

Communications & Power Industries
beverly microwave division
88236

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		TITLE		DEVICE TYPE	
		Fabrication Standards STD No. 302368		WRITER	
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REV	LOCATION	ECO/DCO No.	DESCRIPTION	DATE	APPROVAL
N	All	DCO 6556	Generate new p/n to replace obsoleted VAR-PPP-45105 per DCO.	4/7/11	D. S. D. Sarkisian
P	All	ECO 15884	Revise section 20	3/9/17	G.B. G. Burton
R	20.0 & 29.0	ECO 18534	Correct Table of Contents, clarify verbiage on C of C, PC, & C of A.	12/05/18	G. B. G. Burton

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Latest revision changes are shaded.



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POLICY & PROCEDURE

FABRICATION STANDARDS

302368

ATTENTION

**UNLESS OTHERWISE SPECIFIED ON THE
PURCHASE ORDER(S) OR CPI INTERNAL
SHOP WORK ORDER(S) ALL
REQUIREMENTS OF THE DRAWING(S) OR
SPECIFICATION(S) MUST BE MET.**

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The objective of the Fabrication Standards 302368 is to supplement design information of Communications and Power Industries Products drawings.

All suppliers and CPI manufacturing unite will be responsible for the implementation of the contents of these standards in the performance of work for CPI as covered by CPI purchase orders and by shop work orders.

Failure to comply to the requirements contained in the Fabrication Standards may result in the rejection of the material produced. In the event of a conflict between the standards, the drawing, and/or the purchase order, the purchase order shall take precedence, the drawing next and then the standards.

All questions from suppliers concerning the interpretation of standards shall be directed to the Communications and Power Industries Products Purchasing Department.

Additional information or revisions will be supplied to suppliers and CPI departments from time to time. It shall be the supplier's responsibility and the responsibility of all CPI departments engaged in fabrication of piece parts, subassemblies & finished product to keep these standards up to date.



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1.0 BURRS, SHARP EDGES AND CORNERS

1.1 Burrs

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

1.1.1 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. (Refer to paragraph 1.3).

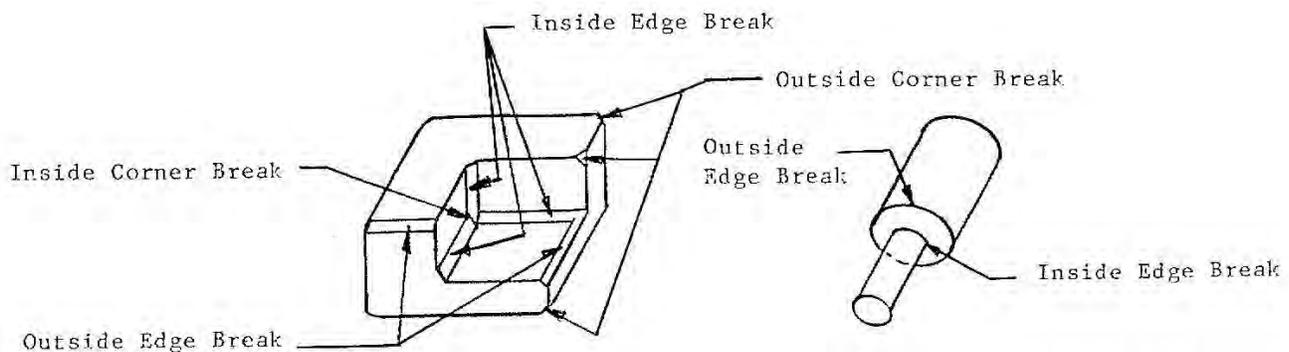
1.1.2 When the notation “BURRS  “ appears on a drawing, burrs shall be removed to the extent that they are not visible with a 10x magnification.

1.1.3 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 the removal of a burr.

1.2 Breaks on Edges and Corners

A break is any alteration to the intersection of two or more surfaces that removes the actual line or point (edge/corner) of intersection. Usually an outside break requires removal of material, an inside break leaves material.





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An edge is an intersection of two planes.

A corner is an intersection of three or more planes.

1.2.1 Tolerance – Other than Holes:

If a specific edge or corner break is not shown on the drawing, the following limits apply to all outside edges and/or corners. .005 inch/inch of the smallest adjacent width or diameter shall apply. Inside edges and/or corners may be broken to a maximum of .010.

1.2.2 Edge Breaks on Plain Holes and Counterbores:

Following limits shall apply

NOMINAL HOLE SIZE	MAXIMUM EDGE BREAK
Up to .375 Dia.	.005
.375 Dia and over	.010

1.2.3 Inside Edges at Bottom of Counterbores:

May be broken .005 maximum unless otherwise noted.

1.2.4 A Sharp Edge/Corner:

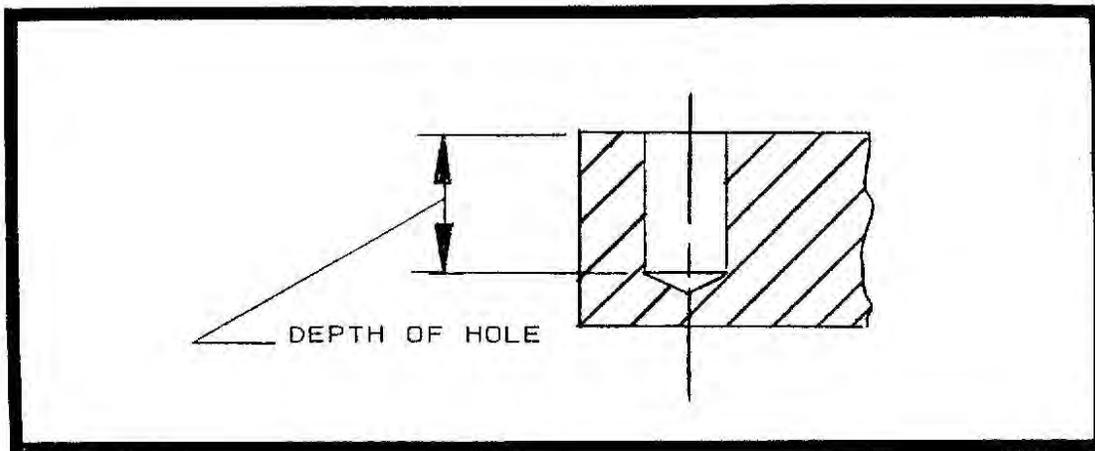
On a drawing shall be interpreted as having a .002 maximum edge break.

1.2.5 Undercuts of inside edges shall be subject to rejection unless otherwise noted.

2.0 HOLES

2.1 Drilled Holes

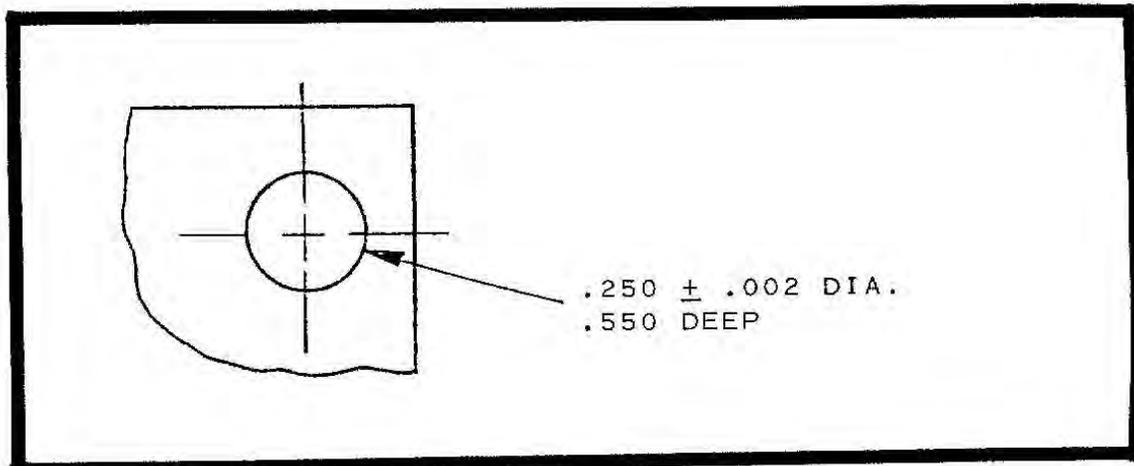
A drilled hole shall be measured for depth as the distance from the surface of entry to the limit of depth of the full diameter, (thus excluding the drill point unless otherwise specified).



