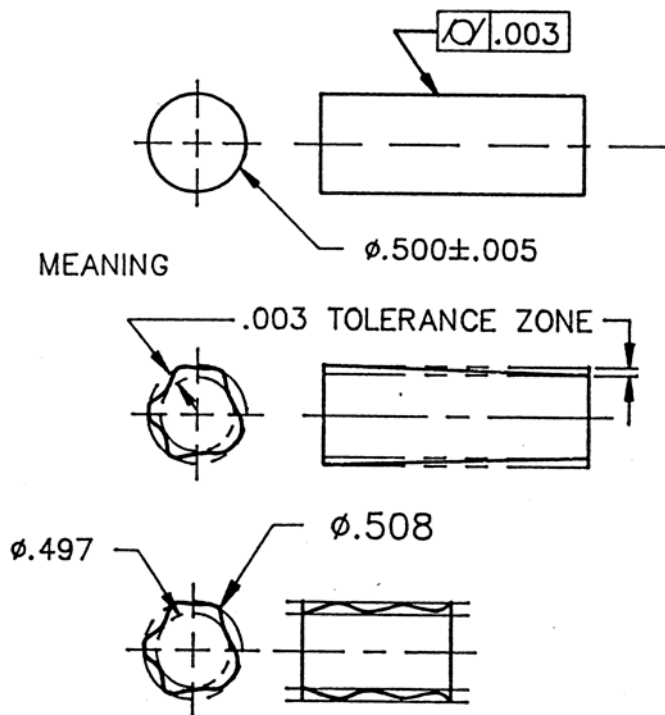
13 Cylindricity (Reference ANSI-Y14.5M)

Cylindricity is the condition of a surface of revolution in which all elements of the surface are equidistant from a common axis.

A cylindricity tolerance specifies a tolerance zone bounded by two concentric cylinders within which the surface must lie.

THE FEATURE MUST BE WITHIN THE SPECIFIED TOLERANCE OF SIZE AND MUST LIE BETWEEN TWO CONCENTRIC CYLINDERS (ONE HAVING A RADIUS .003 LARGER THAN THE OTHER)

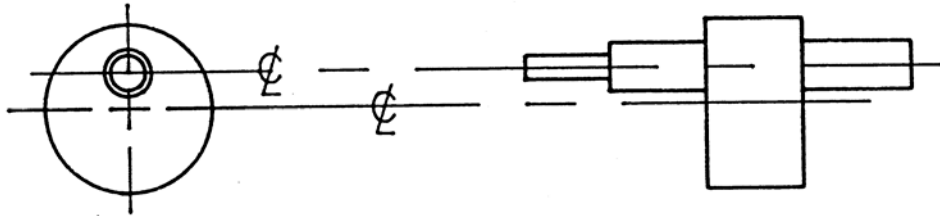
EXAMPLE



THE FEATURE MUST BE WITHIN THE SPECIFIED TOLERANCE OF SIZE AND MUST LIE BETWEEN TWO CONCENTRIC CYLINDERS (ONE HAVING A RADIUS .003 LARGER THAN THE OTHER)

14 Eccentricity

Eccentricity is a condition where two circular areas in the same or parallel planes do not have the same center. Eccentricity is the distance between the different centers projected to one plane. Runout is twice the eccentricity.



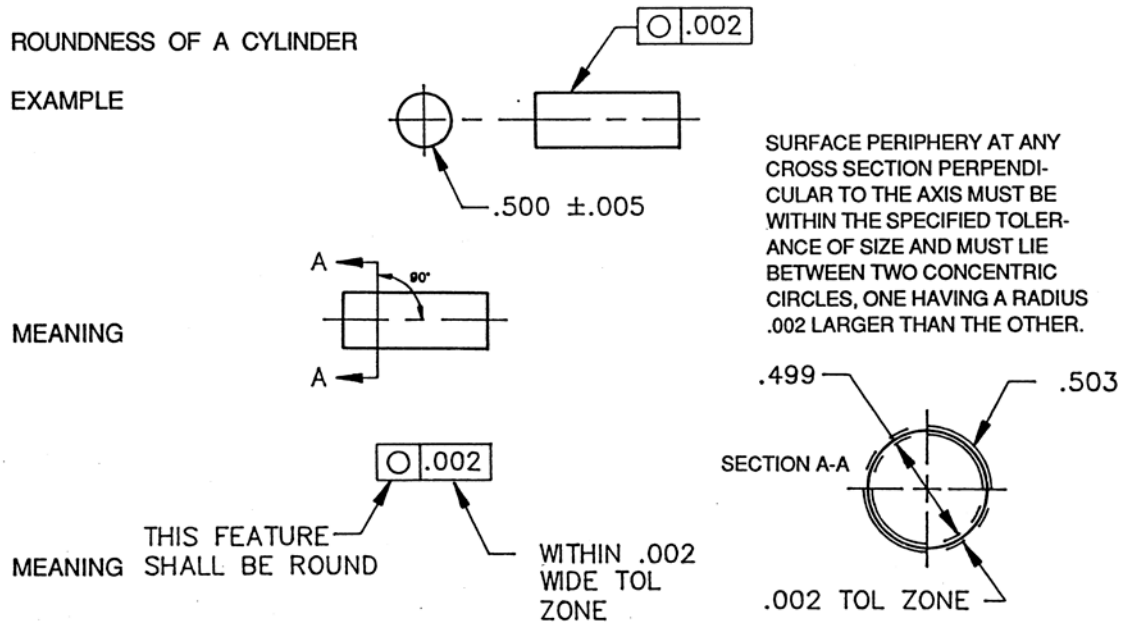
15 Roundness (Reference ANSI-Y14.5)

15.1 Roundness is the condition on a surface of revolution where:

- 1 in the case of a cylinder or cone, all points of the surface intersected by any plane perpendicular to a common axis are equidistant from their axis;
- 2 in the case of a sphere, all points of the surface intersected by any plane passing through a common center are equidistant from that center.

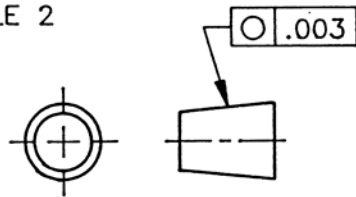
15.2 Roundness Tolerance

A roundness tolerance specifies a tolerance zone bounded by two concentric circles within which each circular element of the surface must lie and applies independently at any plane as described above.

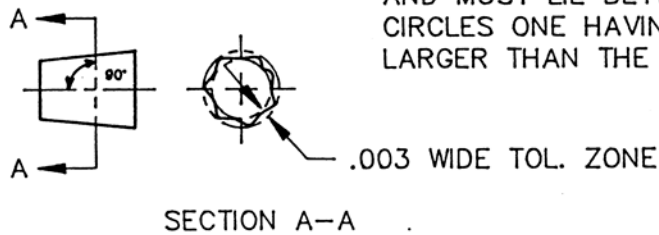


ROUNDNESS OF CONE

EXAMPLE 2

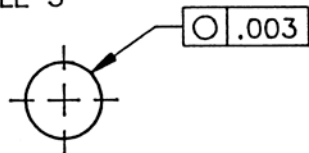


MEANING

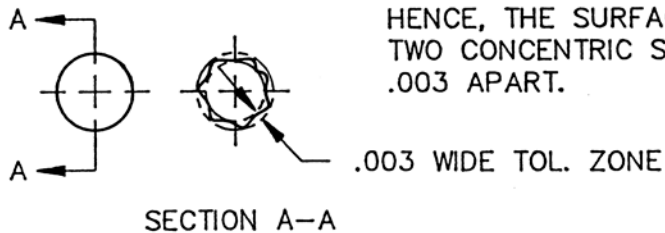


ROUNDNESS OF SPHERE

EXAMPLE 3



MEANING

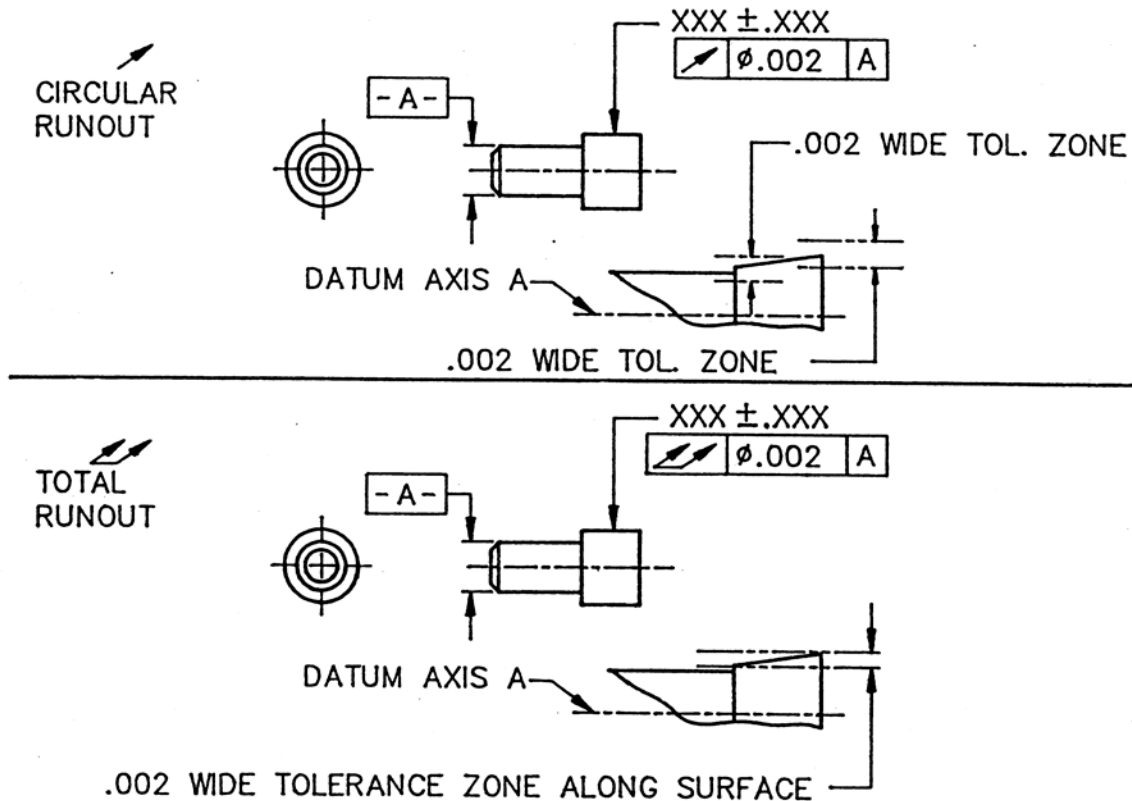


16 Runout

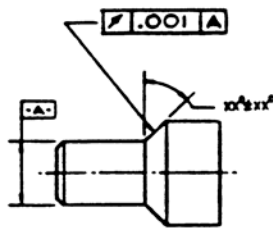
Runout is the composite deviation from the desired form of a part surface of revolution during full rotation (360°) of the part on a datum axis.

Runout tolerance states how far an actual surface or feature is permitted to deviate from the desired form implied by the drawing during full rotation (360°) of the part on a datum axis.

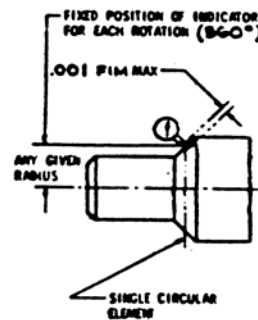
Runout tolerance may be applied in two different ways using the characteristics shown in the following examples.



EXAMPLE

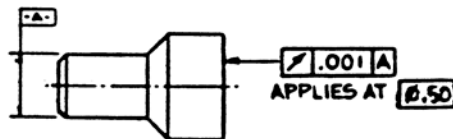


MEANING

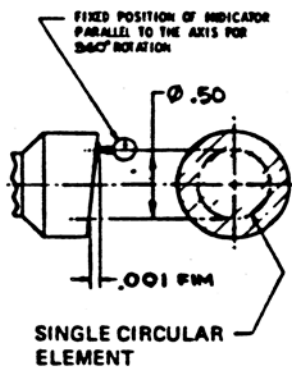


The feature must be within the specified tolerance of size at any measuring position, each circular element of the surface must be within .001 full indicator movement when the part is rotated one full rotation about the specified datum axis with the indicator fixed in a position normal to the surface. (This does not control form of the total specified surface area, but only controls the runout of each circular element.)

EXAMPLE



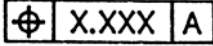
MEANING



The circular element of the surface at $\phi .50$ must be within .001 full indicator movement when the part is rotated one full rotation about the specified datum axis with the indicator fixed in a position parallel to the axis. (this does not control perpendicularity, but controls only the lateral runout (wobble) of each circular element at the specified surface location.)

17 True Positioning

17.1 True Positioning

When the symbol for true position  is shown on a drawing, the location of the center of a hole or pin shall be measured by the basic dimension from a datum and lie within a tolerance circle with a X.XXX diameter. Interpretations of other uses of true position tolerance shall be in accordance with USASI Standard Y 14.5.

17.2 Modifiers

A modifier is the term used to describe the application of the *maximum material condition* (MMC) or *regardless of feature size* (RFS) principles.

17.2.1 Maximum Material Condition (MMC)

A Maximum Material Condition is that condition or part feature wherein it contains the maximum amount of material; e.g., minimum hole size and maximum shaft size.

17.2.2 Regardless of Feature Size (RFS)

This is the condition where the tolerance of form or position must be met irrespective of where the feature lies within its size tolerance.

17.3 Special Symbols

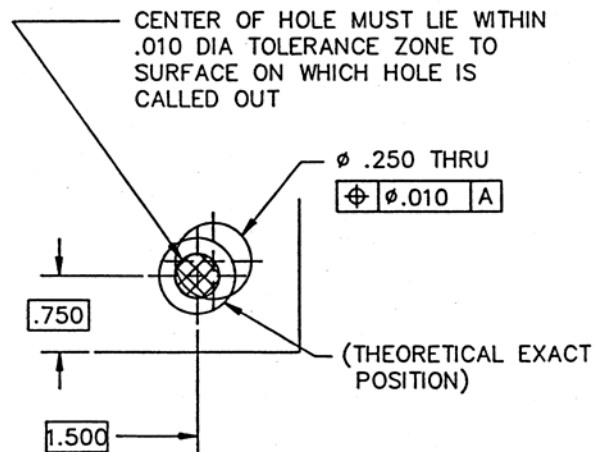
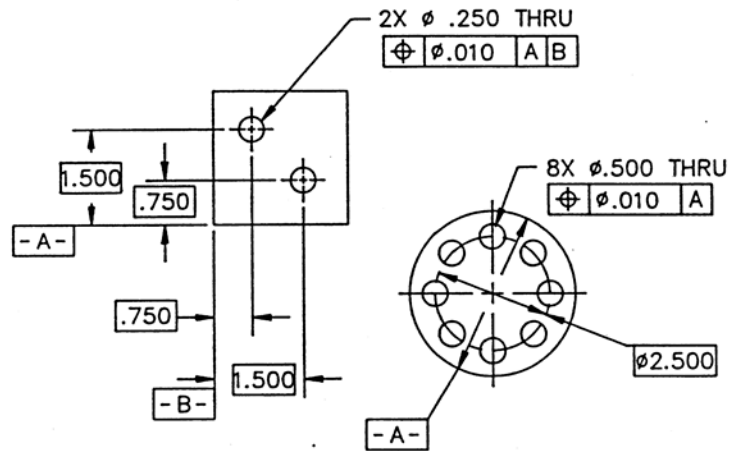
These will usually refer to a projected tolerance zone and a least material condition.

17.3.1 Projected Tolerance Zone

The Projected Tolerance Zone is a tolerance zone applied to a hole into which a pin, stud, screw, or bolt, etc., is to be inserted. It controls the perpendicularity of the hole to the extent of the projection from the hole and as it relates to the mating part clearance. The projected tolerance zone extends above the surface of the part to the functional length of the pin, screw, etc., relative to its assembly with the mating part.

17.3.2 Least Material Condition

The Least Material Condition implies that condition of a part feature wherein it contains the least (minimum) amount of material; e.g., the largest hole size and the smallest shaft size.



18 Hole Positioning

18.1 Hole Positioning - General

Positioning or locating holes as shown on Vacuum Technologies drawings can be illustrated using several methods. These methods are also used to locate pins and other features of symmetrical contour.

18.2 Coordinate Dimensioning

Is a rectangular datum dimensioning most frequently used to dimension holes on Vacuum Technologies drawings. All dimensions are measured from two or three mutually perpendicular datum planes except related holes. The methods shown in Figures 1 and 2, on pg. 26, are used.

18.3 Repetitive Dimensions

Where a series of holes are spaced equally, dimensions may be applied by the notations equally spaced as illustrated in Figures 3 and 4 on pg. 26. When the notation *Equally Spaced* similar to the 2.000 Dia Bolt Circle appears as in Figure 3, the chordal distance between any two holes shall be within the tolerance of the bolt circle diameter. In this case, the chordal distance *A* would carry a tolerance of ± 0.005 due to the decimal tolerance of the bolt circle diameter.

18.4 True Position

The basic location of each hole is given by the use of untoleranced dimensions. This method requires extensive definition, therefore refer to the specification entitled *True Positioning* in this Fabrication Standard.

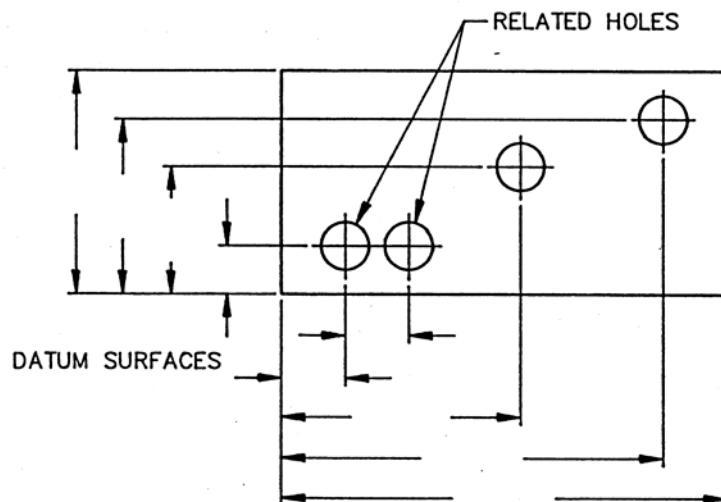


Figure 1 - Co-ordinate Dimensions - Datum Surfaces

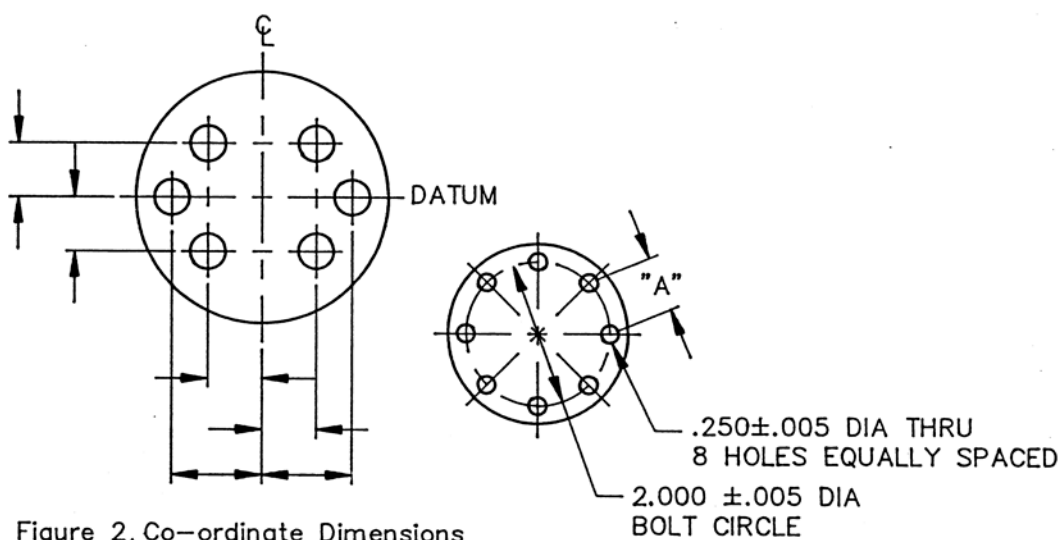


Figure 2. Co-ordinate Dimensions Center Line Datums

Figure 3 - Repetitive Dimensions

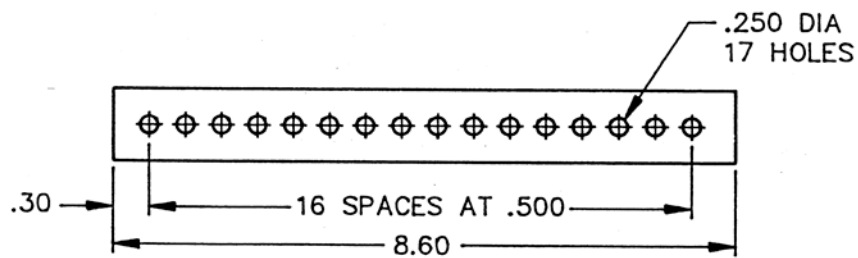


Figure 4 - Repetitive Dimensions

19 Plating and Coating of Surfaces

19.1 Plating and Coating of Surfaces - General

When a part or assembly drawing calls out plating or coating, it shall be implied that dimensions on the drawing are machine/fabrication dimensions, and the part/assembly has been designed to allow for the application of the plating or coating (unless otherwise noted).

19.2 Plating and Coating of Surfaces - Precious Metals

When the plating of precious metals is requested, *Source Inspection at the Vendors' Facility* should be stated on the Vacuum Technologies Purchase Order.

20 Metal Stampings

20.1 Metal Stampings - General

A stamping is a part of predetermined size and shape that is produced by passing cold sheet or strip through a pair of dies. During the cutting and/or pressing operation, the stock assumes the size, shape, and contour of the dies. The following requirements form a part of the Vacuum Technologies drawings for metal stampings.

20.2 Squareness/Perpendicularity of Sides

Between two sheared edges, two formed sides, or a sheared side and a formed side, the squareness shall be within the tolerances specified on the drawing. See Figure 1 in Section 20.6.3 "Minimum Requirements".

20.3 Flatness

Flatness of sheet metal stampings shall conform to the tolerances specified on the manufacturing drawing.

20.4 Right Angle Bends

The formed side of the sheet metal shall be perpendicular to the plate within the tolerance indicated on the manufacturing drawing.

20.5 Bend Radii

Right-angle bends shall have a minimum inside radius shown in Tables 1, 2, and 3. For metals not included, the bend radii shall, at a minimum, be equal to the stock thickness.

20.6 Holes/Slots

The location of a hole or a slot too close to a bend will cause distortion and the shape of the hole may be eccentric so as to prevent function. The following are minimum requirements. See Figure 2 in Section 20.6.3 "Minimum Requirements".

20.6.1 Opening Adjacent to Bend

Minimum inside distance from the edge of a hole to a bend is 1-1/2 times the material thickness plus the bend radius.

20.6.2 Opening Parallel to a Bend

The longer the slot, the greater the allowance which must be made in the distance between the edge of the slot and the bend. Where an opening is parallel to a bend, the following allowances should be made for economical tooling.

20.6.3 Minimum Requirements

When L is up to 1 inch, $H = 2T + R$

When L is 1 inch to 2 inches, $H = 2-1/2T + R$

When L is 2 inches or more, $H = 3T$ to $3-1/2T + R$

Punched, extruded, pierced, or drilled holes shall be in accordance with dimensions and tolerances indicated on the drawing.

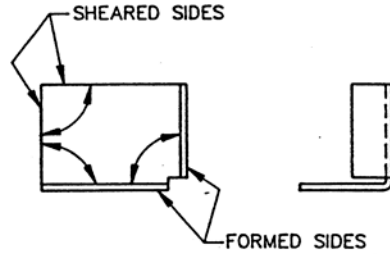


Figure 1

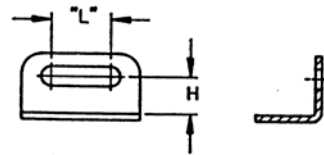
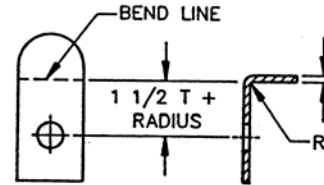


Figure 2

Table 1 Austenitic Stainless Steel				
Steel	Condition	Thickness Range (in.)	Bend Radius	Bend Angle (deg.)
301. 302. 304	Annealed	All	1/3 T	180
	1/4 Hard	To 0.060 Over 0.061	1/3 T 1 T	180 90
	1/2 Hard	To 0.060 Over 0.061	1 T 1 T	180 90
	Hard	To 0.030 0.031 - 0.050	2 T 1 1/2 T	180 90
316	Annealed	All	1 1/2 T	180
	1/4 Hard	To 0.060 Over 0.051	1 T 1 T	180 90

Vacuum Technologies Fabrication Standards

Table 1 Austentic Stainless Steel				
Steel	Condition	Thickness Range (in.)	Bend Radius	Bend Angle (deg.)
	½ Hard	To 0.030	2 T	180
		0.031 - 0.050	3 T	90
		Over 0.051	2 T	90
321, 347	Annealed	All	½ T	180

Table 2 Aluminum Alloys			
Alloy and Temper	Condition	Thickness (in.)	Bend Radius
1100 - 0	Annealed	0.016 - 0.125	Sharp
1100 - H12	¼ Hard	0.016 - 0.125	Sharp
1100 - H14	½ Hard	0.016 - 0.125	Sharp
1100 - H18	Hard	0.064	1- 2T
3300 - 0	Annealed	0.016 - 0.125	Sharp
3003 - H12	¼ Hard	0.016 - 0.125	Sharp
3003 - H14	½ Hard	0.016 - 0.125	Sharp
3003 - H18	Hard	0.064	1½- 3T
5050 - 0	Annealed	0.016 - 0.125	Sharp
5050 - H32	¼ Hard	0.016 - 0.125	0 - 1T
5050 - H34	½ Hard	0.016 - 0.125	0 - 1T
5050 - H38	Hard	0.064	1½- 3T
5052 - 0	Annealed	0.016 - 0.125	Sharp
5052 - H32	¼ Hard	0.016 - 0.125	0 - 1T
5052 - H34	½ Hard	0.016 - 0.125	½ - 1½T
5052 - H38	Hard	0.064	1- 2T
6061 - 0	Annealed	0.016 - 0.125	Sharp
6061 - T4	Heat Treated	0.064	½ - 1½T
7075 - 0	Annealed	0.016 - 0.125	0 - 1T
7075 - T6	Heat Treated	0.064	3 - 5T

Table 3 Carbon and Low Alloy Steel							
SAE Steel	Thickness (in.)						
	0.016	0.025	0.035	0.050	0.062	0.100	0.187
1020-1025	0.03	0.03	0.06	0.05	0.06	0.13	0.19
1070-1095	0.05	0.06	0.09	0.13	0.15	0.31	0.50
4130*	0.03	0.03	0.06	0.09	0.09	0.16	0.31
8630*	0.03	0.03	0.06	0.09	0.09	0.16	0.31

*Annealed

21 Casting Definitions

21.1 Casting Definitions - Specification Sheet

This specification sheet is designed as amplification of descriptive terms to be used in conjunction with drawings furnished to vendors by Vacuum Technologies.

21.2 Casting Definitions - Defined

The following definitions of words common to casting processes are to be used in conjunction with Vacuum Technologies drawings.

21.2.1

Annealing - Any treatment of castings at elevated temperatures which has for its principle purpose softening and removal of residual stresses.

21.2.2

Blister - A defect on the surface of a casting appearing as a shallow blow hole with a thin film of metal projecting above it.

21.2.3

Blow Hole (or *gas hole*) - A cavity-type defect on the surface of the casting due to trapping of a gas in molten or partially molten metal.

21.2.4

Buckle - A defect on a casting surface appearing as an indentation resulting from an expansion scab on the mold surface.

21.2.5

Cold Shut - A seam, lap, or fold-like discontinuity which is formed when two streams of molten metal approach each other from two different directions in the mold cavity, join in physical contact, but lack sufficient fluidity to establish an intimate metal fusion through the intervening oxide film.

21.2.6

Core Seam - A seam-like fissure appearing on the casting at the point where the core has been attached to the mold, caused by incorrect blending of the core into the casing cavity.

21.2.7

Core Shift - The cores are not correctly set or the cores are not adequately anchored in place with the result that some movement occurs when the casting is poured. Either of these may result in a finished casting with incorrect dimensions.

21.2.8 Crack

21.2.8.1

Hot - Developed before the casting has cooled completely, usually due to some part of the mold restraining solid contraction of metal.

21.2.8.2

Shrink - Metal has shrunk and pulled away from the surface during freezing, causing a crack-like shrink.

21.2.8.3

Stress - Fissures, continuous throughout their length. They exist singly and terminate at the surface, usually found in comers of radii, and are usually not of sufficient depth to affect the strength of the casting.

21.2.8.4

Quench - Caused by an uneven quenching (with water that is too cold).

21.2.9

Draft - Taper given to a casting to enable it to be withdrawn from the mold.

21.2.10

Ejection Pin Marks - Marks left on casting by ejection (knockout) pins.

21.2.11

Flash - Thin sections of material occurring along a parting line, where some of the casting material penetrates slightly between mating sections of the mold, extending beyond the mold cavity.

21.2.12

Gate - The point or area where the casting material enters the mold cavity.

21.2.13

Gate Mark - The rough surface left when the cast part is separated from the gate or runner system which carried the molten material into the mold cavity. It can easily be confused with the marks left after trimming off of overflow wells.

21.2.14

Impregnation - A process for sealing by injecting under pressure liquid synthetic resins, tuna oil, etc., into the casting where it is solidified in place by heating or baking.

21.2.15

Inclusions - Particles of sand or other impurities such as oxides, flux, refractories, etc., trapped mechanically during solidification of metal.

21.2.16

Investment Casting - Method of molding using a pattern of wax, plastic, or frozen mercury which is *invested* or surrounded by a molding medium in slurry or liquid form. After the molding medium has solidified, the wax or frozen mercury pattern is removed by subjecting the mold to heat, leaving a cavity for reception of molten metal; also called lost wax process or precision molding.

21.2.17

Mica Effect - Areas on the surface of a casting where the material is not homogeneous, due to too rapid cooling or entrapped inclusions, and the defect has the cast material separated into layers.

21.2.18

Mismatch - Misalignment along the parting line resulting from improper alignment of mold halves.

21.2.19

Misrun - A discontinuity in a casting caused by the failure of the molten metal to completely fill the cavity mold.

21.2.20

Microporosity - Extremely fine pores.

21.2.21

Parting Line - The mark left on the casting where the mold halves meet.

21.2.22

Permanent Mold - A long-life, reusable mold, usually iron.

21.2.23

Pin Hole Porosity - Pores which are larger than micro porosity.

21.2.24

Porosity - Unsoundness in the casting, appearing as pores permitting passage of liquid or gas through the thin wall.

21.2.25

Run Marks or *Heat Check Lines* - Fine lines raised on the surface of the casting caused by heat degradation of mold materials, usually in a die.

21.2.26

Sand Castings - Metal casting produced in sand molds.

21.2.27

Shrink Mark - A depression on the surface of the casting caused by a contraction of material when cooling.

21.2.28

Sponge - Honeycomb structure, as a localized mottled area, caused by inadequate feeding of a section in process of solidification.

21.2.29

Surface Lap - A step in a surface of a casting.

21.2.30

Surface Porosity - Micro or pinhole porosity visibly apparent on the surface of the casting.

21.2.31

Voids - Areas within a casting not filled by the casting material, and not visible on the surface.

21.2.32

Weld Line - A visible line formed where the molten or fluid casting material meets after flowing around a core or other obstructions in the mold, and does not make a homogeneous union.

22 Sand Castings

22.1 Sand Castings - Specification Sheet

This specification sheet is to be used in conjunction with the applicable casting drawing and issued purchase order.

22.1 Sand Castings - Certification

Unless otherwise specified by the drawing or purchase order, the Vacuum Technologies vendor is responsible, where required, for furnishing certification and/or other substantiating evidence that castings procured have been inspected and meet the requirements of the purchase order. Where such certification is required, the following requirements will be adhered to.

22.2 General Requirements

22.2.1

Casting Material - The supplier shall certify that the material used is in accordance with the material called out on the drawing.

22.2.2

Surface Finish - all external surfaces shall be finished in such a manner as to produce a substantially uniform appearance. Internal surfaces shall be free of excess material. Risers, gates, and parting lines shall be removed in a workmanlike manner. Unless otherwise specified on the drawing, the surface of the completed casting shall be equal to or better than $\sqrt{250}$, unless otherwise noted on the drawing.

22.2.3

Dimensions and Tolerances - The supplier shall meet all dimensions and tolerances called out on the drawing. If dimensions or tolerances are not capable of being cast, the supplier shall request direction from the Vacuum Technologies Purchasing Department prior to casting the part.

22.2.4

Draft - Tolerances on cast dimensions do not include draft unless otherwise noted on the drawing. When there is a maximum permissible limit for draft, the drawing will so note. When surfaces must be free of draft or when the direction of draft is of importance, the drawing will be so noted.

22.2.5

Test Bars - When Test Bars are required by the specification or purchase order, they shall be of the same melt of material and the same heat treatment batch as the castings that they are offered as representing. The castings and bars shall be suitably marked for cross -reference.

22.2.6

Radiography and Fluorescent Penetrants - When Radiographs and Fluorescent Penetrants are required for castings, as defined by the Vacuum Technologies Purchase Order, they shall be identified with the casting and with the particular areas of the castings that they represent.

22.2.7

Heat Treatment - The supplier shall certify that the casting is in the heat treat condition as specified on the drawing.

22.2.8

Repair of Castings - Castings shall not be peened, plugged, welded, or impregnated unless approval is granted by the Vacuum Technologies Purchasing and Engineering Departments.

22.2.9 Pre-Production Sampling (When Required)

22.2.9.1

Pre-production samples shall be specified by the Vacuum Technologies Purchase Order.

22.2.9.2

Pre-production samples shall be submitted to the Vacuum Technologies Purchasing Department.

22.2.9.3

Approval will be based upon the inspection of samples by Vacuum Technologies Incoming Inspection Department.

22.2.9.4

The casting vendor shall not pour production units until receipt of approval by the Vacuum Technologies Purchasing Department.

22.3 Inspection of Casting

22.3.1

Castings will be inspected for the following characteristics. Castings shall be of uniform quality and free of particles, foreign matter, and inclusions.