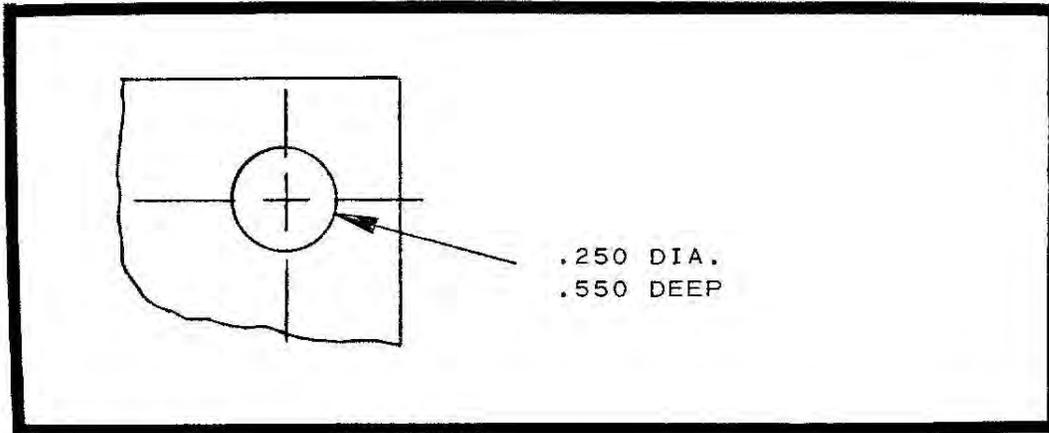
The tolerance of the depth of the hole shall be defined on the drawing.

2.2 Hole Diameter Tolerance

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

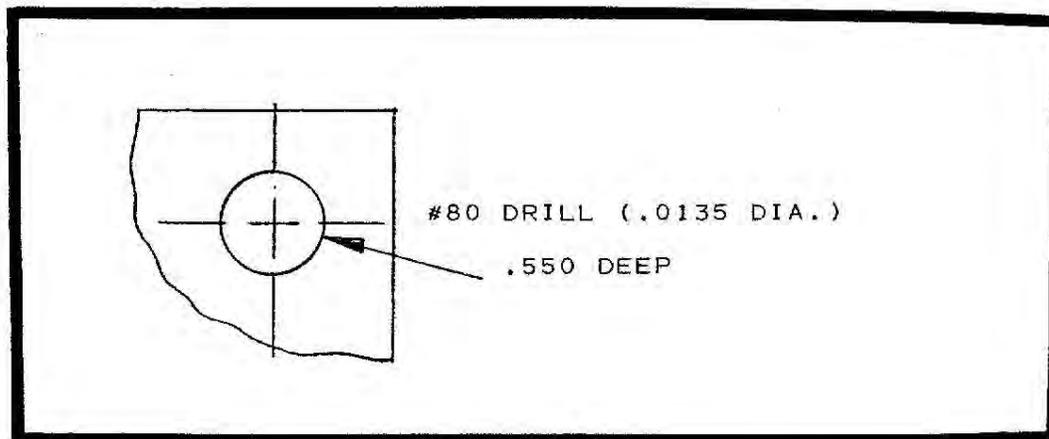


2.2.2 When the drawing calls for a drilled hole without tolerances on the hole dimension, the tolerance block shall apply.



Note: Hole is to be a .250 + Note: Hole is to be a .250 ± .005 diameter .550 ± .005 deep

2.2.3 When the drawing calls for a number, fraction or a letter drill and gives reference to a hole diameter then the following table of hole diameter tolerances shall be applied.



HOLE DIAMETER	TOLERANCE		
	Machine Parts (Metal)	Sheet Metal (Parts)	Non Metal (Parts)
.0135 thru .125	+0.004/-0.001	+0.004/-0.003	+0.003/-0.004
.126 thru .250	+0.005/-0.001	+0.005/-0.003	+0.003/-0.005
.251 thru .500	+0.006/-0.001	+0.006/-0.004	+0.004/-0.007
.501 thru .750	+0.008/-0.001	+0.008/-0.005	+0.005/-0.008
.751 thru 1.000	+0.010/-0.001	+0.010/-0.006	+0.005/-0.015
1.00 thru 2.000	+0.012/-0.001	+0.015/-0.006	
2.001 and over	Tolerance as indicated		

2.3 Reamed Holes

2.3.1 Reamed holes shall carry the following tolerances even though they may be called out as numbers. All reamed holes shall be machine reamed unless specified to the contrary.

2.3.2 The allowable tolerance applied to the diameter of a reamed hole is as follows:

Size	Tolerance
0 – 1/2 inch	+0.0005 inch
	-0.0000 inch
above 1/2 inch – 1 inch	+0.0010 inch
	-0.0000 inch
above 1 inch	+0.0015 inch
	-0.0000 inch

2.4 Countersunk Holes

Clearance Holes for 82 ° Flat countersunk Head Screws

<u>Screw Size</u>		Clearance Holes	Countersink Diameter
Commercial Designation	Basic Major Diameter		
1		.074	.146
		.079	.162
2		.087	.172
		.092	.188
4		.114	.225
		.119	.243
6		.142	.279
		.148	.301
8		.167	.332
		.173	.356
10		.194	.385
		.200	.411
1/4		.254	.507
		.263	.537
5/16		.313	.635
		.322	.670
3/8		.383	.762
		.392	.802
7/16		.450	.812
		.459	.853
1/2		.512	.875
		.522	.919
9/16		.575	1.000
		.585	1.050
5/8		.637	1.125
		.647	1.181
3/4		.762	1.375
		.773	1.444

3.0 THREADS

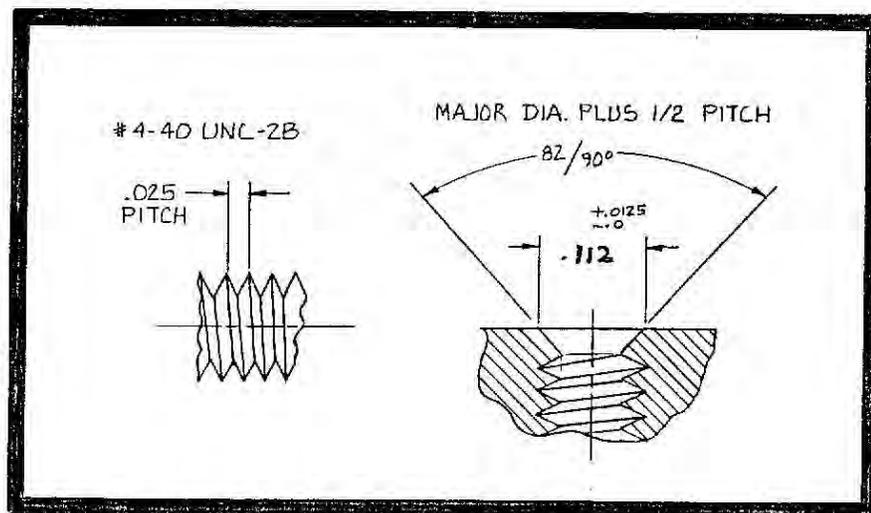
3.1 General

3.1.1 All threads, unless otherwise specified on the drawing shall conform to the unified tabulations and formulations of the National Bureau of Standards Handbook H28. Unified Form Threads, American National Form Threads, Special Threads and Unified Miniature Screw Threads shall be defined by the Unified System

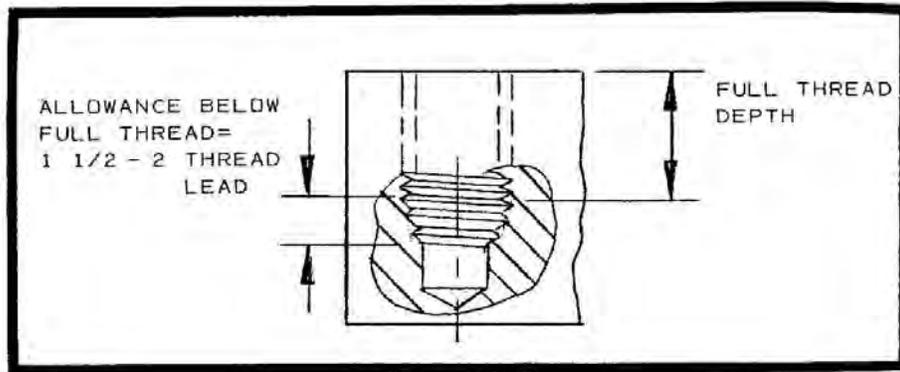
3.1.2 The class of fit for external threads shall be defined as Class 2A and for internal threads shall be defined as Class 2B unless otherwise specified on the drawing.

3.2 Threaded Holes

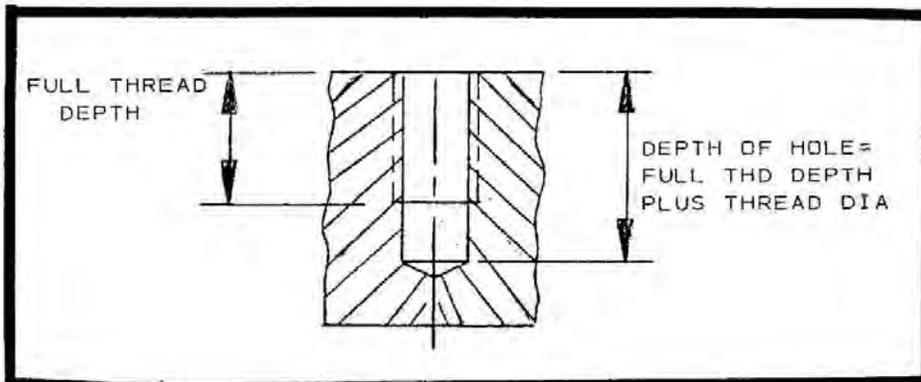
3.2.1 All threaded holes shall be countersunk 82° or 90° to the major diameter of the thread with a tolerance of plus ½ the pitch of the thread.