22.3.1.1

Voids or Blow Holes shall not be permitted on critical surfaces such as mounting surfaces. These surfaces shall be called out on specific drawings.

22.3.1.2

Voids and gas holes greater than 0.060 inch in diameter or 0.060 inch in depth on the surfaces shall be cause for rejection other than those defined in Para 4.2.1

22.3.1.3

Material Segregation - Segregation of casting material shall be cause for rejection.

22.3.1.4

Surface Porosity - Casting shall be capable of meeting the specified surface finish of



unless called out differently in the field of the drawing.

22.3.1.5

Flatness - Flatness of cast surfaces shall not exceed 0.005 inch TIR per linear inch of length unless otherwise specified on the drawing.

22.3.1.6

Parallel Sections - Two parallel sections shall be cast within ± 0.005 inch per linear inch of separation, unless otherwise specified.

22.3.1.7

Comers, Edges, and Fillets - Unless otherwise specified, radii shall not exceed 0.12 inch on both outside and inside corners, edges, or fillets.

22.3.1.8

Sharp Edges - It shall be standard practice to remove all sharp edges.

22.3.1.9

Burrs (Core Seam or Flash) - It shall be standard practice to remove all *burrs*.

22.3.2 Additional Imperfections

22.3.2.1

Foundry tool marks

22.3.2.2

Warpage preventing further machining within tolerance.

22.3.2.3

Evidence of shrinking

22.3.2.4

Omitted features

22.3.2.5

Omitted or incorrect marking

22.3.2.6

Dimensional discrepancies

22.3.2.7

Improper packaging of parts which results in damaged items.

23 Investment Castings

This specification sheet is to be used in conjunction with the applicable casting drawing and issued purchase order.


Unless otherwise specified by the drawing or purchase order, the Vacuum Technologies vendor is responsible, where required, for furnishing certification and/or other substantiating evidence that castings procured have been inspected and meet the requirements of the purchase order. Where such certification is required, the following requirements will be adhered to.

23.1 General Requirements

23.1.1 Casting Material

The supplier shall certify that the material used is in accordance with the material called out on the drawing.

23.1.2 Surface Finish

All external surfaces shall be finished in such a manner to reproduce a substantially uniform appearance. Internal surfaces shall be free of excess material and all irregularities shall be carefully blended. Risers, gates, and parting lines shall be removed in a workmanlike manner leaving as little excess material as possible. Unless otherwise specified on the drawing, the surface of the completed casting shall be better than or equal to  rms.

23.1.3 Dimensions and Tolerances

The supplier shall meet all dimensions and tolerances called out on the drawing. If dimensions or tolerances are not capable of being cast, the supplier shall request direction from the Vacuum Technologies Purchasing Department prior to casting the part.

23.1.4 Draft

Tolerances on cast dimensions do not include draft unless otherwise noted on the drawing. When there is a maximum permissible limit for draft, the drawing will so note. When surfaces must be free of draft or when the direction of draft is of importance, the drawing will be so noted.

23.1.5 Test Bars

When test bars are required by the specification or purchase order, they shall be of the same melt of material and the same heat treatment batch as the casting that they are offered as representing. The castings and bars shall be suitable marked for cross reference.

23.1.6 Radiography and Fluorescent Penetrants

When radiographs and fluorescent penetrants are required of castings, as defined by Vacuum Technologies drawings, they shall be identified with the individual casting and with the particular areas of that casting that they represent.

23.1.7 Heat Treatment

The supplier shall certify that the casting is in the heat treat condition as specified on the drawing.

23.1.8 Repair of Castings

Castings shall not be peened, plugged, welded, or impregnated unless approval is granted by the Vacuum Technologies Purchasing Department.

23.1.9 Pre-Production Sampling (when required)

23.1.9.1

Pre-production samples shall be specified by the Vacuum Technologies Purchase Order.

23.1.9.2

Pre-production samples shall be submitted to the Vacuum Technologies Purchasing Department

23.1.9.3

Approval will be based on the inspection of samples by the Vacuum Technologies Incoming Inspection Department.

23.1.9.4

The casting vendor shall not pour production units until receipt of approval by the Vacuum Technologies Purchasing Department.

23.2 Inspection of Castings

Castings shall be of uniform quality and free of particles, foreign matter, and inclusions. Castings will be inspected for the following characteristics.

23.2.1


Voids and Blow Holes-Voids or blow holes shall not be permitted on critical surfaces such as internal waveguide surfaces, waveguide flanges or mounting surfaces,. tuning, slab line, or waveguide cavities. Their surfaces shall be called out on specific drawings.

Voids and gas holes greater than 0.040 diameter or 0.040 depth on the surfaces shall be cause for rejection other than those defined.

23.2.2

Material Segregation - Segregation of casting material shall be cause for rejection.

23.2.3

Surface Porosity - Casting shall be capable of meeting the specified surface finish of  unless called out differently in the field of the drawing.

23.2.4

Flatness - Flatness of cast surfaces shall not exceed 0.005 inch TIR per linear inch of length, unless otherwise specified on the drawing.

23.2.5

Parallel Sections - Two parallel sections shall be cast within ± 0.005 inch per linear inch of separation, unless other specified on the drawing.

23.2.6

Comers, Edges, and Fillets - Unless otherwise specified, radii shall not exceed 0.015 inch on both outside and inside comers, edges, or fillets.

23.2.7

Sharp Edges - It shall be standard practice to remove all sharp edges.

23.2.8

Burrs (Core Seam or Flash) - It shall be standard practice to remove all *Burrs*.

23.2.9 Additional Imperfections

23.2.9.1

Foundry tool marks

23.2.9.2

Warpage preventing further machining within tolerances

23.2.9.3

Evidence of shrinkage

23.2.9.4

Omitted features

23.2.9.5

Omitted or incorrect markings

23.2.9.6

Dimensional discrepancies

23.2.9.7

Improper packaging or parts which results in damaged items.

24 Forgings

This specification sheet is to be used in conjunction with applicable forging drawing and, unless otherwise specified on the drawing, all forged parts, in order to ensure consistent dimensioning and quality, shall conform to the following.

24.1 General Requirements

24.1.1

Forging to be free of unfilled areas, cold shuts, scale pits, flakes, and mistrims (0.020 maximum).

24.1.2

Surfaces noted *X* indicate subsequent machining area.

24.1.3

No sandblasting or shot peening prior to flaw inspection.

24.1.4

Machined forgings shall withstand hydrogen/vacuum firing at 1,000 °C and maintain vacuum integrity (1×10^{-6} Torr) when subjected to a helium leak check.

24.1.5

A CERTIFICATE OF ANALYSIS AND A CERTIFICATE OF COMPLIANCE IS REQUIRED WITH EACH LOT SUBMITTED.

24.2 Forgings - Definitions

The following definitions of words common to forging processes are to be used in conjunction with Vacuum Technologies drawings.

24.2.1 Cold Shuts

Cold shuts which appear as small cracks usually at a radius or fillet is caused by improper die design that causes metal to flow so that it doubles upon itself without fusion.

24.2.2 Unfilled Condition

Unfilled condition occurs from improper die design or forging technique which causes metal flow to cease before the cavity has been filled at all points.

24.2.3 Scale Pits

Scale pits or irregular depressions in the surface of the forging are caused by improper cleaning of oxides or scale from the surface of the forging stock before or during the forging operation thus allowing the oxide or scale to be driven into the surface of the forging. When the forging is cleaned in subsequent blasting or pickling operations, the removal of scale that has been driven into the surface of the forging leaves depressions.

24.2.4 Die Shift

Die shift is caused by misalignment between the top and bottom dies thus shifting the metal forged in one half of the die out of alignment with the metal forged in the other die half.

24.2.5 Flakes

Flakes or internal ruptures may occur in large sections of certain alloys as a result of improper cooling practice or the presence of hydrogen. Rapid cooling will cause the exterior of a large section to shrink more rapidly than the interior, thereby causing internal fractures. Rapid cooling can also prevent hydrogen from diffusing properly and the resulting gas pressure can become great enough to cause bursts. With the advent of vacuum-melted and vacuum-degaussed materials and proper cooling practice, flakes have virtually been eliminated as forging defects.

24.2.6 Overheated Metal


Overheated metal resulting from improper heating procedures prior to forging causes metallurgical changes that are injurious to the physical properties of the forging.

24.2.7 Improper Grain Flow


Improper grain flow develops inferior physical properties as a result of poor die design that fails to cause metal flow to progress in a manner that makes maximum use of the directional properties of the metal.



25 Surface Finishes

25.1 Surface Finishes - General

Surface Finish or Surface Roughness is specified using the symbol  where the RMS value is defined as the maximum value of finely spaced surface irregularities.

25.2 Surface Finishes - Tolerances

It is standard practice that the surface roughness for parts fabricated for Vacuum Technologies shall not exceed , 0.00125 maximum tolerance. Deviations from this requirement shall be either called out on the drawings, on the Purchase Requisitions, or in other specifications which are a part of this Fabrication Standard.

One specific deviation from the  maximum surface condition is the  maximum surface roughness which is permitted for castings.

25.2.1

Parts fabricated with a surface roughness less than  are acceptable.

25.2.2

Under no conditions will a part be accepted if the dimensional tolerances are exceeded due to its surface roughness.

25.2.3

The effect of flaws such as cracks, blow holes, checks, ridges, and scratches shall not be included in the roughness height measurements.


25.2.4

When functional requirements call for control of surface characteristics in addition to the roughness height measurement, it shall be spelled out as: SURFACE SHALL BE FREE FROM FLAWS.

25.2.5

Flaws are defined as irregularities which occur at one place or at relatively infrequent intervals in the surface; e.g., a scratch, ridge, holes, peaks, cracks, checks, nicks, dents, gouges, and tool marks.

25.2.6

Circular lays shall be required at O-ring groove surfaces. This shall be noted by the addition of a C to the surface finish symbol; e.g.  C.

26 Acceptance Criteria for Painting

26.1 Unacceptable Painting

26.1.1

Wrong Color - Color or gloss deviated from contract requirement and/or approved paint samples or chip.

26.1.2

Poor Coverage - Paint does not cover or extend beyond specified areas. The presence of paint on flanges or heat sink surface is not acceptable.

26.1.3

Scratch - Base metal is exposed or the painted surface is damaged due to scratching.

26.1.4

Smudge, Mar, Blemish - Superficial mark or deformity or physical damage.

26.1.5

Blister, Void, or Chip - Any degree visible to the naked eye shall be cause for rejection.

26.1.6

Sags or Runs - Irregularities of the paint due to the uneven flow.

26.1.7

Rough Coating - Coating surface lacks smooth appearance due to improper spray technique. Roughness of the coating may be detected by running finger across the painting surface.

26.1.8

Contaminated Coating - Paint over sand, metal particles, or dirt.

26.1.9

Excessive Paint - Amount of paint that is more than adequate. Noticeable layering of globules due to touch-ups.

26.1.10

Wet Paint - Wet, tacky, bleedout, or uncured paint coating.

27 Inspection of Plating

27.1 Unacceptable Plating

27.1.1

Scratch - Base metal is exposed or damage to the plated surface is detected by the following.

27.1.1.1

Peeling - Detachment of the plated coating from the base metal. Vendor to be responsible for surface preparation and must assume responsibility for part preparation unless otherwise specified.

27.1.1.2

Void, Pit, Pin Hole - Base metal is exposed or a top layer of plating exposed sub-layer.

27.1.1.3

Blister - Blisters are closed voids and rejectable. An open blister is a void as classified under para. 27.1.1.2 .

27.1.1.4

Coating Too Thin - Base metal color faintly showing through the coating.

27.1.1.5

Wrong Plating - Color or type of plating deviated from drawing or specification.

27.1.1.6

Incorrect Coverage - Plating does not cover areas specified in drawing.

27.1.1.7

Poor Adhesion - Not adhering to base metal properly.

27.1.1.8

Specialty Coating - These will require source inspection.

28 Coolants, Lubricants, and Solvents

28.1 Coolants, Lubricants, and Solvents - General

Coolants, lubricants, and solvents used in fabricating parts for Vacuum Technologies must be free from chlorides, sulfur, or sulfur-containing compounds or must not exceed the maximums listed below.

28.1.1

All dilution of the commercial materials must be with water, a sulfur- or chloride-free blending oil, or solvent.

28.1.2

All parts should be wiped clean of excess oils and lubricants prior to delivery to Vacuum Technologies unless otherwise specified.

28.2 Coolants, Lubricants, and Solvents - Acceptability Parameters

The following parameters define the acceptability of coolants, lubricants, and solvents for use in manufacturing Vacuum Technologies parts.

28.2.1

The use of the lubricant shall have no detrimental effect on the life or operating characteristics of the product in which the parts are used. This implies an easy and complete removal by standard cleaning processes.

28.2.2

The compound shall not harden, corrode, or deteriorate the parts under prolonged storage conditions.

28.2.3

Coolants, lubricants, and solvents which contain chloride greater than 1 ppm (part per million) are not to be used.

28.2.4

Total active sulfur content shall not exceed 0.01 percent.

28.2.5

Total sulfur content shall not exceed 0.03 percent.

28.2.6

All lubricants must be free of high vapor pressure materials; i.e., the concentration of Hg, Cs, K, P, Na, S, Mg, U, Sb, Cd, Zn, Te, Sr, Da, Pb, and Mn shall not exceed 0.01 percent individual concentrations.

29 Weld Fabrication Standards, Gas Tungsten Arc Welding (GTAW) Process

29.1 Scope

This document provides Fabrication Standards and Inspection Criteria for acceptance or rejection of welds and weldments (welded assemblies) made by the GTAW process. This standard supersedes Welding Standard M7-6009.

29.2 General Requirements

29.2.1

Exceptions: Specific requirements as detailed on the applicable drawing and/or Purchase Order shall take precedence over this Specification, but shall not release the vendor or fabrication department from complying with all other non-conflicting provisions set forth herein.

29.2.2

Rejection: Welds or weldments which do not conform to the requirements of this Specification, applicable drawing, and/or Purchase Order shall be subject to rejection.

29.2.3

Weld Quality: Class I shall be the standard for all welds and weldments unless specified as Class II.

29.3 Definitions - Weld Classification

29.3.1

Class I welds are required for vacuum-tight seals and have higher quality requirements than Class II welds.

29.3.2

Class II welds are structural welds and are not involved in vacuum-tight seals.

29.4 General Standards (Applies to Class I and Class II Welds)

29.4.1

The weld bead shall be reasonably smooth or show an even repetitive ripple that fuses smoothly with adjacent material. Weld beads that exhibit an uneven ripple, that vary in size, that blend unevenly, or that have a poor visual shape shall be rejected.

29.4.2

An undercut shall be acceptable when the groove or valley has a rounded contour and the depth and length of the undercut is within the limits of Figures 6 and 7 on page pg. 59 and 60.

29.4.3

Weld beads should be free of excess weld splatter, blowholes, porosity, undercuts, overlapping, cracks, and burn-through within limits specified in this Standard.

29.4.4

Misalignment greater than that specified in Figure 11 on pg. 64 for the material thickness being welded shall be cause for rejection.

29.4.5

All visible weld oxide and discoloration in the weld region must be removed from welds prior to shipment or inspection. Where it is not practical to remove the oxide, a straw color, light blue, or brown may be acceptable.

29.5 Class I Weld Standards

29.5.1

Lack of fusion shall be cause for rejection. See Figure 3 on pg. 58 for details.

NOTE: This standard does not imply that 100% weld penetration is required unless specified on the drawing.

29.5.2

Surface cracks or linear porosity of the weld bead that can be visually or non-destructively detected shall be cause for rejection. See Figures 4 and 5 on pg. 58.

29.5.3

Inclusions in the weld bead that can be visually or non-destructively detected shall be cause for rejection.

29.5.4

Combinations of continuous inside and outside welds on the same joint, shall be cause for rejection. Uniformly distributed tack welds may be made on the opposite side of a continuously-welded joint.

29.5.5

Fillet and butt weld joints are the preferred joint types. Lap weld joints should be avoided.

29.5.6

Weld *splatter* visible in the region of the joint shall be cause for rejection.

29.5.7

Vacuum component welds should be made on the high vacuum side of the joint, unless otherwise specified on the drawing.

29.5.8

All welds must be vacuum-tight when checked with a suitable helium mass spectrometer leak detector. In addition, any indication of leaks detected shall constitute a non-vacuum tight assembly regardless of the order of magnitude of the leak.

29.6 Class II Weld Standards

29.6.1

Intermittent welds shall be of uniform size and placement along the weld joint when used. Varying lengths of skip weld and/or non-uniform distribution of welds shall be cause for rejection.

29.6.2

Porosity of inclusions (visible or non-destructively detectable) shall be acceptable in all types of welds regardless of the base metal when not in excess of the following.

29.6.2.1

Porosity or inclusions that are less than 1/32 inch diameter or length shall not be closer together than 1/64 inch.

29.6.2.2

Porosity of inclusions that are 1/32 to 1/16 inch diameter or length shall not be closer together than 1/16 inch.

29.6.2.3

For base metal thickness to 0.125 inch, the maximum diameter or length of defect shall not exceed 50 percent of the base metal thickness.

29.6.2.4

For base metals over 0.125 inch in thickness, the maximum diameter or length of defect shall not exceed 3/32 inch.

29.7 Defect Description and Acceptance Standards

Applies to Class I and Class II welds except as noted.

	Defect	Defect Description	Defection Acceptance Standards
29.7.1	Lack of fusion	The failure to fuse completely adjacent members of weld joint.	Non-Acceptable (see Figure 3 on pg. 58)
29.7.2	Linear voids or porosity (visually detectable)	A condition where three or more 1/64 inch or larger diameter voids in a line occupy a distance of 1/4 inch or less.	Not acceptable on Class I welds (see Figure 4 on pg. 58)
29.7.3	Misalignment	Failure of base metals to fit or match properly.	Acceptable if not in excess of Figure 11 on pg. 64
29.7.4	Metallic inclusions (visually or non-destructively detectable)	Metal other than weld metal or base metal entrapped in weld metal or between weld metal and base metal	None acceptable
29.7.5	Non-metallic inclusions (visually or non-destructively detectable)	Non-metallic solid material in weld metal or between weld metal and base metal	Shall be considered porosity and inspected to the same standards
29.7.6	Scattered voids or porosity (visually or non-destructively detectable)	Occasional voids occurring in random pattern throughout the weld deposit	None acceptable on Class I welds. Acceptable on Class II welds (non-vacuum) if not in excess of Para. 29.6.2
29.7.7	Suck-back	A depression in the backside of a butt weld joint caused by shrinkage of weld metal	None acceptable (see Figure 12 on pg. 65)
29.7.8	Undercut	A groove melted into the base metal adjacent to the weld deposit	Acceptable if not in excess of Figures 6 and 7 on pg. 59 and 60
29.7.9	Underfill	The failure to fill a prepared joint with filler metal	None acceptable

Vacuum Technologies Fabrication Standards

	Defect	Defect Description	Defection Acceptance Standards
29.7.10	Transverse of longitudinal under Bead Cold Shuts (visually detectable)	Grooves in the weld penetration bead that indicate incomplete fusion	None acceptable (see Figure 13 on pg. 65)
29.7.11	Arc strike	Pits or craters in the base metal caused by striking the arc in an area not covered by weld deposit	None acceptable
29.7.12	Crater crack	A depression with cracks at the weld bead termination	None acceptable
29.7.13	Porosity or voids with sharp tails (visually or non-destructively detectable)	Porosity or voids characterized by sharp tails	None acceptable (see Figure 5 on pg. 58)
29.7.14	Cracks (visually or non-destructive detectable)	A parting or cleft due to fracture of the base of weld metal	None acceptable
29.7.15	Overlap	A protrusion of weld metal beyond the limits of fusion at the edge of the weld	None acceptable (see Figure 14 on pg. 65)
29.7.16	Backside shrinkage	A depression in the back side fillet weld joint caused by shrinkage of parent metal	Acceptable if not in excess of 0.01 T*
29.7.17	Excessive convexity	Excessive distance from face of a convex fillet weld perpendicular to a line joining the toes	Acceptable if not in excess of Figure 8 on pg. 61
29.7.18	Excessive concavity	Excessive distance from face of a concave weld bead perpendicular to a line joining the toes	Acceptable if not in excess of Figure 9 on pg. 62
29.7.19	Excess butt weld bead	Excessive weld bead width for base metal thickness	Acceptable if not in excess of Figure 10 on pg. 63

Vacuum Technologies Fabrication Standards

	Defect	Defect Description	Defection Acceptance Standards
29.7.20	Excessive fillet weld leg	Excessive weld leg length for base metal thickness	Acceptable if not in excess of Figure 1 on pg. 57
29.7.21	Weld bead not centered	Weld bead face or root not centered on weld joint	Not acceptable if in excess of ± 0.020 inch on metal thickness 0.040 inch or above; not acceptable if in excess of ± 0.010 inch on metal thickness of 0.020 to 0.040 inch (see Figure 2 on pg. 58)

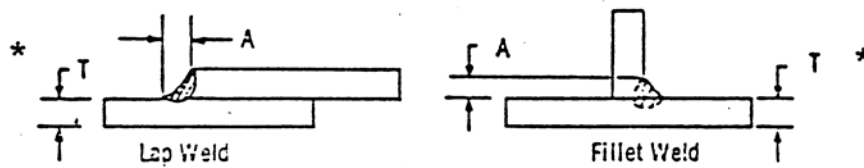


Figure 1 Fillet Leg Size

Table 1 ** Fillet Leg Size	
T (Material Thickness) (Inches)	Maximum Allowable A (Inches)
0.016 - 0.040	0.10
0.041 - 0.070	0.12
0.071 - 0.100	0.14
0.101 - 0.130	0.16
0.131 - 0.160	0.18
0.161 - 0.190	0.20
0.191 - 0.220	0.22
0.221 - 0.260	0.26
0.261 - 0.300	0.30
0.301 - 0.360	0.60
0.361 - 0.420	0.42
0.421 - 0.500	0.50

** When materials of different thicknesses are welded together, the weld size shall be determined on the basis of the thinner material.

* T = Thickness or minimum gauge being joined.

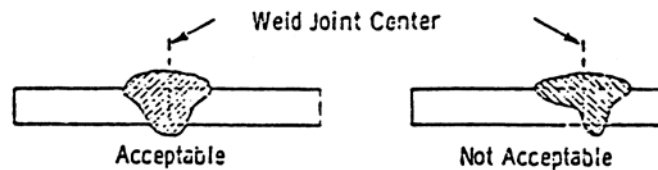


FIGURE 2, Weld Bead Centering

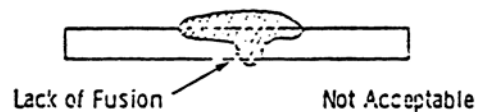
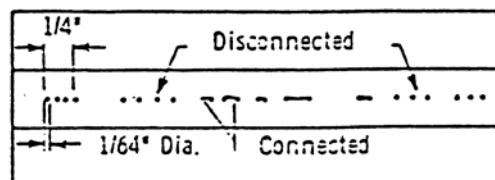


FIGURE 3, Lack of Fusion



Example of Connected and Disconnected Linear Porosity or Voids — None Acceptable

FIGURE 4, Porosity



Porosity or Voids with Sharp Tails — None Acceptable

FIGURE 5, Porosity

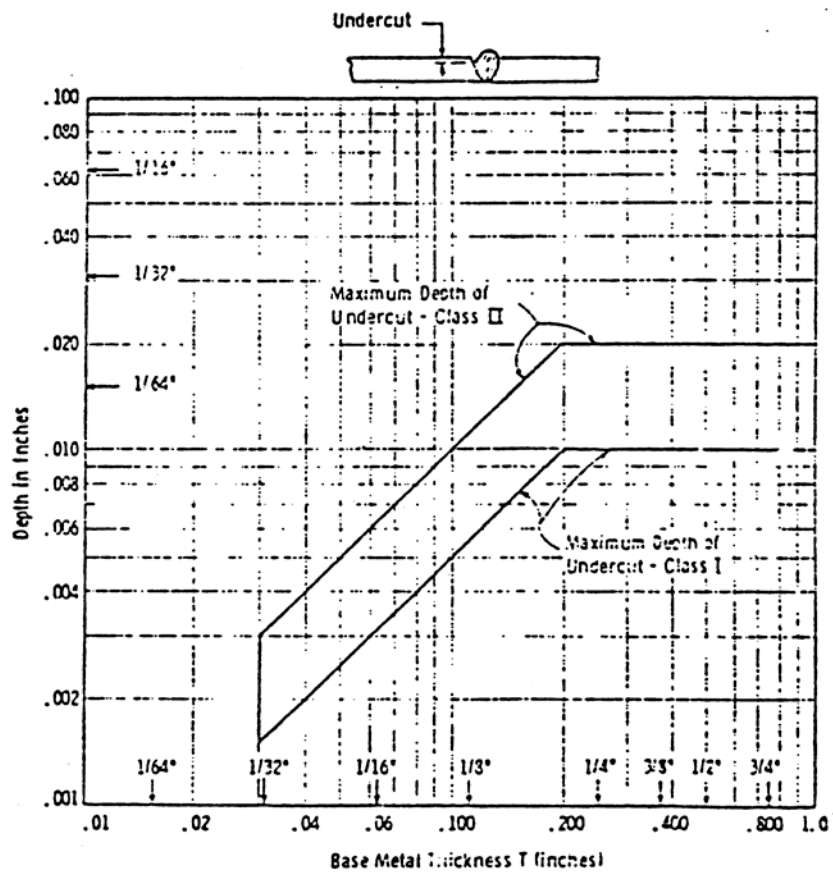


FIGURE 6, Undercut (Depth)

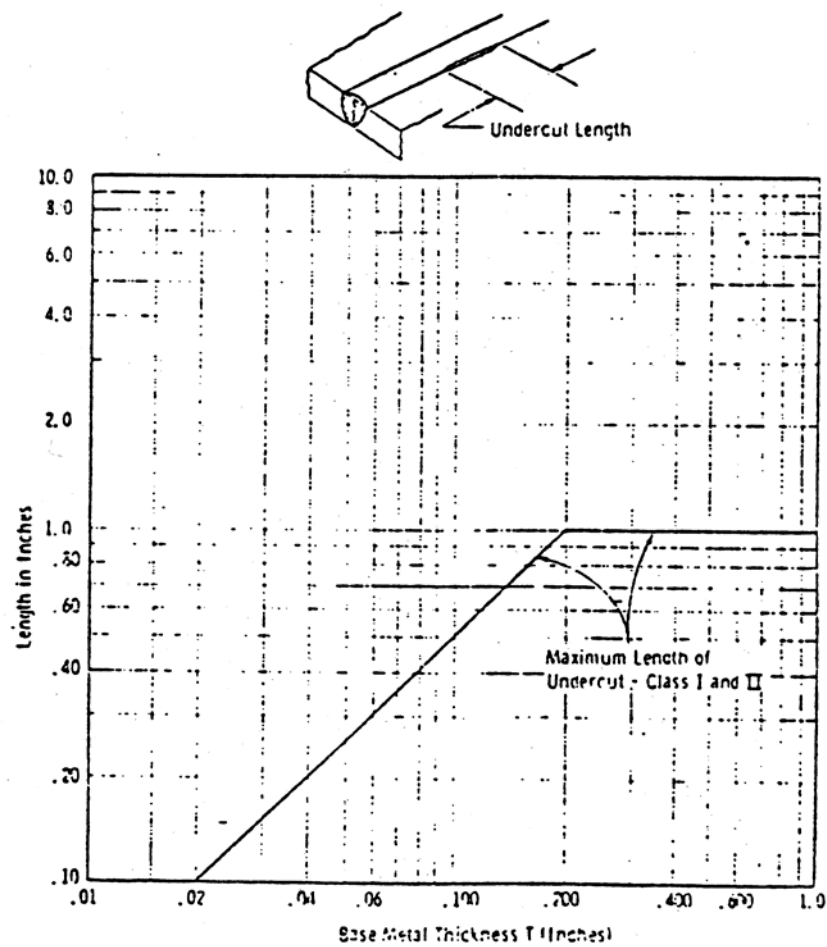


FIGURE 7, Undercut (Length)