3.2.2 The specified depth of a threaded hole shall mean there will be full threads.



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” gage shall not penetrate more than one and one-half turns. The go-gage shall freely penetrate 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 or reworked standard hardware) and threaded protrusions shall be necked or undercut to the root diameter of the thread, unless otherwise specified. The length of such an undercut shall not exceed 3 full threads or be less than 1 full thread.

3.4 Metric Threads

Metric threads, unless otherwise specified on the drawing, shall conform to the I. S. O. Metric System (International Organization for Standardization) Ref. A.N.S.I. # B1.16 1972

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 sign "X". Example: M16 X 1.5.

3.4.2 Thread Classes

Unless otherwise specified on the drawing, the class of metric threads shall be "6G" for external threads and "6H" for internal threads.

3.5 Helicoils

When helicoil inserts are to be used on CPI parts, the following should be adhered to.

3.5.1 Class of Fit

For standard and screw-lock inserts #3 thru #8 use 2B, for larger size #10 and above use 2B or 3B.

4.0 SYMBOLS

The following list of symbols are the most commonly used on CPI drawings (otherwise reference ANSI-Y14.5).

	Flatness		Diameter
	Angularity		Straightness
	Roundness (Circularity)		Parallelism
	Profile of Any Surface		Cylindricity
	Runout		Profile of Any Line
	Concentricity		True Position
	Perpendicularity (Squareness, Normality)		Symmetry

Modifiers

	Maximum Material Condition
	Regardless of Feature Size

Special Symbols

	Projected Tolerance Zone
	Least Material Condition

5.0 DATUMS

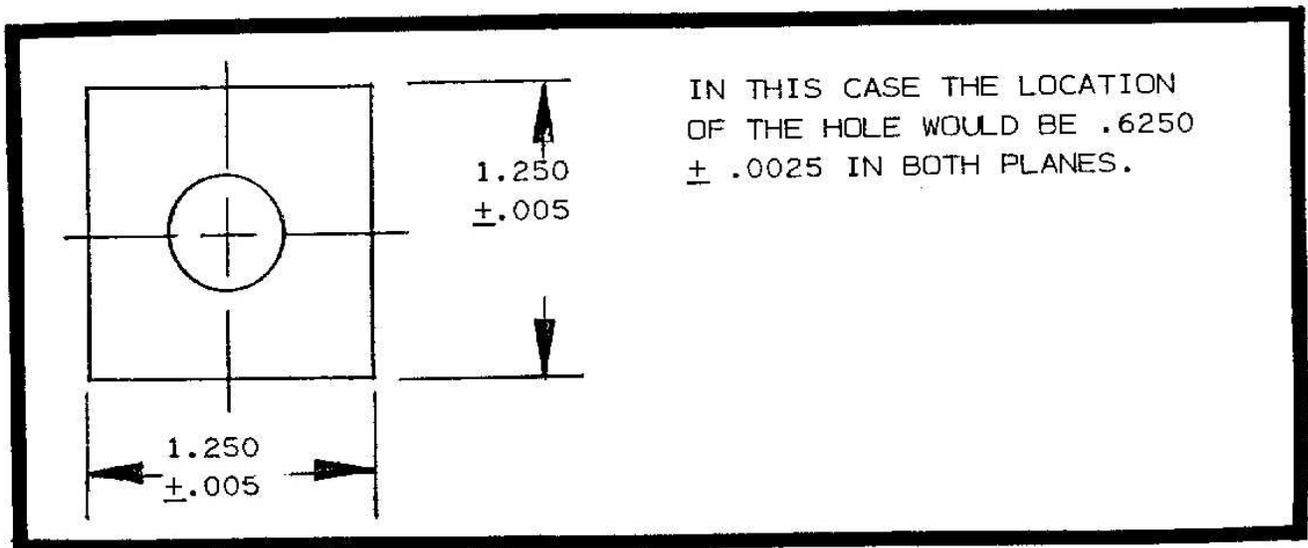
Datums are points, lines, planes or surfaces assumed to be exact for purposes of computation from which the location or geometric relationship (form) of features of a part may be established.

5.1 Casting & Forging Datums

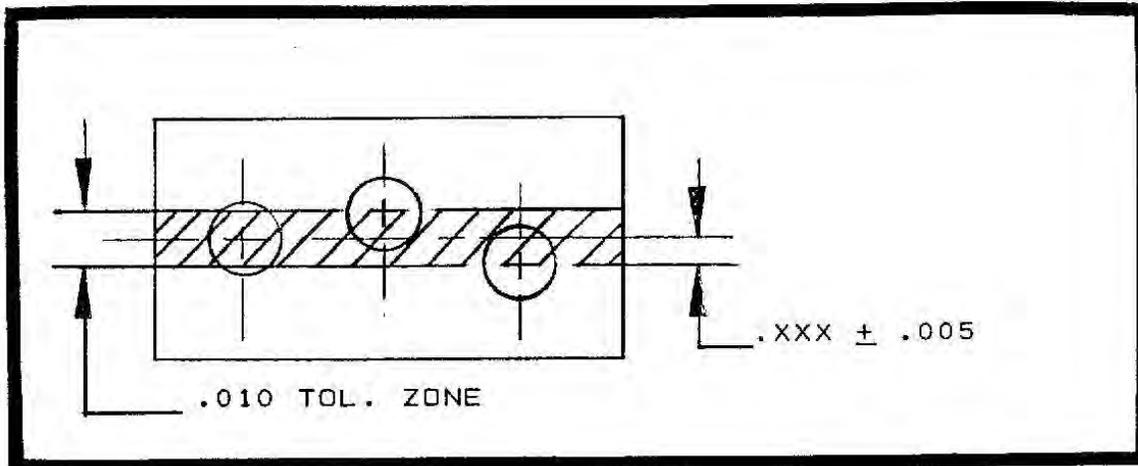
Datums for castings and forgings may be temporary datums used only to locate machined surfaces which will subsequently serve as the permanent datum. Such temporary datums may or may not be removed by machining. Machining datums are surfaces or centers of features which are not changed by subsequent machining.

5.2 Implied Tolerances with Respect to Centerlines

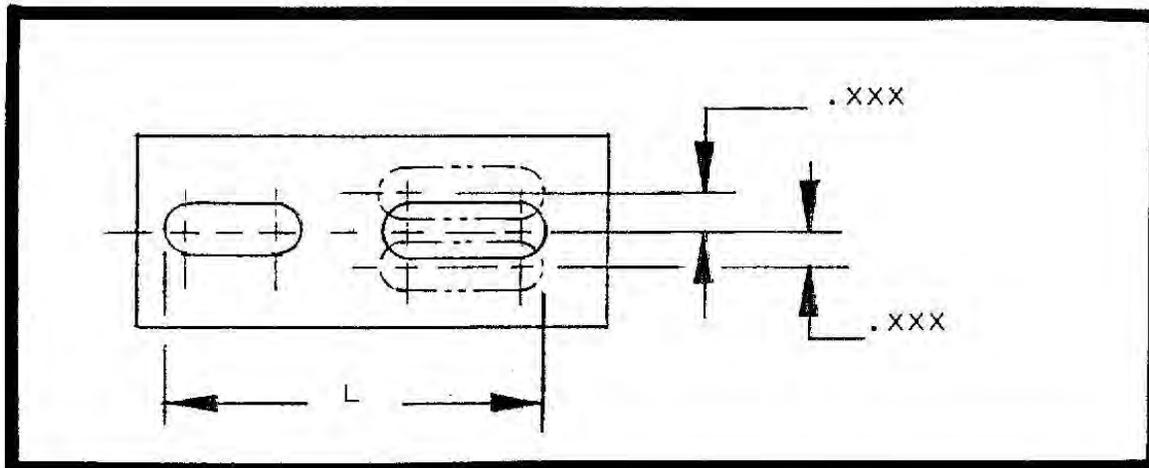
5.2.1 When centerlines are used to depict the location of features such as holes, slots, bosses, etc., the location of the center line shall be one half of the nominal dimension with one half of the tolerance of that dimension.



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

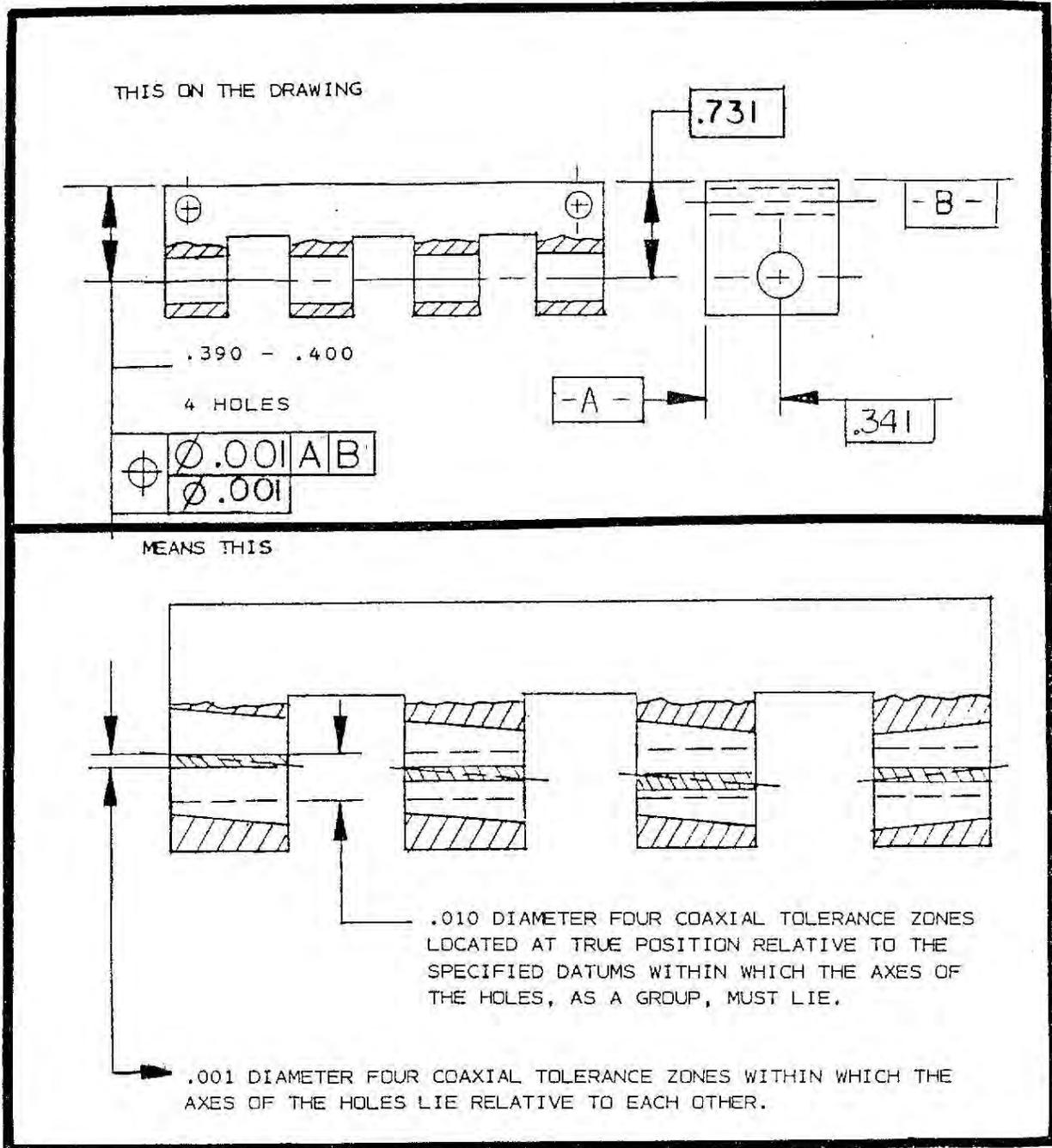


5.4 When slots such as keyways are indicated to be in line, the following tolerances shall apply.



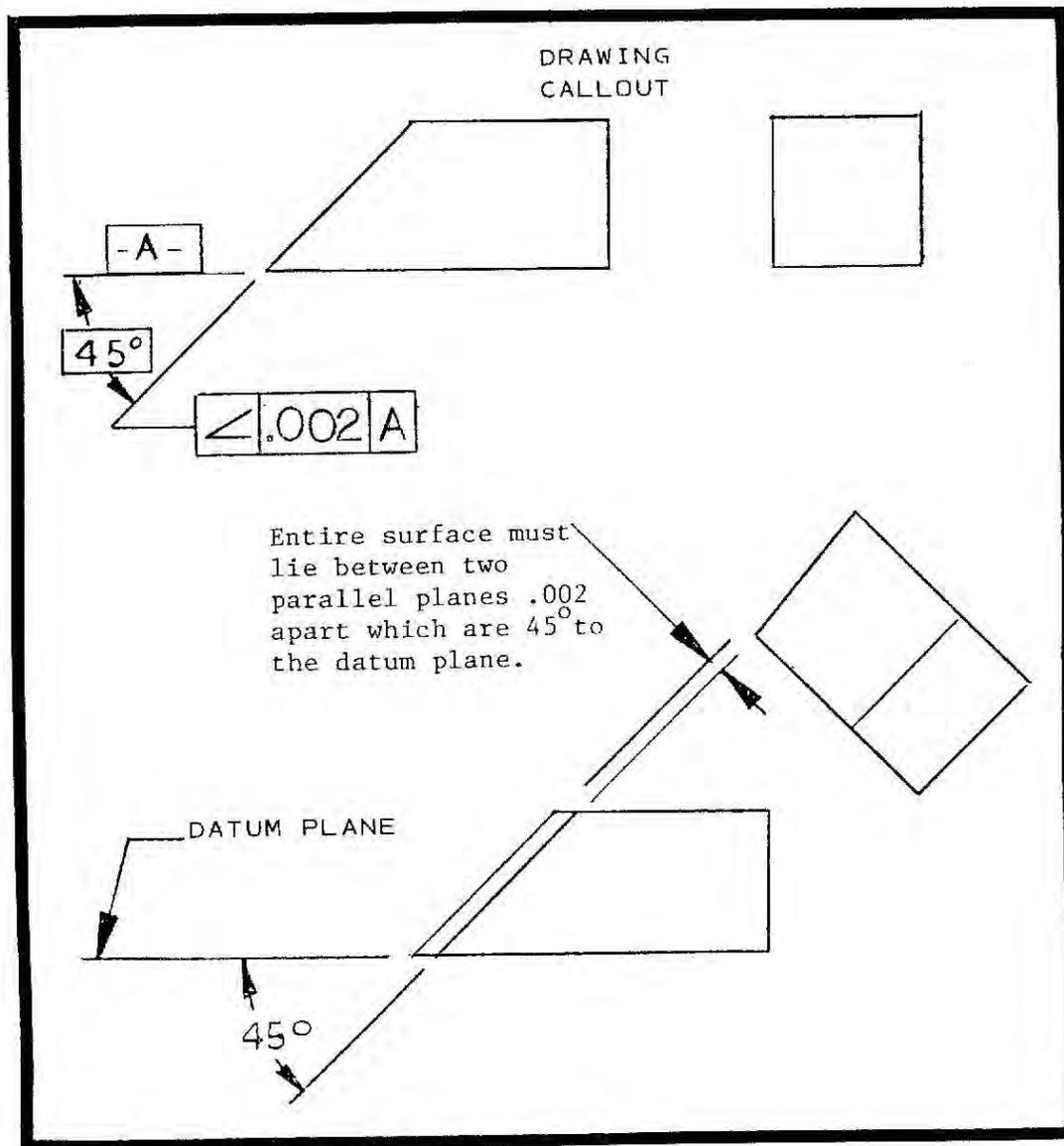
L (Length)	Tolerance of .XXX
Up to 1.00	$\pm .0005$
Up to 2.00	$\pm .00075$
Up to 3.00	$\pm .0010$
Up to 5.00	$\pm .0020$
Up to 8.00 to 10.00	$\pm .0025$
Up to 10.00 to 18.00	$\pm .0035$

5.5 When holes are indicated by a note to be in line with other holes, the following shall apply.

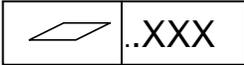


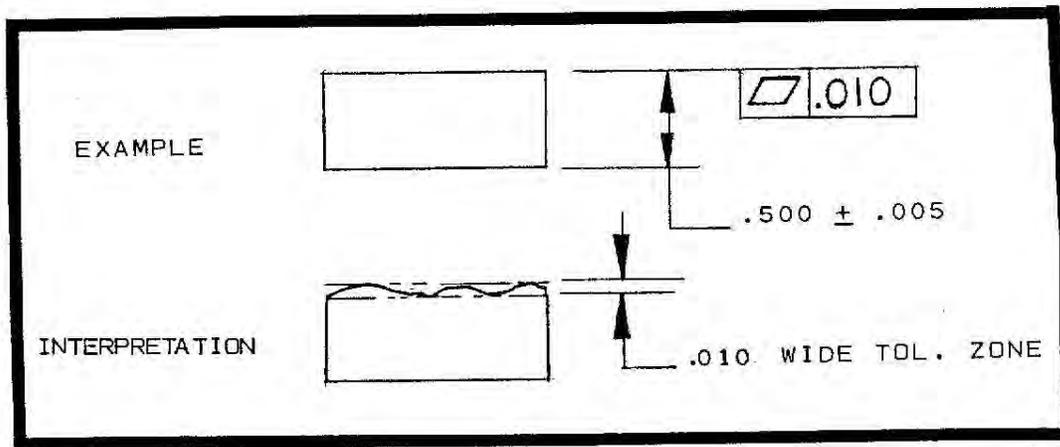
6.0 ANGULARITY

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



7.0 FLATNESS

When the symbol for flatness  appears on CPI Beverly drawings, 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 .495 to .505 and must lie between two parallel planes .010 apart.