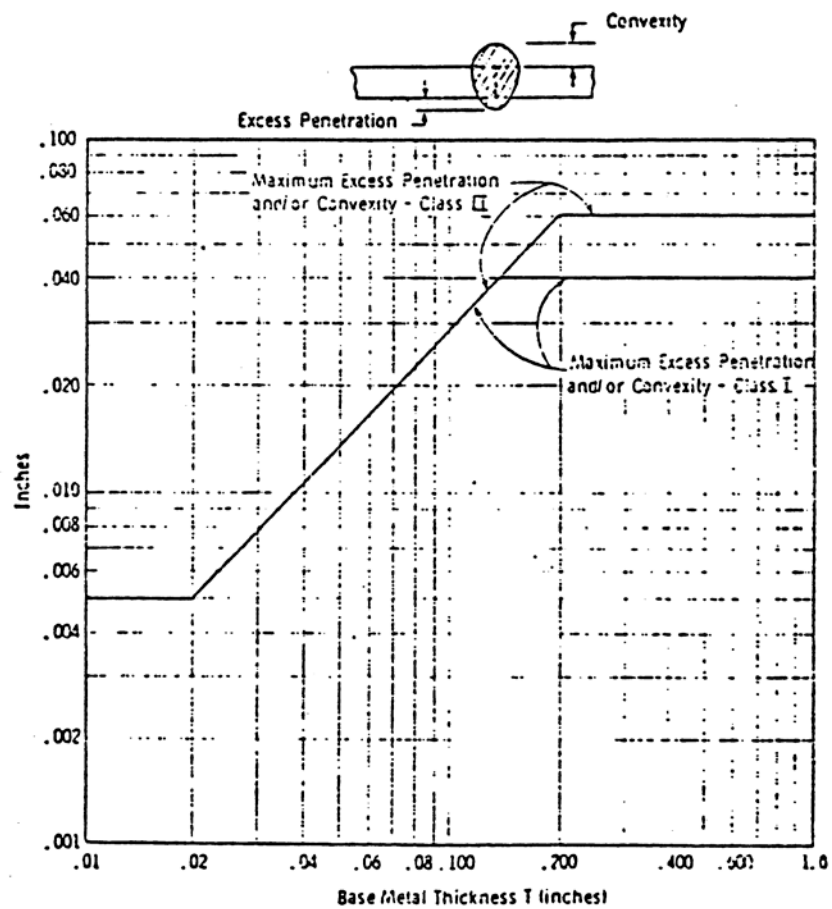


FIGURE 8, Excess Penetration and Convexity

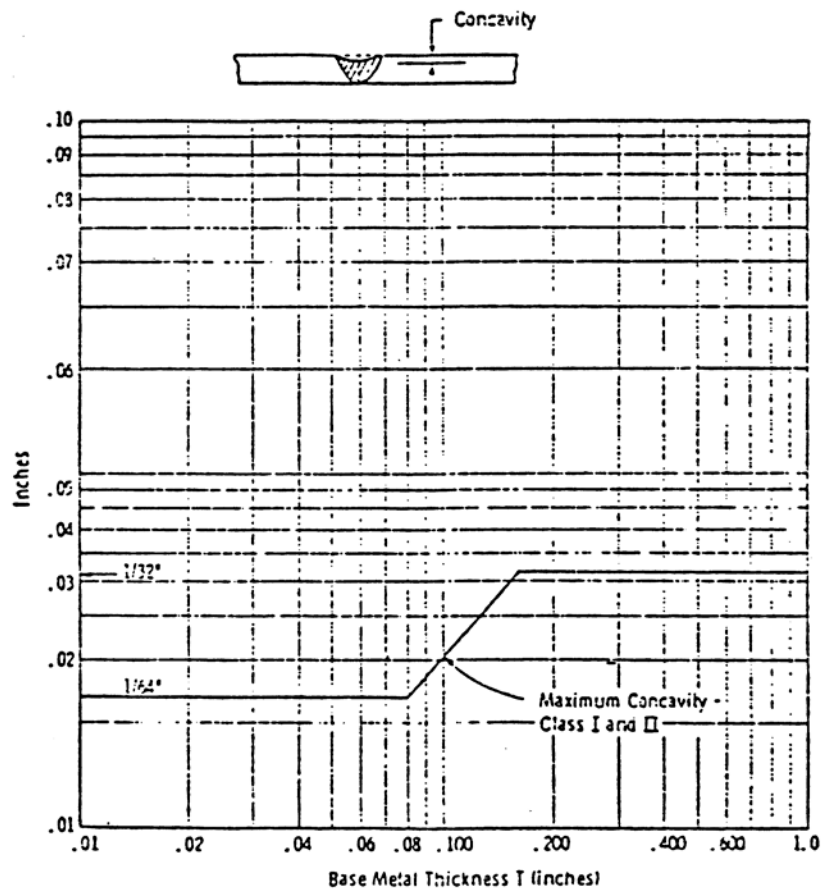


FIGURE 9, Concavity

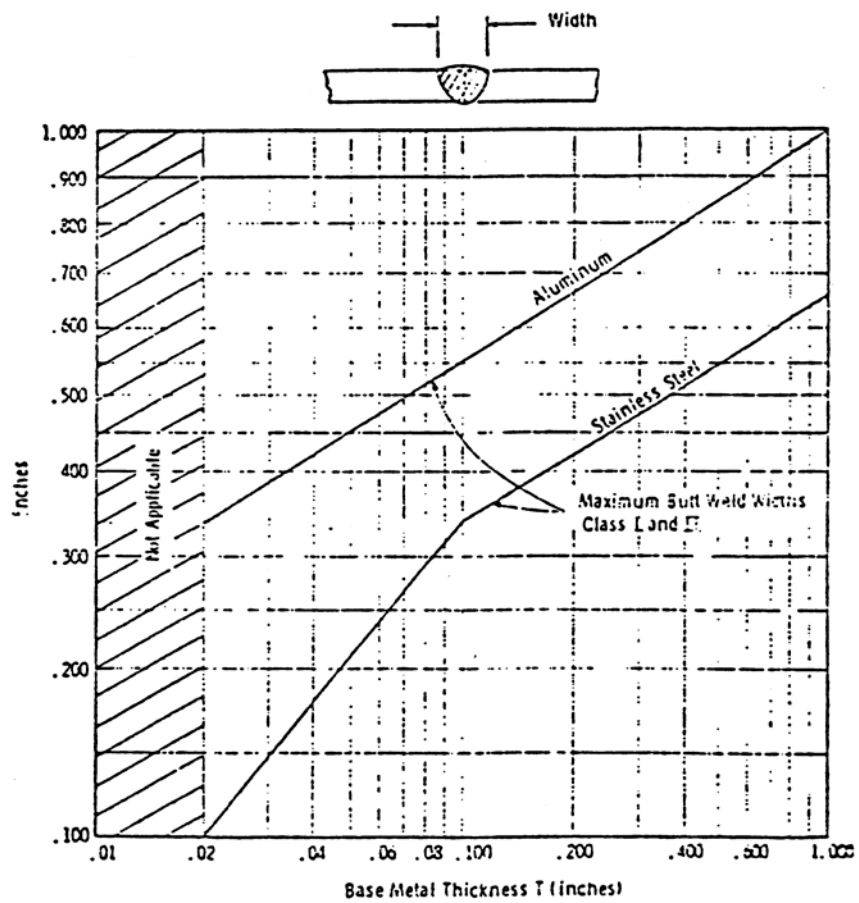


FIGURE 10, Butt Weld Width

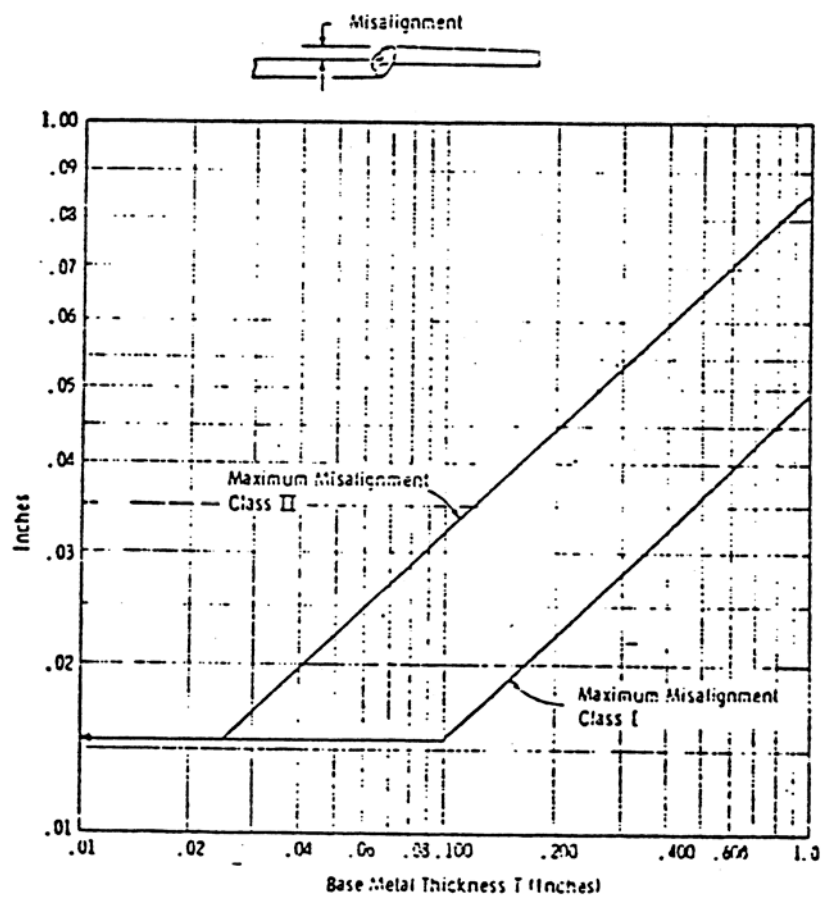


FIGURE 11, Misalignment

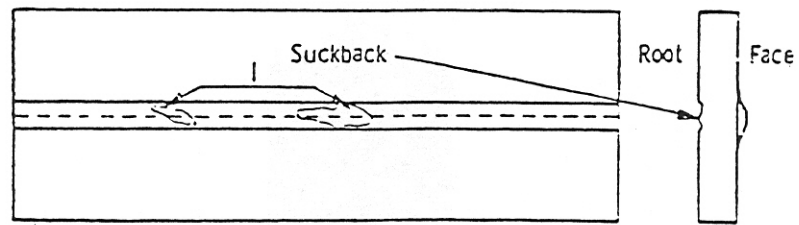


FIGURE 12, Suckback

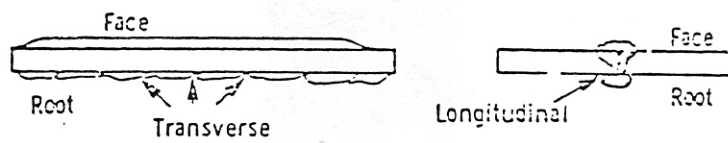


FIGURE 13, Cold-Shuts

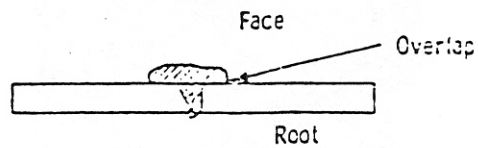


FIGURE 14, Overlap

30 Welding Symbols

Welding symbols are shown on pages 67 through 79.

The applications of welding symbols are shown on pages 80 through 87.

Brazing symbols are shown on pages 88 and 89.

30.1 Welding Symbols

BASIC ARC AND GAS WELD SYMBOLS								BASIC RESISTANCE WELD SYMBOLS			
TYPE OF WELD								TYPE OF WELD			
BEAD	FILLET	PLUG OR SLOT	GROOVE					SPOT	PROJ.	SEAM	FLASH OR UPSET
			SQUARE	V	BEVEL	U	J				
SUPPLEMENTARY SYMBOLS								BASIC TESTING SYMBOLS			
WELD OR TEST ALL AROUND	FIELD WELD	CONTOUR			TYPE OF TEST		SYMBOL				
		FLUSH	CONVEX	FINISH							
				C - CHIP G - GRIND M - MACHINE	RADIOGRAPHIC MAGNETIC - PARTICLE PENETRANTS ULTRASONIC		RT MT PT UT				

STANDARD LOCATION OF ELEMENTS OF A WELDING SYMBOL

FINISH SYMBOL

CONTOUR SYMBOL

ROOT OPENING, DEPTH OF FILLING FOR PLUG AND SLOT WELDS

SIZE, SIZE OR STRENGTH FOR RESISTANCE WELDS

REFERENCE LINE

SPECIFICATION, PROCESS OR OTHER REFERENCE

TAIL (MAY BE OMITTED WHEN REFERENCE IS NOT USED)

BASIC WELD SYMBOL OR DETAIL REFERENCE

GROOVE ANGLE; INCLUDED ANGLE OF COUNTERSINK FOR PLUG WELDS

LENGTH OF WELD

PITCH (CENTER TO CENTER SPACING) OF WELDS

ARROW CONNECTING REFERENCE LINE TO ARROW SIDE OF JOINT, OR GROOVED MEMBER, OR BOTH

FIELD WELD SYMBOL

WELD ALL AROUND SYMBOL

NUMBER OF SPOT OR PROJECTION WELDS

(N)

(BOTH SIDES)

(ARROW SIDE)

(OTHER SIDE)

STANDARD LOCATION OF ELEMENTS OF A TESTING SYMBOL

NUMBER OF TESTS

SPECIFICATION, PROCESS, OR OTHER REFERENCE

TAIL

REFERENCE LINE

BASIC TESTING SYMBOL

(N)

(OTHER SIDE)


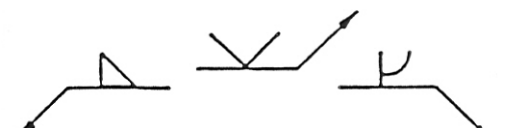
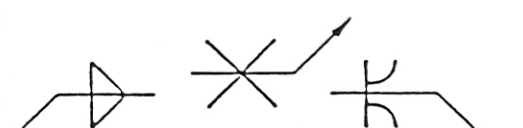
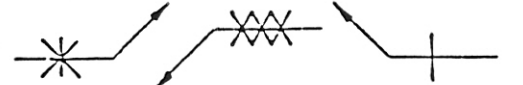

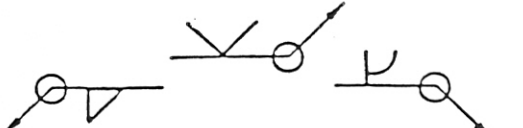
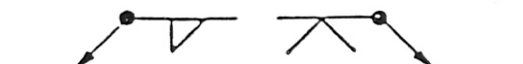
(ARROW SIDE)





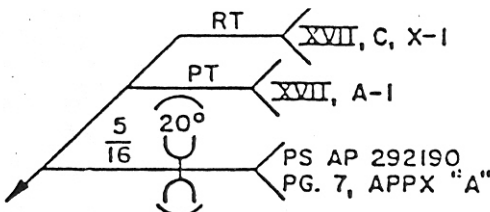
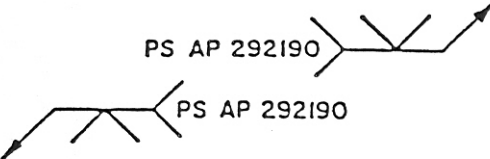
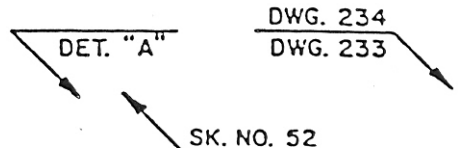
(BOTH SIDES)

LENGTH OF SECTION TO BE TESTED

ARROW

TEST-ALL-AROUND SYMBOL


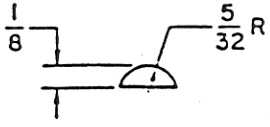

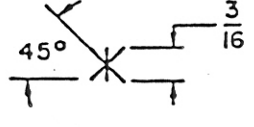

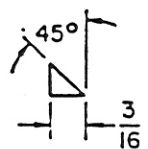

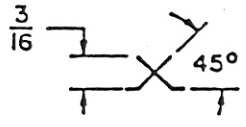

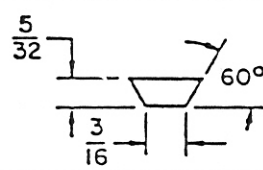

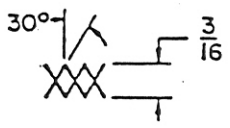

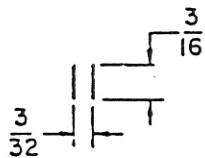

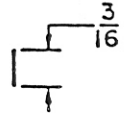

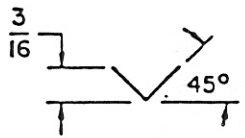

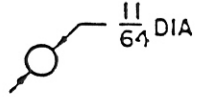

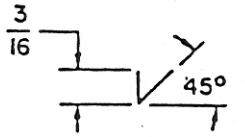

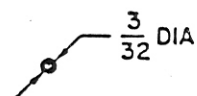

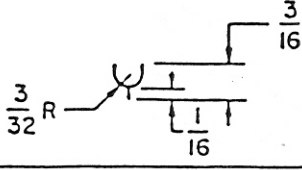

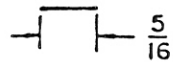

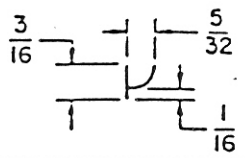

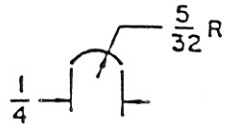
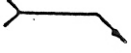
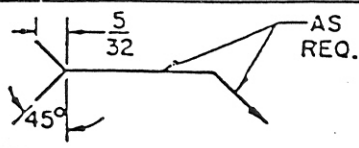
Welds on the arrow side of the joint shall be shown by placing the weld symbol on the side of the reference line toward the reader.	
Welds on the other side of the joint shall be shown by placing the weld symbol on the side of the reference line away from the reader.	
Welds on both sides of the joint shall be shown by placing weld symbols on both sides of the reference line.	
Spot, seam, flash, and upset weld symbols have no arrow-side or other-side significance in themselves, although supplementary symbols used in conjunction therewith may have such significance. Spot, seam, flash, and upset weld symbols shall be centered on the reference line.	
When a specification, process, or other reference is used with a welding symbol, the reference shall be placed in the tail.	
Welds extending completely around a joint shall be indicated by means of the weld-all-around symbol.	
Field welds (welds not made in a shop or at the place of initial construction) shall be indicated by means of the field weld symbol.	

<p>Fillet and bevel- and J-groove weld symbols shall be shown with the perpendicular leg always to the left.</p>	
<p>When a bevel- or J-groove welding symbol is used, the arrow shall point with a definite break toward the member that is to be chamfered. (In cases where the member to be chamfered is obvious or detailed, this requirement may be disregarded.)</p>	
<p>Information on welding symbols shall be placed to read from left to right along the reference line in accordance with the usual conventions of drafting.</p>	
<p>For joints having more than one weld, a symbol shall be shown for each weld.</p>	
<p>Where additional references are required such as process specification paragraph references to Penetrant Tests (PT), Radiographic Tests (RT), and joint welding procedures, the welding symbol is to be expanded to include these references.</p>	
<p>Where an applicable process specification is in existence it shall appear in the tail of the welding symbol or in a note on the drawing such as <i>Weld per PS AP-292190</i>.</p>	
<p>When the basic weld symbols are inadequate to indicate the desired weld, the weld shall be shown by a cross section, detail or other data with a reference thereto on the welding symbol, observing the usual location significance.</p>	

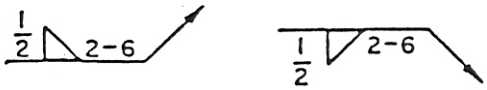
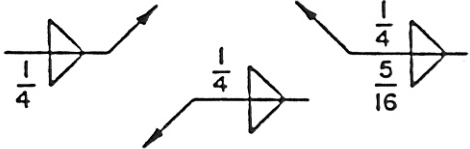
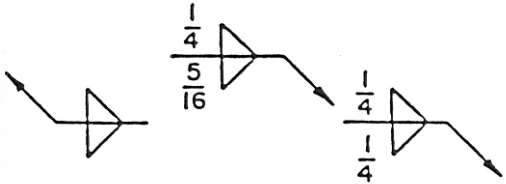
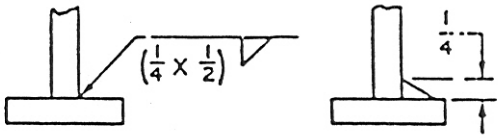
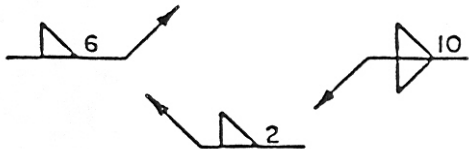
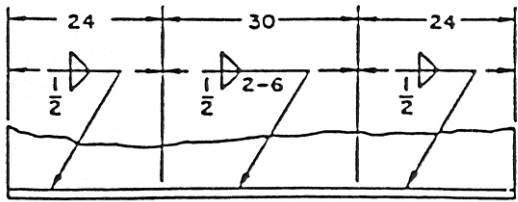
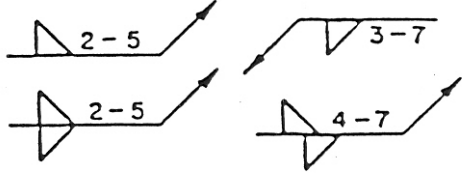
Vacuum Technologies Fabrication Standards

It is recommended that weld symbols be produced to the approximate dimensions shown but the use of templates that produce slightly varying sizes, and proportions is acceptable.