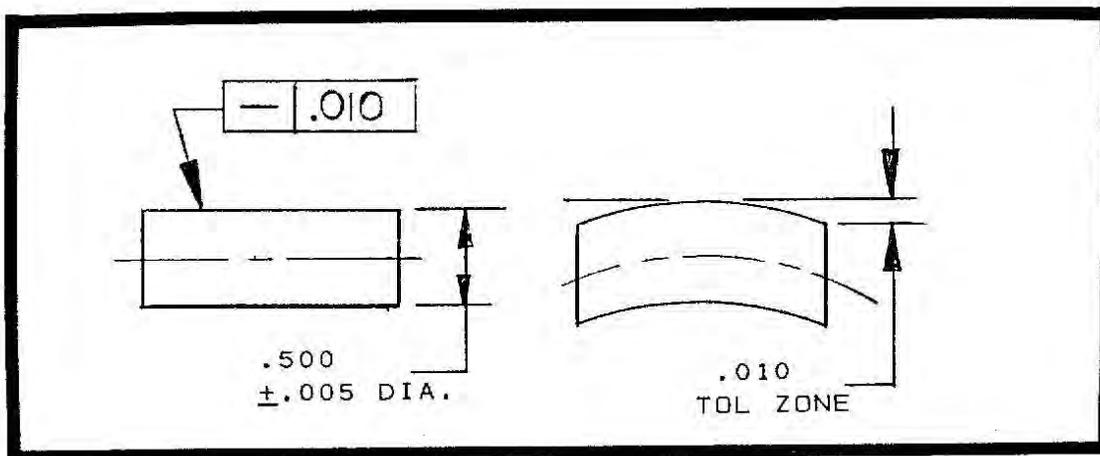
- 7.1 When the symbol or requirement for flatness does not appear on the drawing the following paragraphs shall apply. The definition and interpretation for flatness shall be in accordance with Paragraph 7.0.
 - 7.1.1 Deviation from flatness of machined surfaces, generally in the form of a wave or recurrent waves, that is not caused by flexing (determinable by hand pressure) shall not exceed 0.001 inch per inch of length.
 - 7.1.2 Deviation from flatness of sheet metal parts such as stampings shall conform to the maximum values indicated in metal stampings standard (Section 21.0, Paragraph 21.2)

8.0 STRAIGHTNESS

When the symbol for straightness

—	.XXX
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 appears on CPI Beverly drawings it shall be defined as a condition where an element is a straight line. The straightness tolerances specifies a tolerance zone of uniform width along a straight line, within which all points of the considered line must lie.

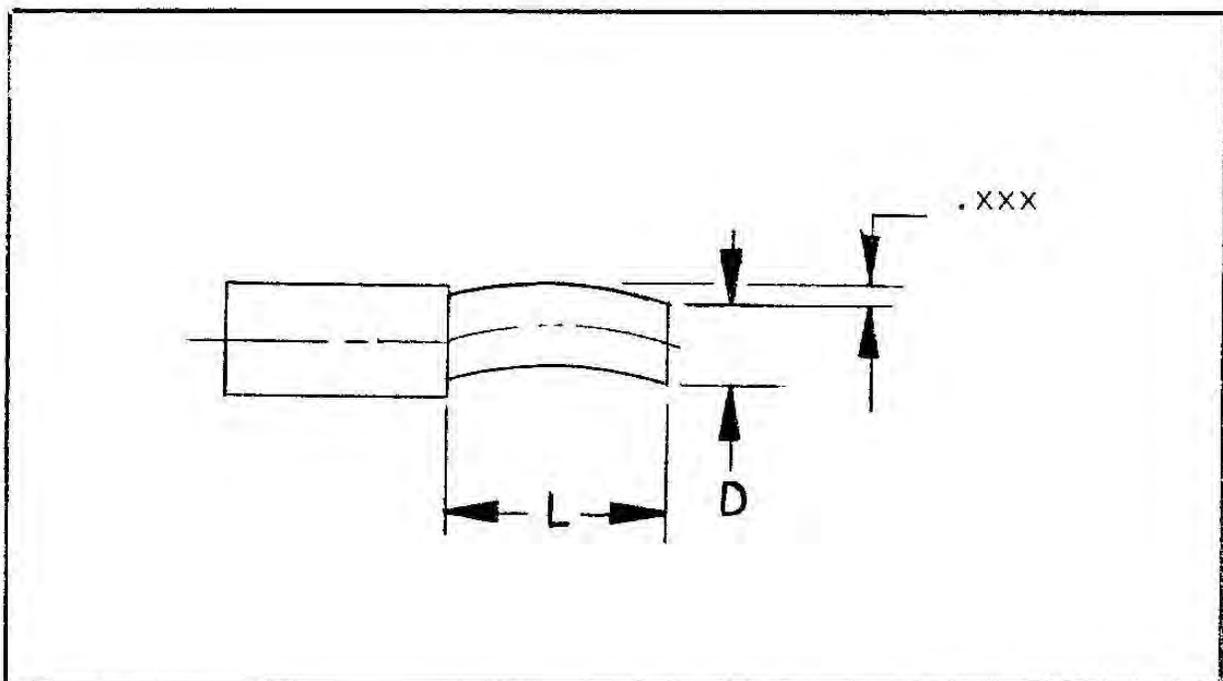


The feature must be within the specified .495 to .505 tolerance of size and any longitudinal element of its surface must be between two parallel lines. .010 a part where the two lines and the nominal axis of the feature share a common plane.

8.1 When the symbol or requirement for straightness does not appear on the drawing, the requirements of the following paragraphs shall apply.

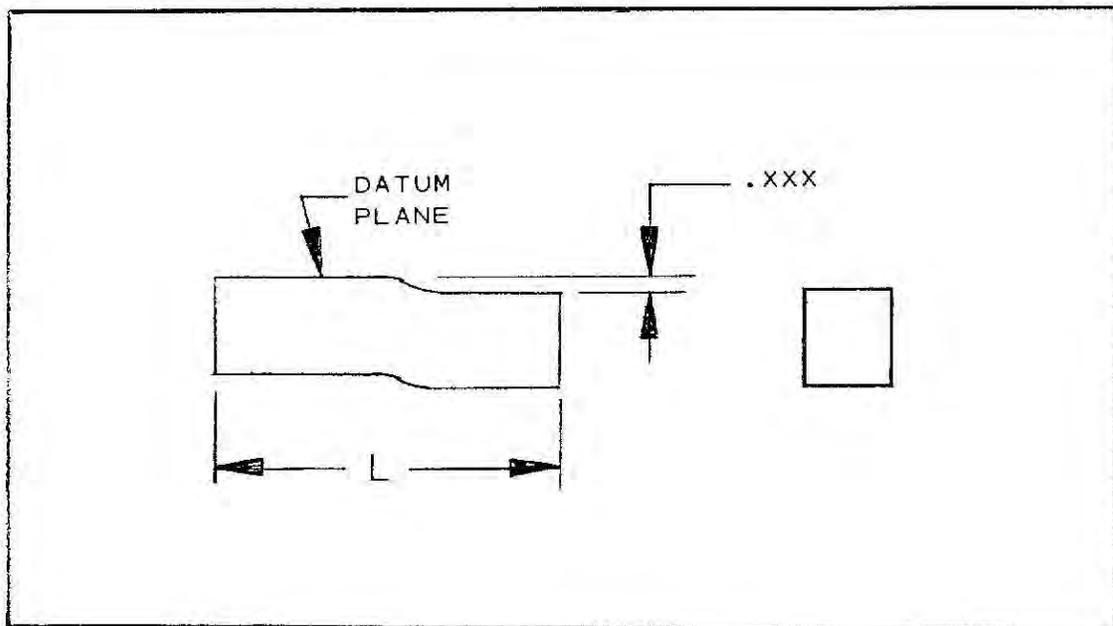
8.1.1 Deviation from straightness of conical and cylindrical features shall conform to the following table.

Length (L)	Diameter (D)	MAS. Camber (XXX)
0 to .9999"	0 to 1.0"	.0015
1.0000" to 1.9999"	0 to 1.0	.0020
2.0000" to 2.9999"	0 to 1.0"	.0025
3.0000" to 5.0000"	0 to 3.0"	.0030



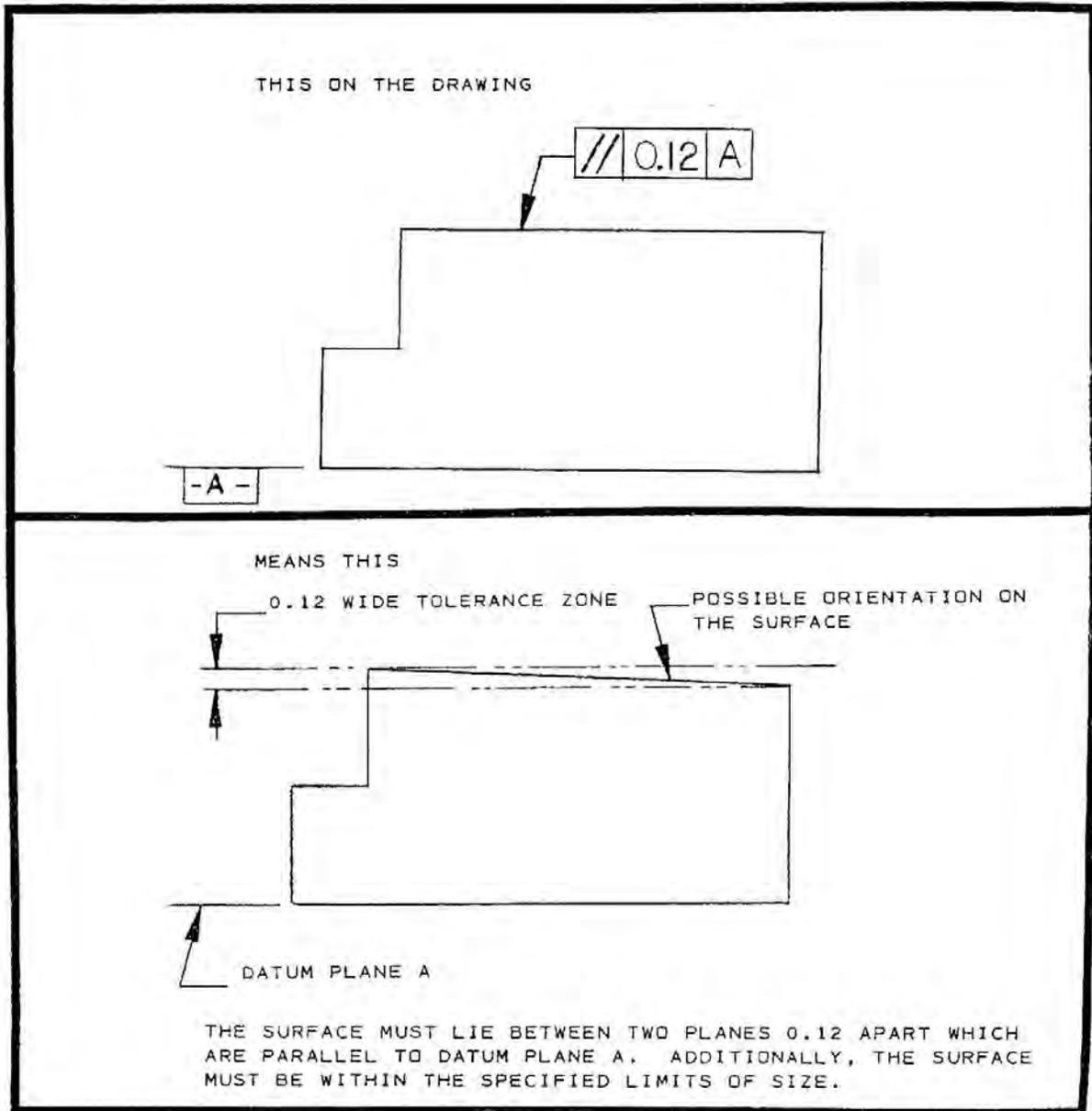
8.2 Deviation from straightness of a plane surface or element having other than a cylindrical cross section shall conform to the following.

Length (L)	Maximum Deviation (XXX)
0 to 1.9999"	.0020
2.0000" to 2.9999"	.0025
3.0000" to 4.9999"	.0030
5.0000" to 7.0000"	.0035
8.0000" to 9.9999"	.0050
10.0000" to 15.0000"	.0080



9.0 PARALLELISM

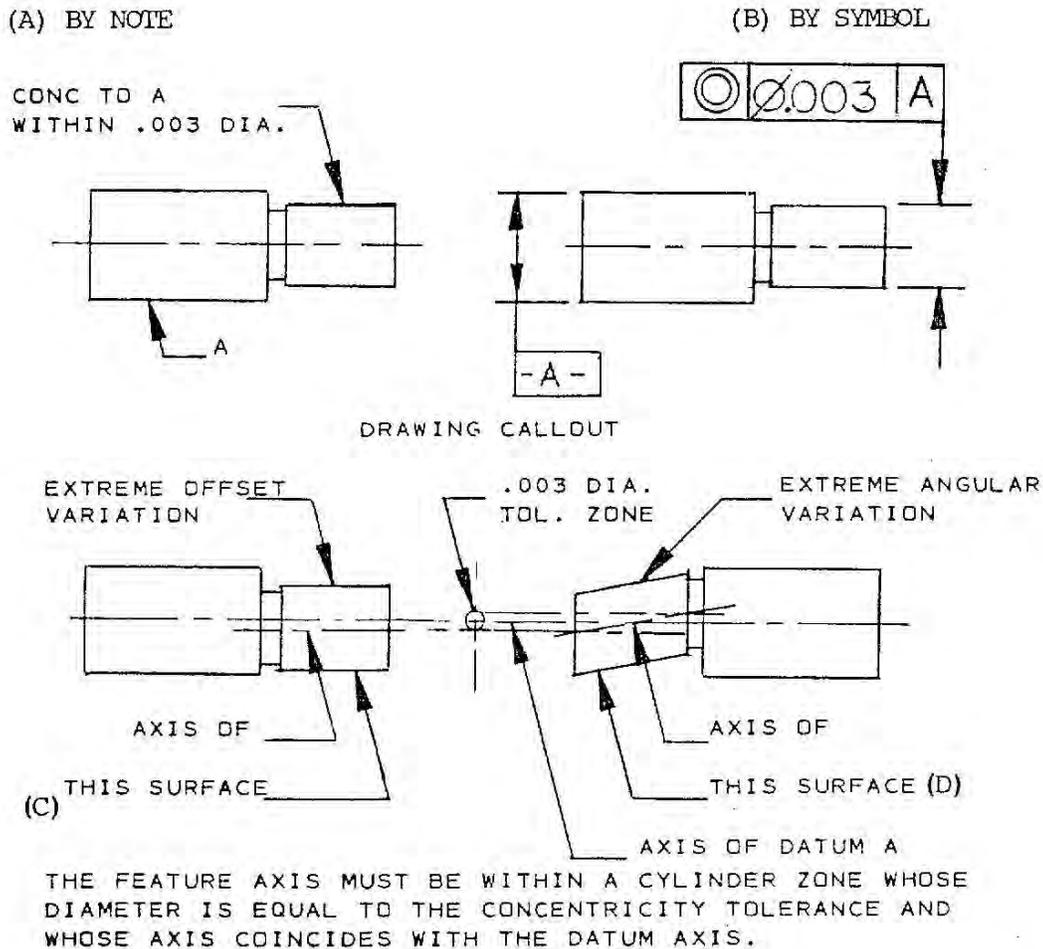
Parallelism is the condition of a surface, line or axis which is equidistant at all points from a datum plane or axis.



10.0 CONCENTRICITY

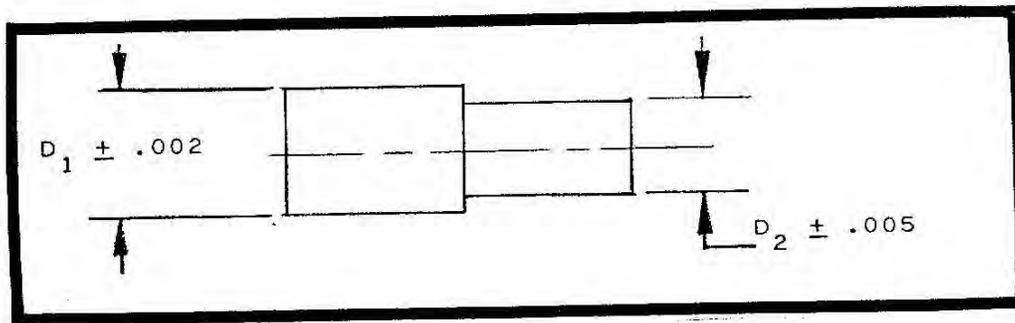
Concentricity shall be interpreted as being the condition of surfaces of revolution, holes or diameters wherein they have a common axis. The symbol for concentricity ◎ or a note shall be used on all CPI drawings. The datum(s) shall be specified immediately after the symbol. Concentricity tolerance as specified shall be a total indicator reading (T.I.R.).

Figures (A) and (B) illustrate the method of call out. Figures (C) and (D) provide the respective interpretation.



10.1 When the symbol for concentricity does not appear on the drawing, the concentricity between any two round features shown on the same center line shall be equal to one half (1/2) of the total tolerance of the two surfaces in question.