30.2 Recommended Proportions of Welding Symbols

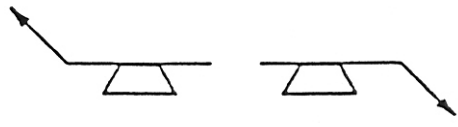
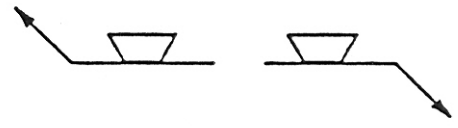
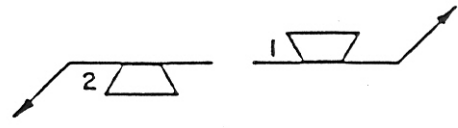
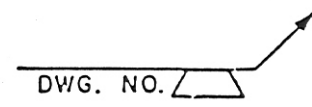
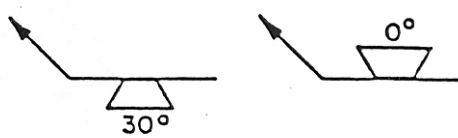
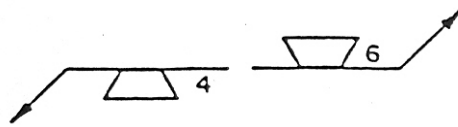
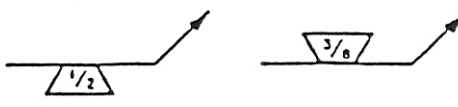
			
BEAD		SPOT	
			
FILLET		PROJECTION	
			
PLUG OR SLOT		SEAM	
			
SQUARE		FLASH OR UPSET	
			
V WELD		ALL AROUND	
			
BEVEL		FIELD	
			
U WELD		FLUSH	
			
J WELD		CONVEX	
			
		SYMBOL	

30.3 Dimensioning of Welds (Fillet)

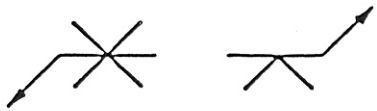
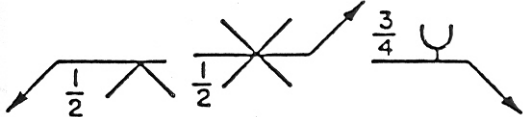
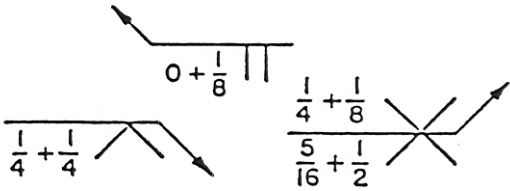
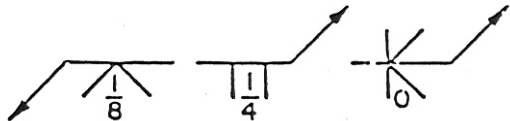
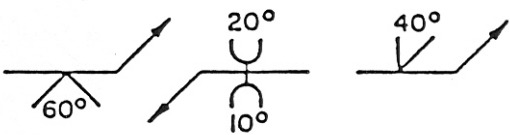
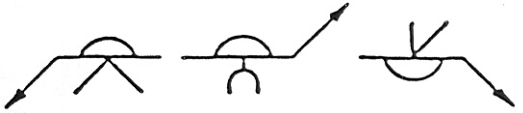
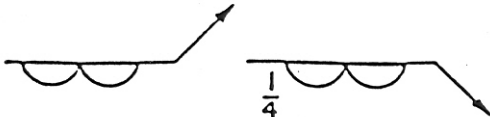
<p>Fillet dimensions and weld symbols shall be shown on the same side of the reference line, with the dimension to the left of the symbol.</p>	
<p>When no general note governing the dimensions of fillet welds appears on the drawing, the dimensions of fillet welds on both sides of a joint shall be shown. When both welds have the same dimensions, one or both may be dimensioned. When the welds differ in dimensions, both shall be dimensioned.</p>	
<p>When both welds have dimensions governed by the note, neither need be dimensioned. When the dimensions of one or both welds differ from the dimensions given in the general note, both shall be dimensioned.</p>	
<p>The size of a fillet weld with unequal legs shall be shown in parentheses to the left of the weld symbol. Weld orientation is not shown by the symbol and shall be shown on the drawing when necessary.</p>	
<p>The length of a fillet weld, when indicated on the welding symbol, shall be shown to the right of the weld symbol.</p>	
<p>Specific length of fillet welding may be indicated by symbols in conjunction with dimension lines.</p>	
<p>The pitch (center-to-center spacing.) of intermittent fillet welding shall be shown as the distance between centers of increments on one side of the joint, and to the right of the length dimension. Staggered intermittent fillet welding shall be as shown.</p>	

30.4 Plug or Slot Welds

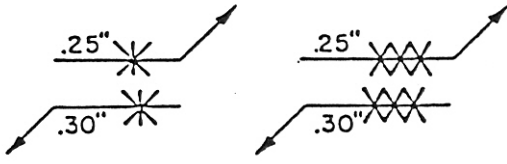
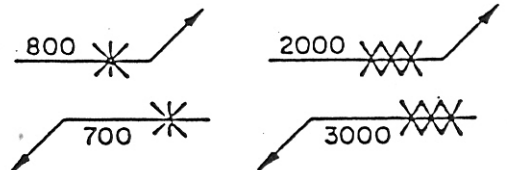
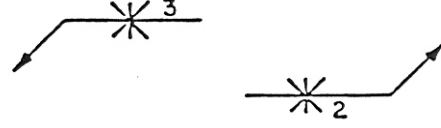
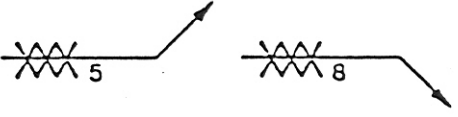
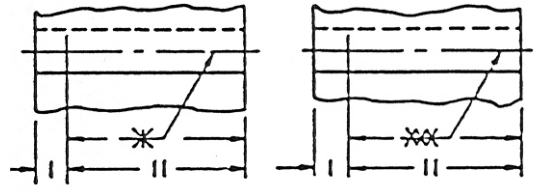

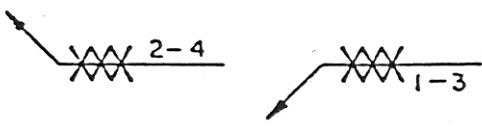
Holes in the arrow-side member of a joint for plug or slot welding shall be indicated by placing the weld symbol on the side of the reference line toward the reader.

Holes in the arrow-side member of a joint for plug or slot welding shall be indicated by placing the weld symbol on the side of the reference line toward the reader.	
Holes in the other-side member of a joint for plug or slot welding shall be indicated by placing the weld symbol on the side of the reference line away from the reader.	
The size of a plug weld shall be shown to the left of the weld symbol.	
The dimensions of a slot weld shall appear in the detail drawing number shown to the left of the weld symbol.	
Included angle of countersink for plug welds shall be shown.	
Pitch of center- to-center spacing of plug or slot welds shall be shown to the right of the weld symbol.	
Depth of filling of plug or slot welds shall be complete unless otherwise indicated. When the depth of filling is less than complete, the depth in inches shall be shown inside the weld symbol.	

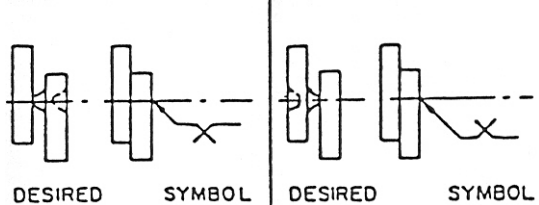


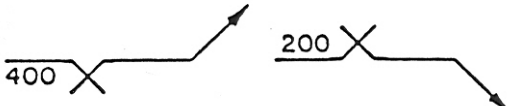

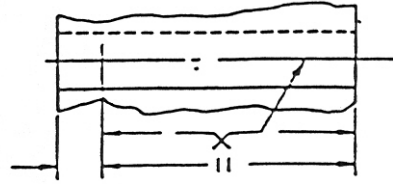
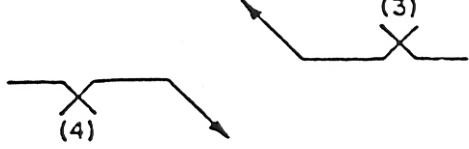
30.5 Groove and Bend Welds

<p>The size of single-groove and symmetrical double-groove welds that extend completely through the member or members being joined need not be shown on the welding symbol.</p>	
<p>The size of groove welds that extend only partly through the member or members being joined shall be shown on and to the left of the welding symbol.</p>	
<p>Welds with specified root penetration shall be indicated by showing both the depth of chamfering and the root penetration, separated by a plus sign and placed to the left of the weld symbol. The depth of grooving and the root penetration shall read in that order from left to right along the reference line.</p>	
<p>Root opening of groove welds, when not the user's standard, shall be shown inside the weld symbol.</p>	
<p>Groove angle of groove welds shall be the user's standard, unless otherwise indicated. Groove angle of groove welds, when not the user's standard, shall be as shown.</p>	
<p>Bead welds used as backing welds of single-groove welds shall be shown by placing a single bead weld symbol on the side of the reference line opposite the groove weld symbol.</p>	
<p>Surfaces, built up by welding, whether by single- or multi-pass bead welds, shall be shown by the dual bead weld symbol. Dimensions used in conjunction with the dual bead weld symbol shall be shown on the same side of the reference line as the weld symbol.</p>	

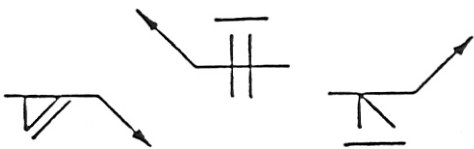
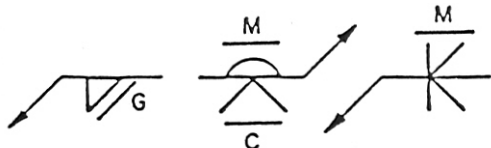
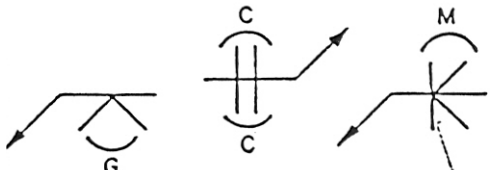
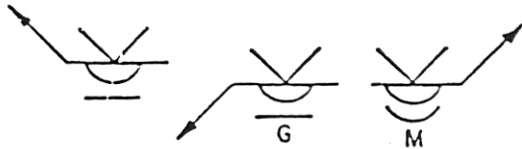

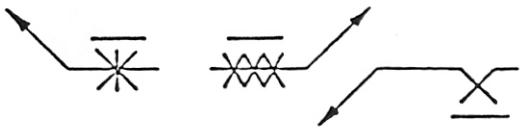
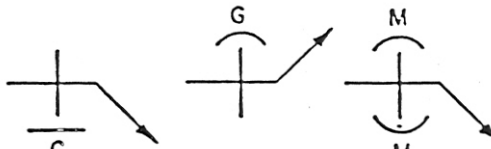
30.6 Resistance Welds-Spot and Seam

<p>The size of spot welds shall be designated as the diameter of the weld expressed decimally with inch marks, to the left of the weld symbol. The size of seam welds shall be designated as the width of the weld expressed decimally with inch marks, to the left of the weld symbol.</p>	
<p>The strength of spot welds shall be designated as the minimum acceptable shear strength in pounds per spot and shall be shown to the left of the weld symbol. The strength of seam welds shall be designated as the minimum acceptable shear strength in pounds per linear inch and shall be shown to the left of the weld symbol.</p>	
<p>The pitch (center-to-center spacing) of spot welds shall be shown to the right of the weld symbol.</p>	
<p>The length of a seam weld shall be shown to the right of the weld symbol.</p>	
<p>When spot or seam welding extends less than the distance between abrupt changes in the direction of the welding or less than the full length of the joint, the extent shall be dimensioned.</p>	
<p>When a definite number of spot welds is desired in a certain joint, the number shall be shown in parentheses, either above or below the weld symbol.</p>	
<p>The pitch (center-to-center spacing) of intermittent seam welding shall be shown to the right of the length dimension as the distance between centers of the weld increment.</p>	

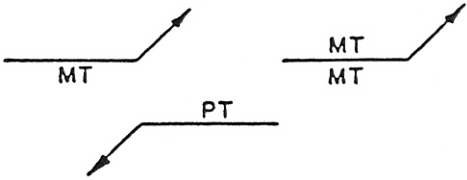
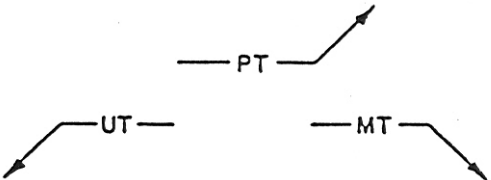
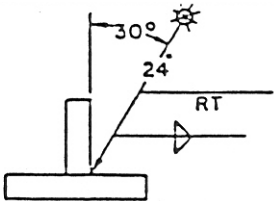
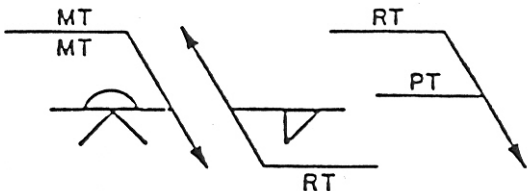
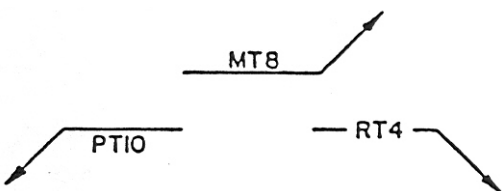
30.7 Resistance Welds-Projection

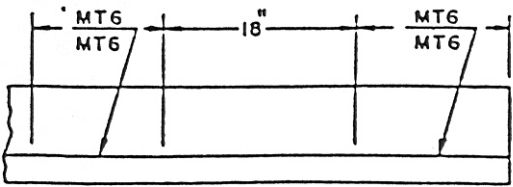
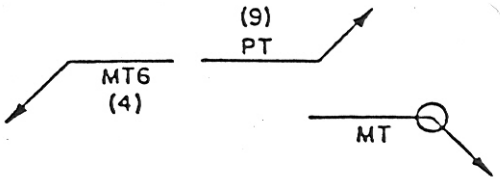
<p>Embossments on the arrow-side member of a joint for projection welding shall be indicated by placing the weld symbol on the side of the reference line toward the reader and embossments on the other-side member of a joint shall be indicated by placing the weld symbol on the side of the reference line away from the reader.</p>	
<p>Dimensions or strength of projection welds shall be shown on the same side of the reference line as the weld symbol.</p>	
<p>The size of projection welds shall be designated as the diameter of the weld expressed decimally in hundredths of an inch and shall be shown, with inch marks, to the left of the weld symbol.</p>	
<p>The strength of projection welds shall be designated as the minimum acceptable shear strength in pounds per weld and shall be shown to the left of weld symbol.</p>	
<p>The pitch (center-to-center) spacing of projection welds shall be shown to the right of the weld symbol.</p>	
<p>When projection welding extends less than the distance between abrupt changes in the direction of the welding or less than the full length of the joint, the extent shall be dimensioned.</p>	
<p>When a definite number of projection welds is desired in a certain joint, the number shall be shown in parentheses.</p>	

30.8 Surface Contours of Welds

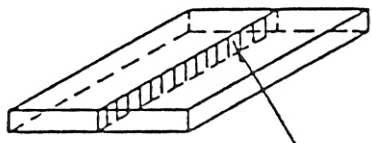
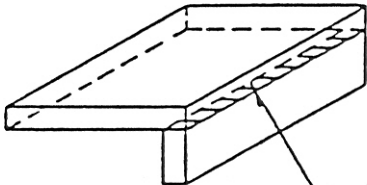
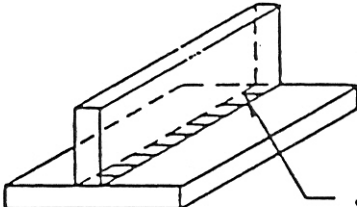
<p>Fillet or groove welds that are to be welded approximately flush without recourse to any method of finishing shall be shown by adding the flush-contour symbol to the weld symbol, observing the usual location significance.</p>	
<p>Fillet or groove welds that are to be made flush by mechanical means shall be shown by adding both the flush contour symbol and the user's standard finish symbol to the weld symbol, observing the usual location significance.</p>	
<p>Fillet or groove welds that are to be mechanically finished to a convex contour shall be shown by adding both the convex-contour symbol and the user's standard finish symbol to the weld symbol, observing the usual location significance.</p>	
<p>Backing welds that are to be welded approximately flush or made flush or convex by mechanical means shall be shown by adding both the flush contour symbol and the user's standard finish symbol to the bead weld symbol.</p>	
<p>Plug welds that are to be welded approximately flush or to be made flush by mechanical means shall be shown by adding both the flush-contour symbol and the user's standard finish symbol to the weld symbol.</p>	
<p>When the exposed surface of one member of a spot-, seam-, or projection-welded joint is to be flush, that surface shall be indicated by adding the flush-contour symbol to the weld symbol, observing the usual location significance.</p>	
<p>Flash and upset welds that are to be made flush or convex by mechanical means shall be shown by adding both the flush-contour symbol and the user's standard finish symbol to the weld symbol, observing the usual location significance.</p>	

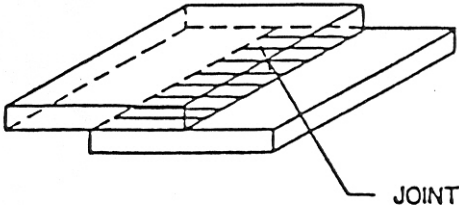
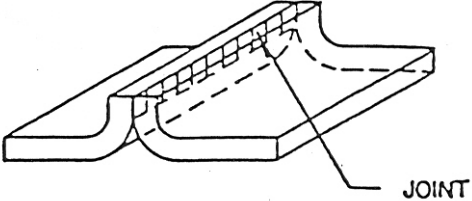
30.9 Nondestructive Testing Symbols

<p>Tests to be made on the arrow side of the part shall be indicated by the test symbol on the side of the reference line toward the reader. Tests to be made on the other side, of the part shall be indicated by the test symbol on the side of the reference line away from the reader. Tests to be made on both sides of the part shall be indicated by test symbols on both sides of the reference line.</p>	 <p>The diagram shows three reference lines with arrows. The first line has 'MT' on the arrow side. The second line has 'PT' on the non-arrow side. The third line has 'MT' on both sides.</p>
<p>When nondestructive testing symbols have no arrow or other side significance, the testing symbols shall be centered on the reference line.</p>	 <p>The diagram shows three reference lines with arrows. 'UT' is centered on the first line, 'PT' is centered on the second line, and 'MT' is centered on the third line.</p>
<p>When specified, the location of the source of radiation and the direction of radiation shall be shown in conjunction with the radiographic testing symbol. The location of the source of radiation shall be indicated by a symbol located on the drawing at the desired source of radiation, connected and oriented as necessary by dimensions.</p>	 <p>The diagram shows a radiographic testing symbol (RT) with a source symbol (a sun-like icon) and dimensions (30° and 24\"</p>
<p>Nondestructive testing symbols and welding symbols may be combined. Nondestructive testing symbols may be combined.</p>	 <p>The diagram shows three reference lines with arrows. The first line has 'MT' on both sides and a welding symbol (a semi-circle with two lines). The second line has 'RT' on both sides and a welding symbol (a triangle). The third line has 'RT' on both sides and a welding symbol (a triangle).</p>
<p>To specify tests of welds or parts where only length of section need be considered, the length in inches shall be shown to the right of the basic test symbol.</p>	 <p>The diagram shows three reference lines with arrows. The first line has 'MT8' on the arrow side. The second line has 'PT10' on the non-arrow side. The third line has 'RT4' on the non-arrow side.</p>

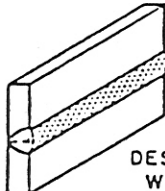
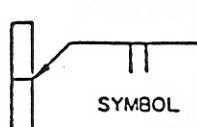
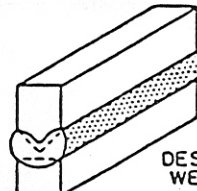
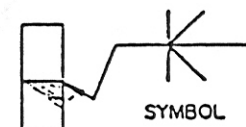
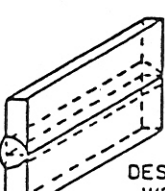
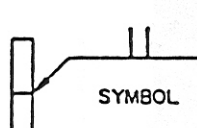
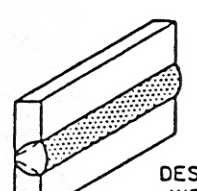
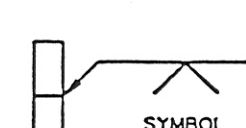
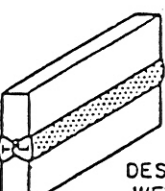
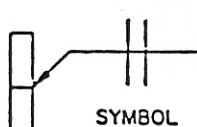
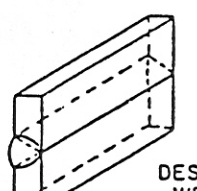
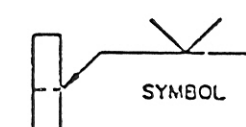
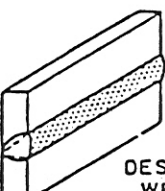
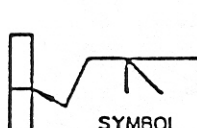
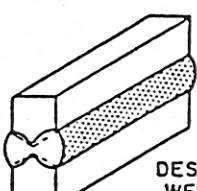
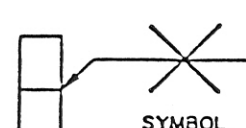
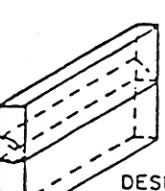
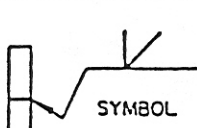
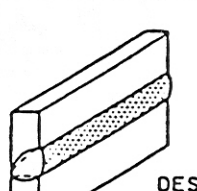
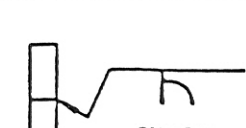
<p>To show the exact location of a section to be tested as well as its length, dimension lines shall be used. When the full length of a part is to be tested, no length dimension need be shown on the testing symbol.</p>	
<p>To specify a number of tests to be taken at random, the number of desired tests shall be shown in parenthesis. To specify tests to be made all around a part, the test-all-around symbol shall be used.</p>	

30.10 Application of Welding Symbols

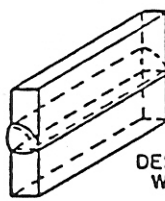
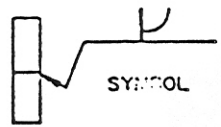
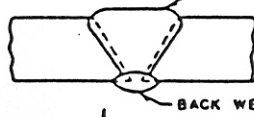
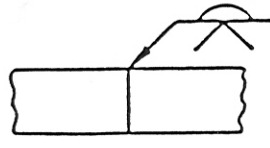
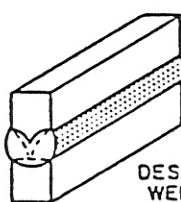
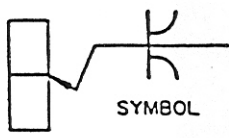

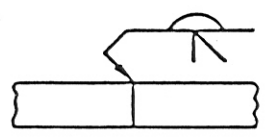
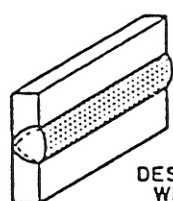
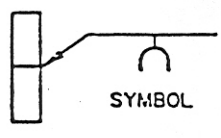
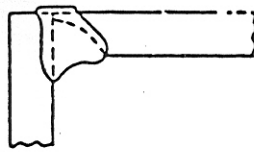
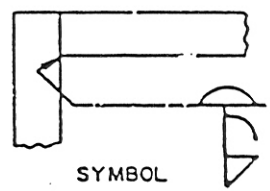
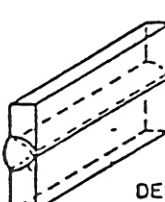
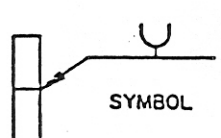
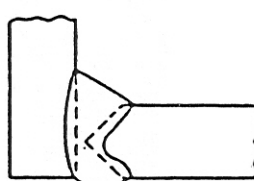
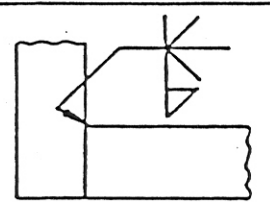
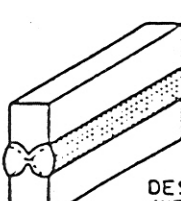
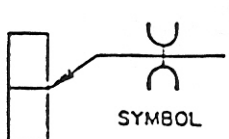
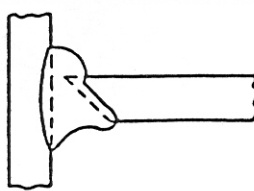
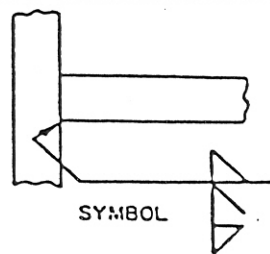
<p>Applicable Welds</p> <ul style="list-style-type: none"> Square-groove V-groove Bevel-groove U-groove J-groove Flash Upset 	 <p>JOINT</p> <p>BUTT JOINT</p>
<p>Applicable Welds</p> <ul style="list-style-type: none"> Square-groove V-groove Bevel-groove U-groove J-groove Fillet Flash 	 <p>JOINT</p> <p>CORNER JOINT</p>
<p>Applicable Welds</p> <ul style="list-style-type: none"> Bevel-groove J-groove Fillet Slot Plug 	 <p>JOINT</p> <p>TEE JOINT</p>

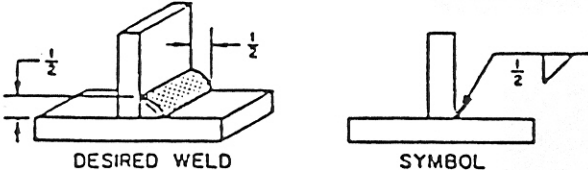
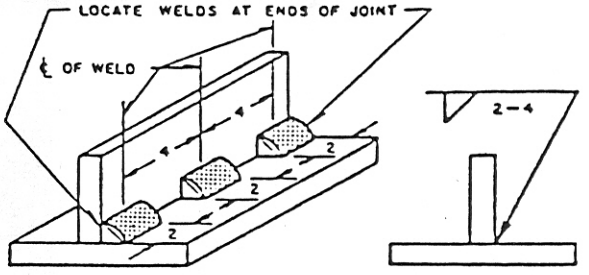
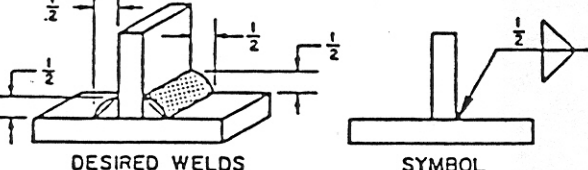
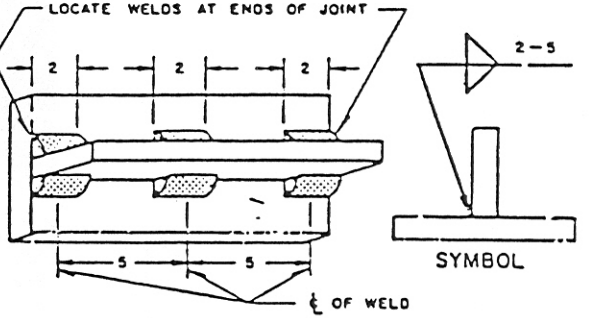
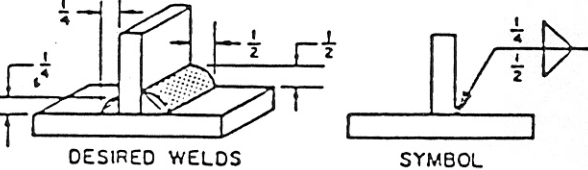
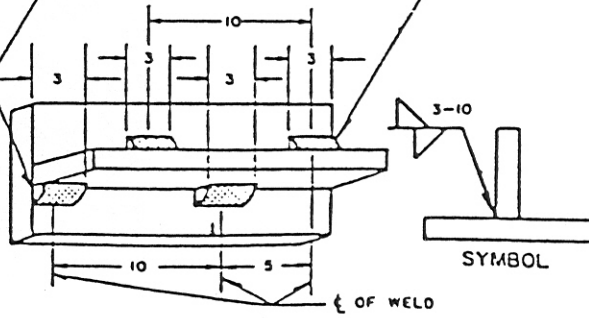
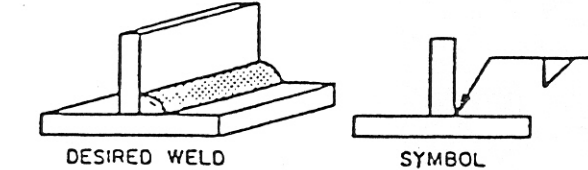
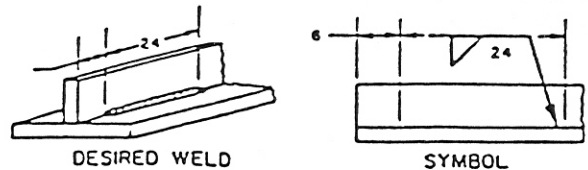
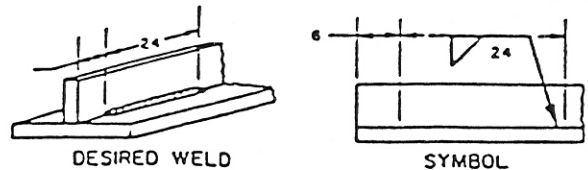
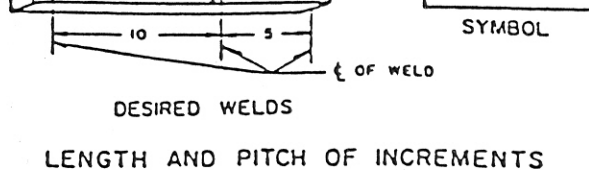
Applicable Welds Fillet Bevel-groove J-groove Slot Plug Spot Projection Seam	 <p>LAP JOINT</p>
Applicable Welds Square-groove V-groove Bevel-groove U-groove J-groove Spot Projection Seam	 <p>EDGE JOINT</p>

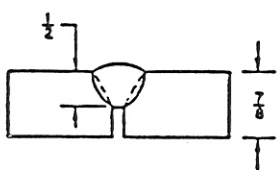
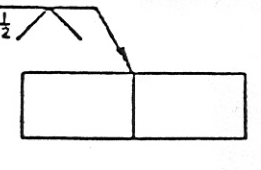
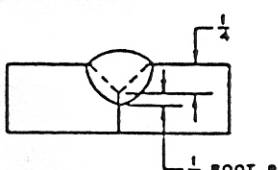
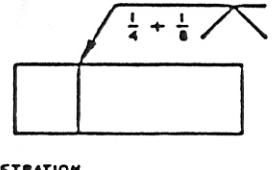
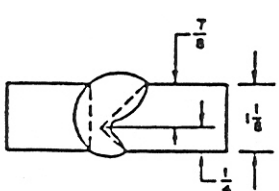
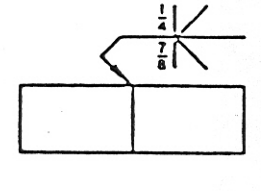
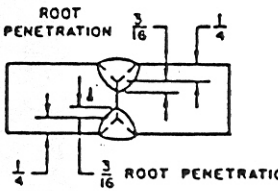
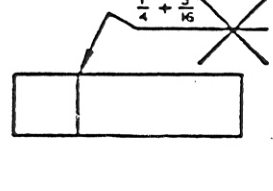
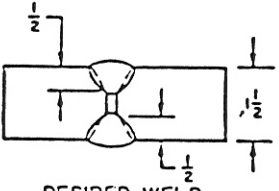
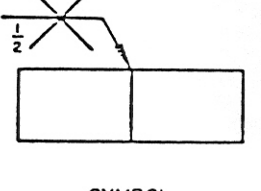
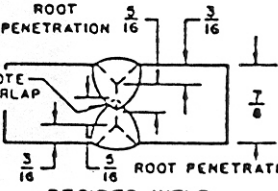
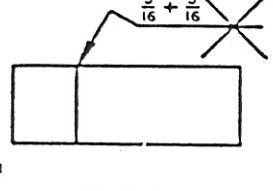
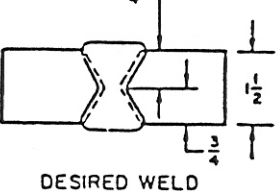
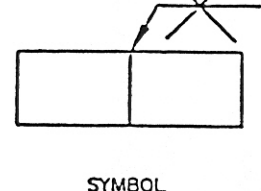
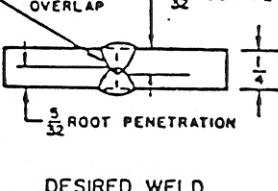
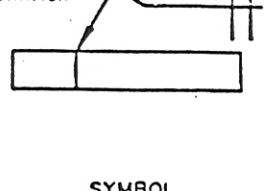
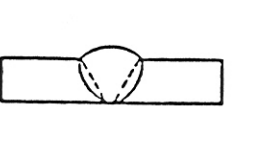
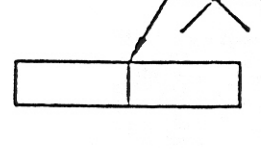
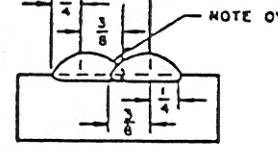
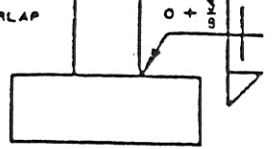
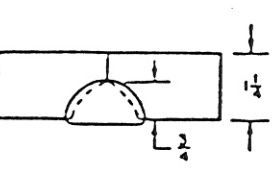
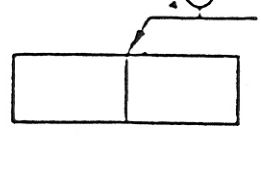
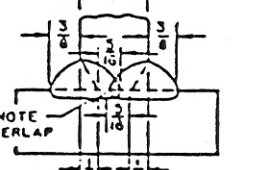
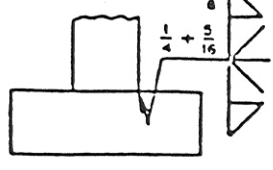
Vacuum Technologies Fabrication Standards

 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>ARROW-SIDE SQUARE-GROOVE</p>	 <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>BOTH-SIDES BEVEL-GROOVE</p>
 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>OTHER-SIDE SQUARE-GROOVE</p>	 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>ARROW-SIDE V-GROOVE</p>
 <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>BOTH-SIDES SQUARE-GROOVE</p>	 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>OTHER-SIDE V-GROOVE</p>
 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>ARROW-SIDE BEVEL-GROOVE</p>	 <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>BOTH-SIDES V-GROOVE</p>
 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>OTHER-SIDE BEVEL-GROOVE</p>	 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>ARROW-SIDE J-GROOVE</p>

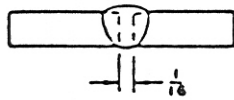
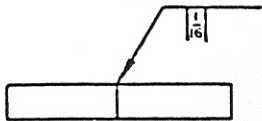
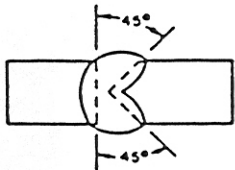
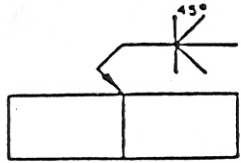
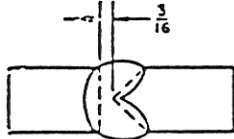
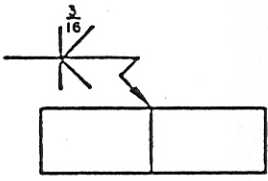
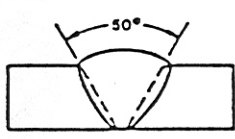
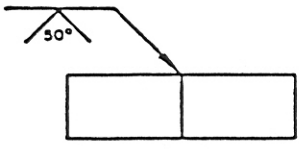
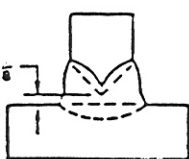
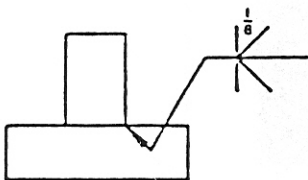
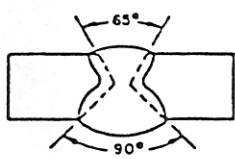
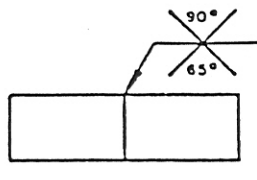
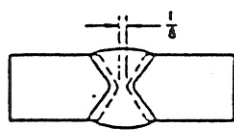
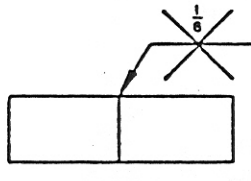
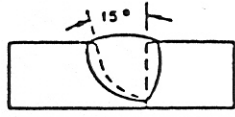
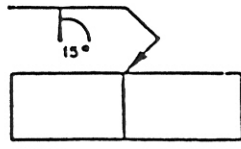