EXAMPLE:



The concentricity in T. I. R between D_1 and D_2 will be:

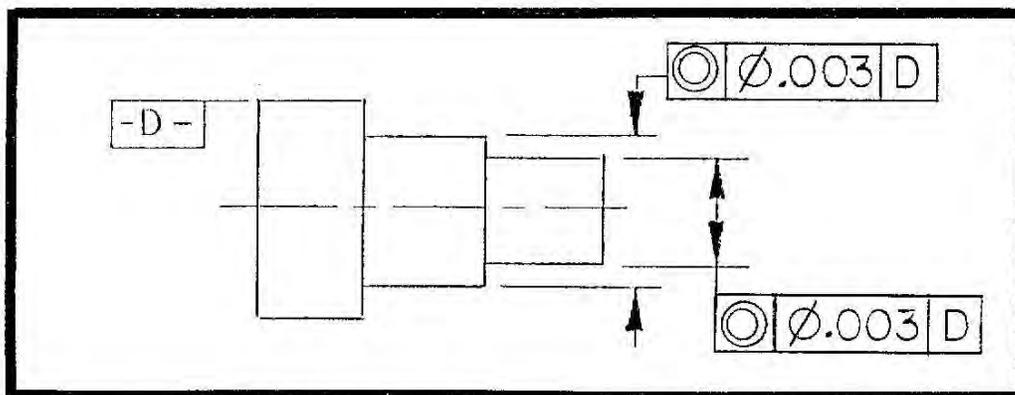
Tolerance $D_1 = .004$

Tolerance $D_2 = .010$

$$\frac{.014}{2} = .007 \text{ TIR}$$

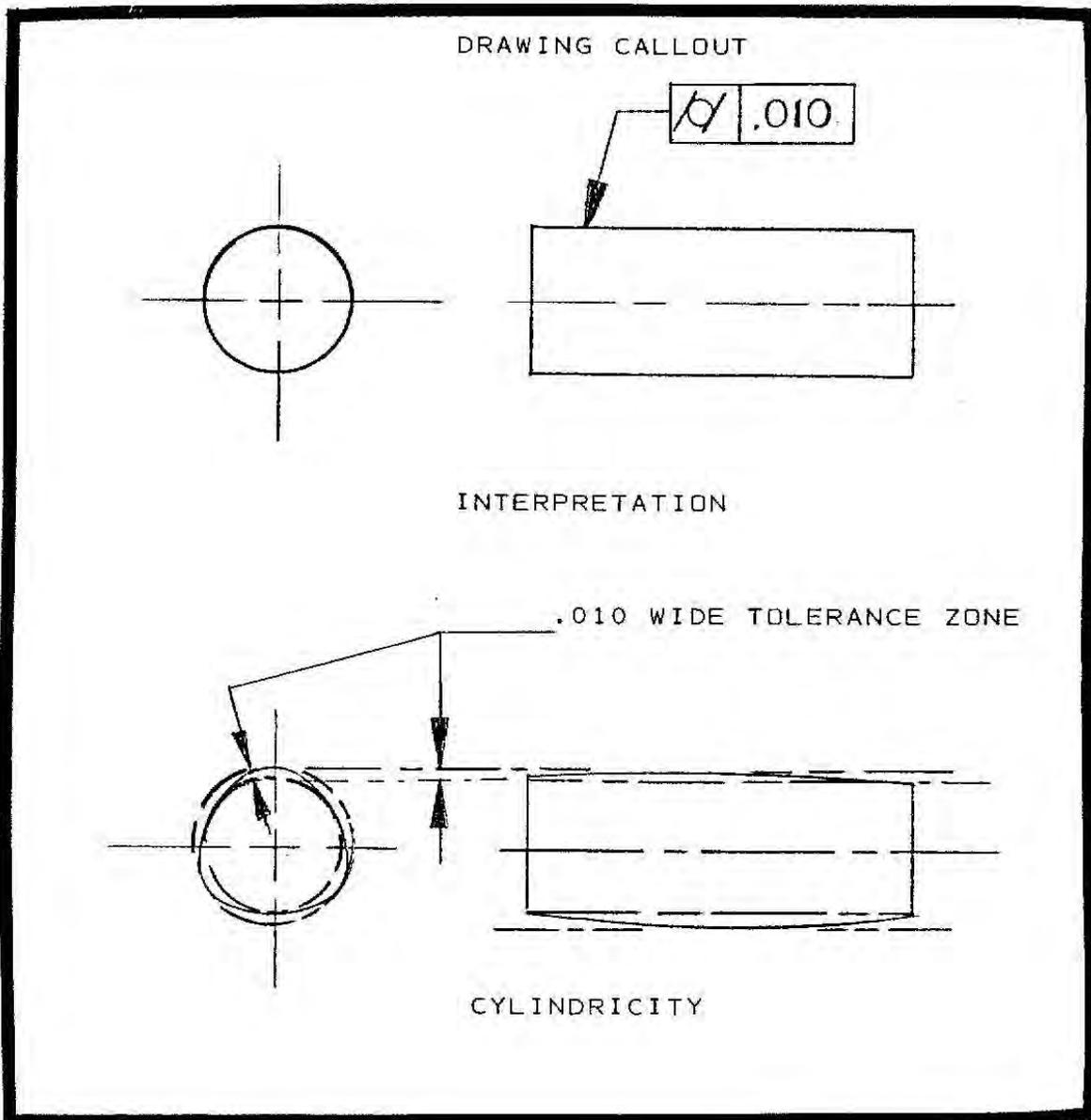
In the case of more than two (2) surfaces, one or more must be labeled as datum diameter.

EXAMPLE:



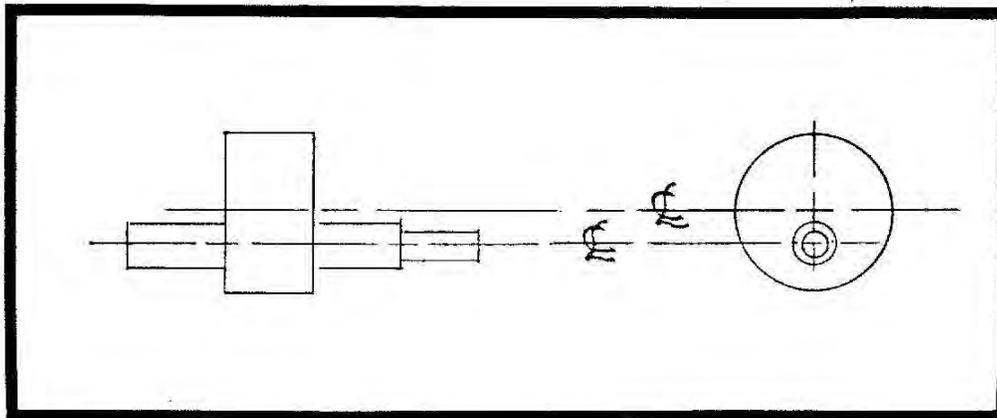
11.0 CYLINDRICITY

Cylindricity is a condition of a surface of revolution in which all elements form a perfect cylinder.



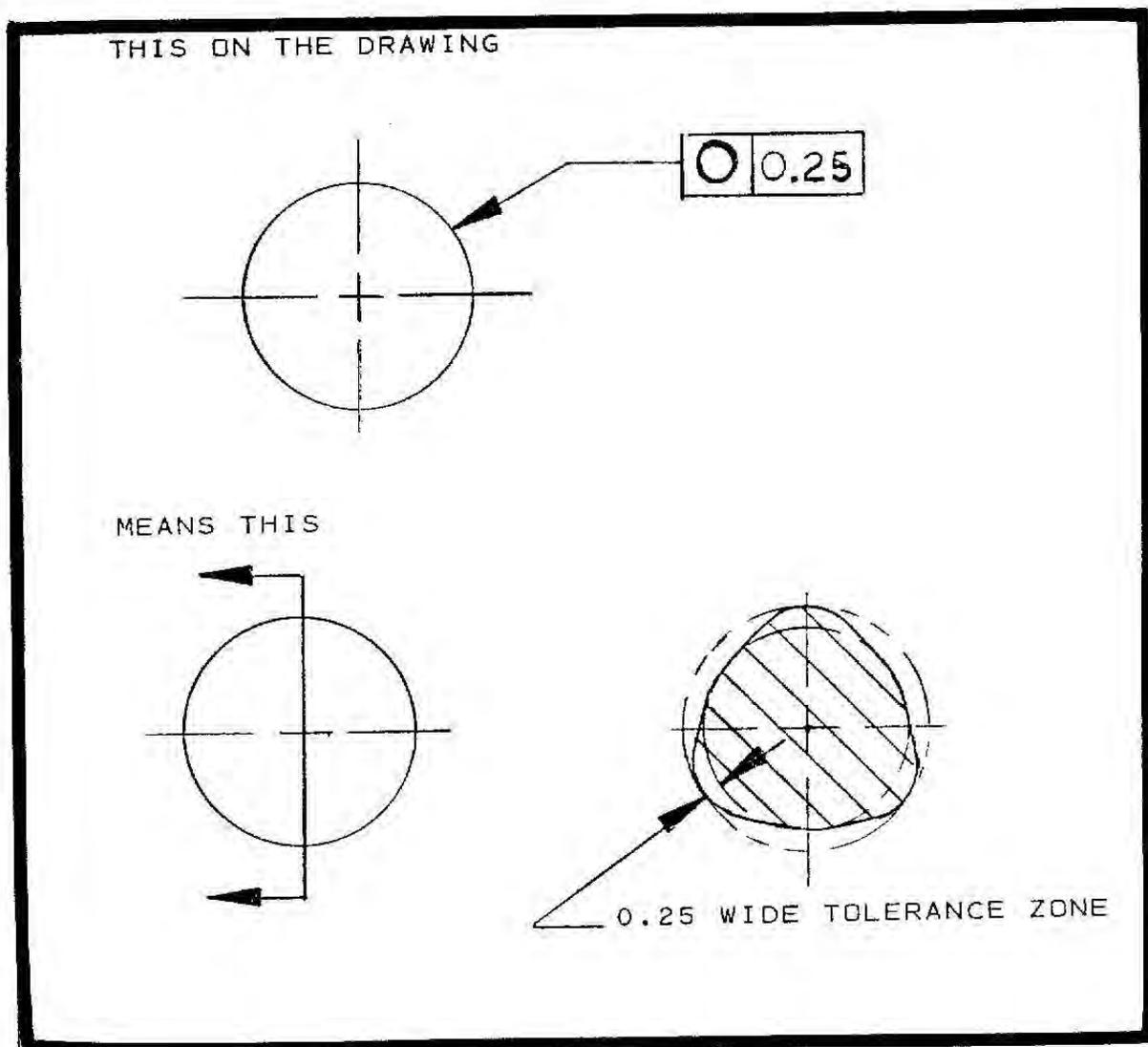
12.0 ECCENTRICITY

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.