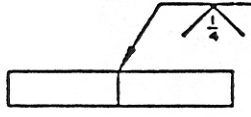

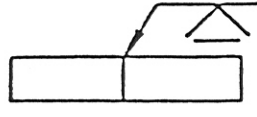
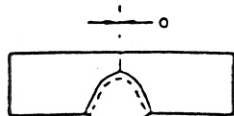
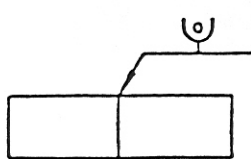
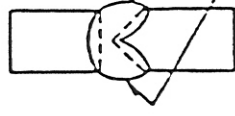
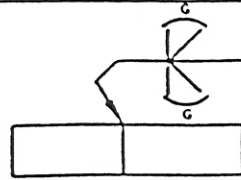
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 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>OTHER-SIDE J-GROOVE</p>	<p>GROOVE WELD MADE BEFORE WELDING OTHER SIDE</p>  <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>USE OF BEAD WELD SYMBOL TO INDICATE SINGLE-PASS BACK WELD</p>
 <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>BOTH-SIDES J-GROOVE</p>	 <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>SINGLE-BEVEL-GROOVE AND BEAD</p>
 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>ARROW-SIDE U-GROOVE</p>	 <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>BEAD, SINGLE-J-GROOVE AND FILLET</p>
 <p>DESIRED WELD</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>OTHER-SIDE U-GROOVE</p>	 <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>FILLET AND DOUBLE-BEVEL-GROOVE</p>
 <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>SECTION OR END VIEW</p> <p>BOTH-SIDES U-GROOVE</p>	 <p>DESIRED WELDS</p>  <p>SYMBOL</p> <p>SINGLE-BEVEL-GROOVE AND DOUBLE FILLET</p>

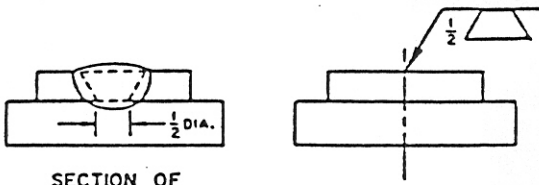
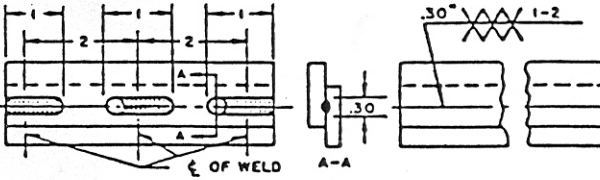
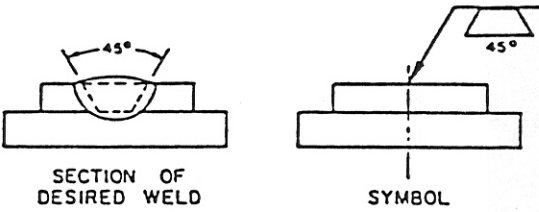
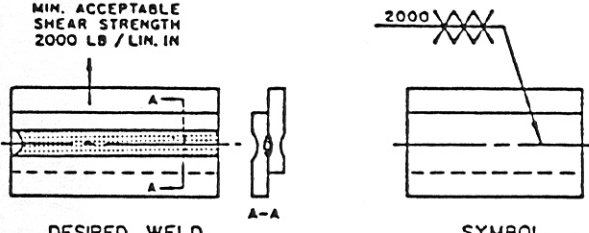
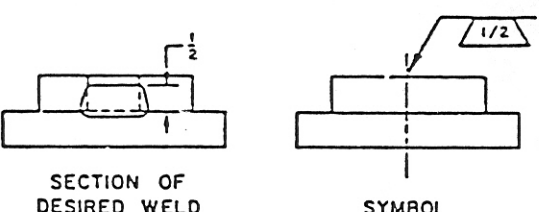
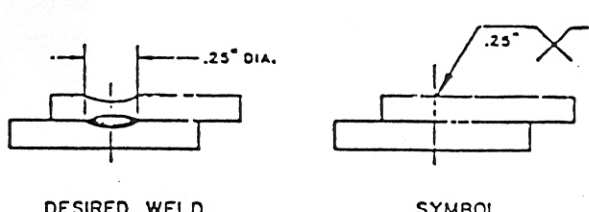
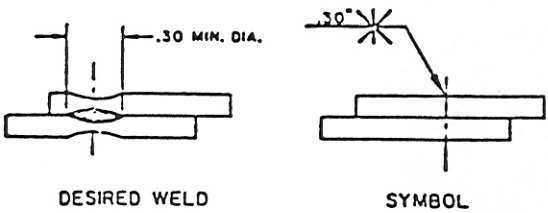
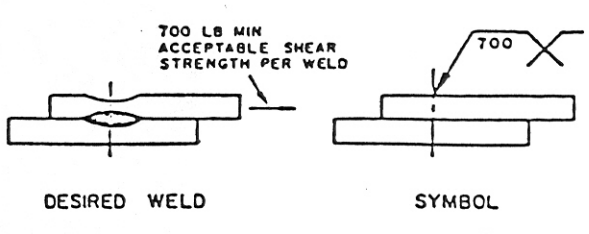
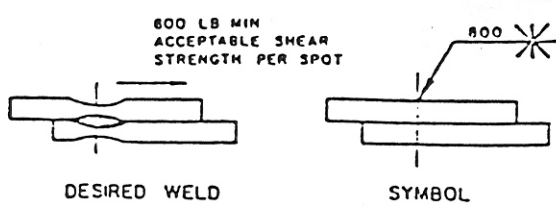
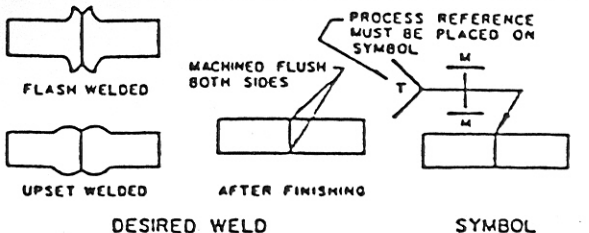
 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>SIZE OF SINGLE-FILLET WELD</p>	 <p>LOCATE WELDS AT ENDS OF JOINT</p> <p>DESIRED WELDS</p> <p>SYMBOL</p> <p>LENGTH AND PITCH OF INCREMENTS OF INTERMITTENT WELDING</p>
 <p>DESIRED WELDS</p> <p>SYMBOL</p> <p>SIZE OF EQUAL DOUBLE-FILLET WELDS</p>	 <p>LOCATE WELDS AT ENDS OF JOINT</p> <p>DESIRED WELDS</p> <p>SYMBOL</p> <p>LENGTH AND PITCH OF INCREMENTS OF CHAIN INTERMITTENT WELDING</p>
 <p>DESIRED WELDS</p> <p>SYMBOL</p> <p>SIZE OF UNEQUAL DOUBLE-FILLET WELDS</p>	 <p>LOCATE WELDS AT ENDS OF JOINT</p> <p>DESIRED WELDS</p> <p>SYMBOL</p> <p>LENGTH AND PITCH OF INCREMENTS OF STAGGERED INTERMITTENT WELDING</p>
 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>CONTINUOUS FILLET WELD</p>	 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>LENGTH OF FILLET WELD</p>
 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>SIZE OF FILLET WELD HAVING UNEQUAL LEGS</p>	 <p>LOCATE WELDS AT ENDS OF JOINT</p> <p>DESIRED WELDS</p> <p>SYMBOL</p> <p>LENGTH AND PITCH OF INCREMENTS OF STAGGERED INTERMITTENT WELDING</p>

 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELDS</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELDS</p>	 <p>SYMBOL</p>

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 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>
 <p>DESIRED WELD</p>	 <p>SYMBOL</p>	 <p>DESIRED WELD</p>	 <p>SYMBOL</p>

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 <p>SECTION OF DESIRED WELD</p> <p>SYMBOL</p> <p>SIZE OF PLUG WELD</p>	 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>LENGTH AND PITCH OF INTERMITTENT SEAM WELDS</p>
 <p>SECTION OF DESIRED WELD</p> <p>SYMBOL</p> <p>INCLUDED ANGLE OF COUNTERSINK OF PLUG WELDS</p>	 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>STRENGTH OF SEAM WELDS</p>
 <p>SECTION OF DESIRED WELD</p> <p>SYMBOL</p> <p>DEPTH OF FILLING OF PLUG WELDS</p>	 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>DIAMETER OF PROJECTION WELDS</p>
 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>DIAMETER OF SPOT WELDS</p>	 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>SHEAR STRENGTH OF PROJECTION WELDS</p>
 <p>DESIRED WELD</p> <p>SYMBOL</p> <p>SHEAR STRENGTH OF SPOT WELDS</p>	 <p>FLASH WELDED</p> <p>UPSET WELDED</p> <p>DESIRED WELD</p> <p>SYMBOL</p> <p>FLASH AND UPSET WELDS FINISHED FLUSH</p>

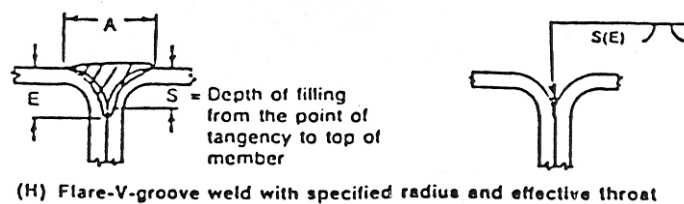
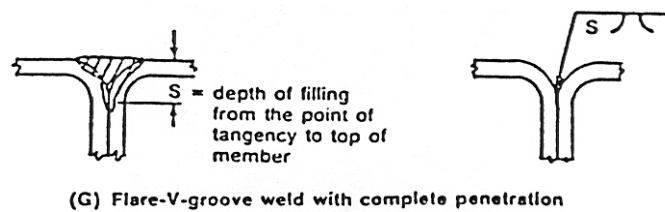
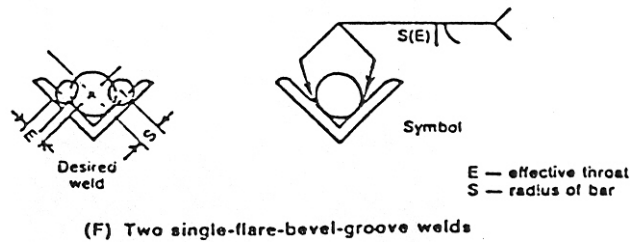
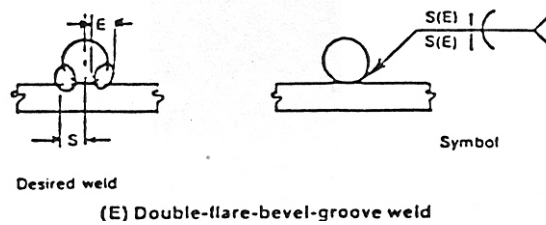
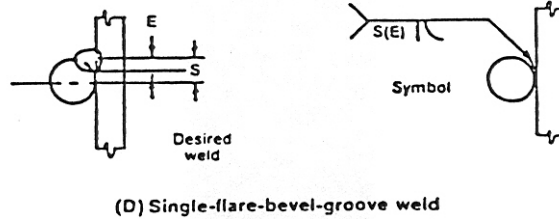
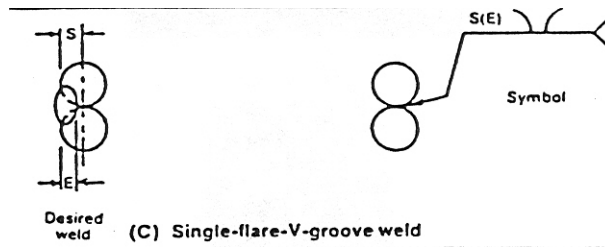


Table 5.1 Brazing Process Letter Designation Symbols

Process	Symbol
Infrared brazing	IRB
Torch brazing	TB
Furnace brazing	FB
Induction brazing	IB
Resistance brazing	RB
Dip brazing	DB

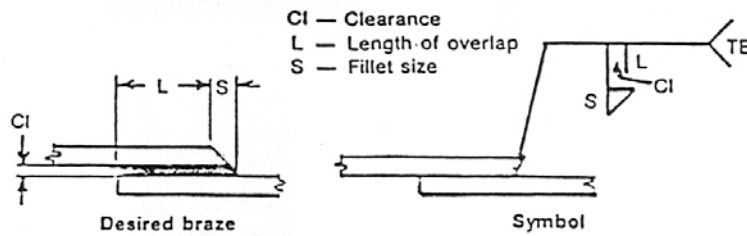
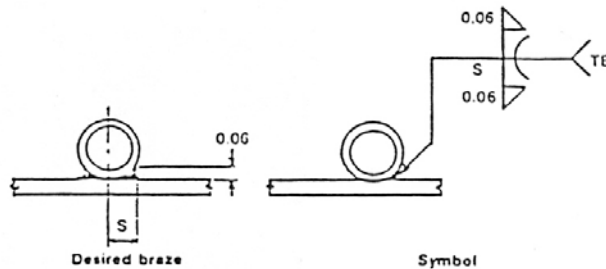
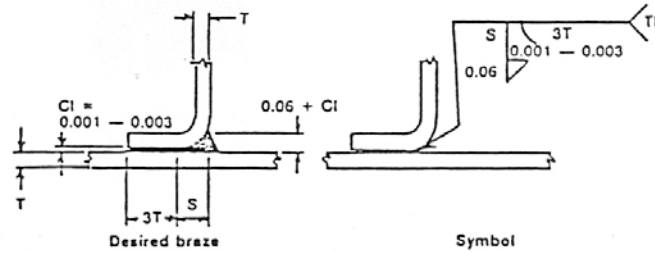
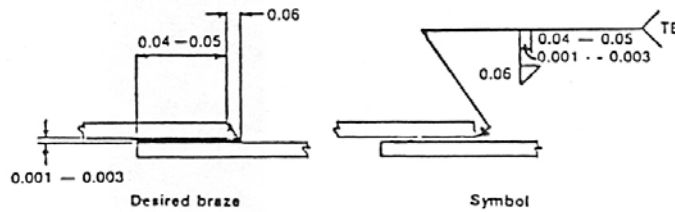
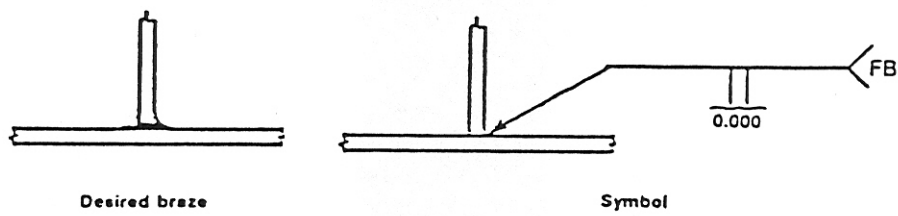
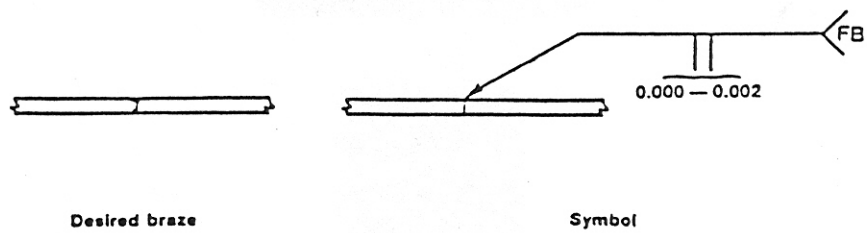


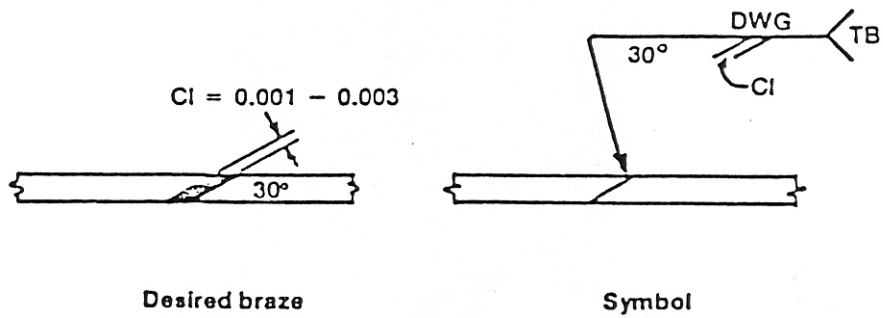
Fig. 5.1—Location of elements of the brazing symbol.



NOTE: The above symbols with fillet size should be used for brazements made with local heating methods only: e.g. torch, induction. Where high strength joints are desired and where furnace brazing is used, fillets should be fabricated in the base metal.



NOTE: No fillet symbol or dimensions should be used when furnace brazing unless for a specific application in a flat position or when special filler metals or techniques are used.



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