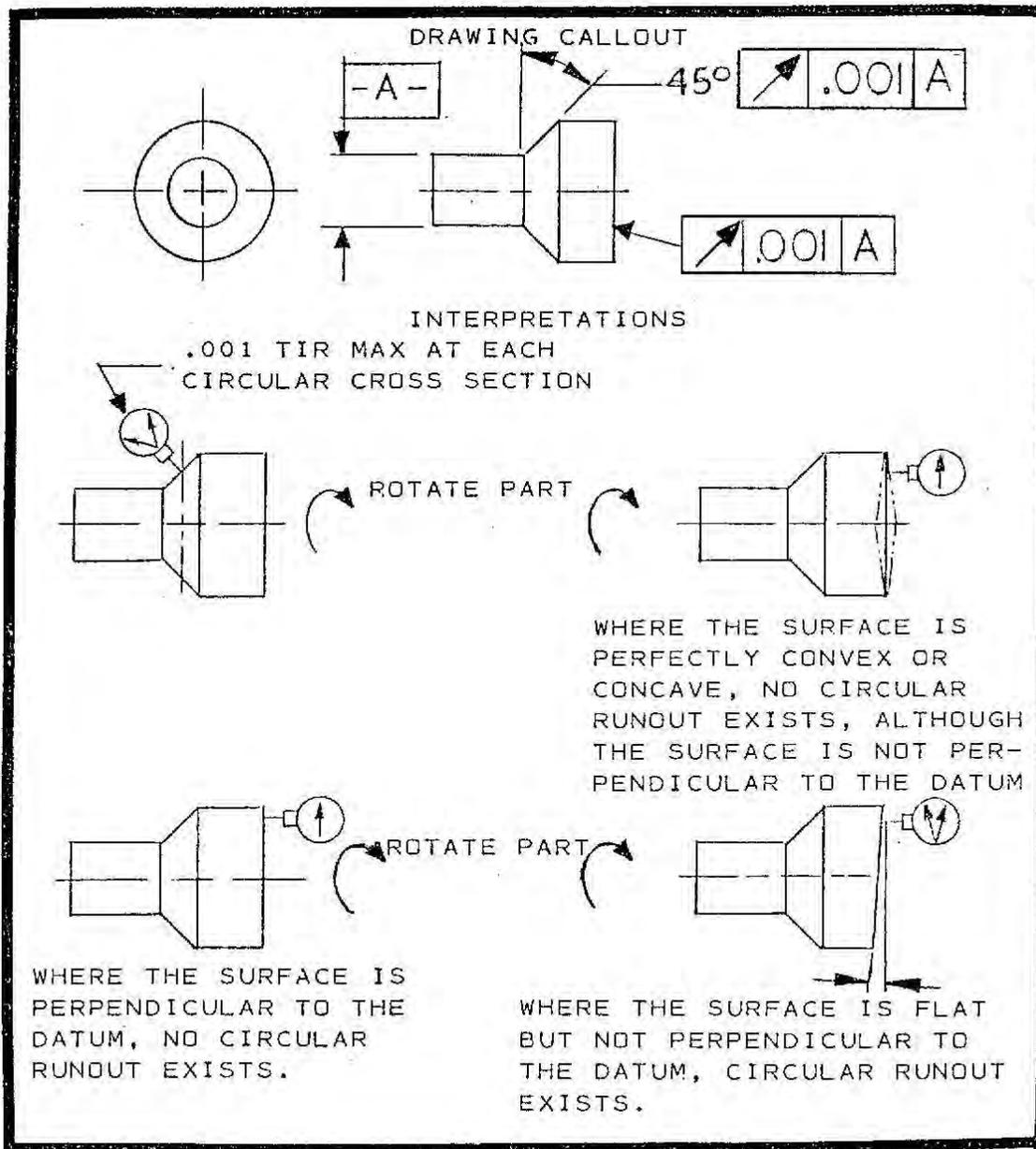
13.0 ROUNDNESS

Roundness is the condition on a surface of revolution (cylinder, cone, sphere) where all points of the surface intersected by any plane (1) perpendicular to a common axis (cylinder, cone) or (2) passing through a common center (sphere) are equidistant from the axis.



14.0 RUNOUT

Runout is the deviation from the desired form of a part surface of revolution detected during full rotation of the part on a datum axis when using a dial indicator (or equivalent measuring device).



15.0 PERPENDICULARITY

Perpendicularity shall be defined as the condition of surfaces, axes or lines which are at right angles to each other.

15.1 When a perpendicularity requirement is not referenced on the drawing in the form of a note, or by utilization of the

symbol,

⊥	.XXX	D
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 the following guidelines will be observed.

15.1.1 The perpendicularity of a plane surface to a datum plane shall be confined by two parallel planes with the tolerance indicated by Table 1. The datum plan shall always be the largest dimension.

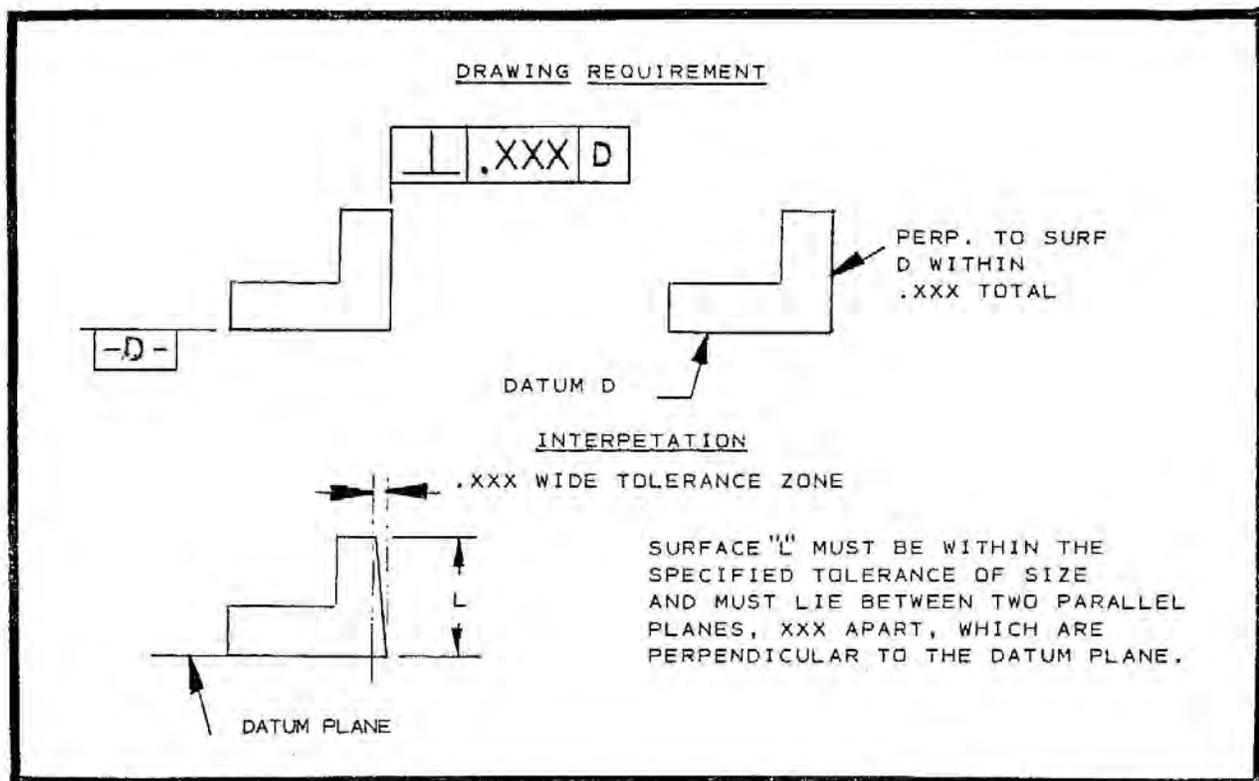
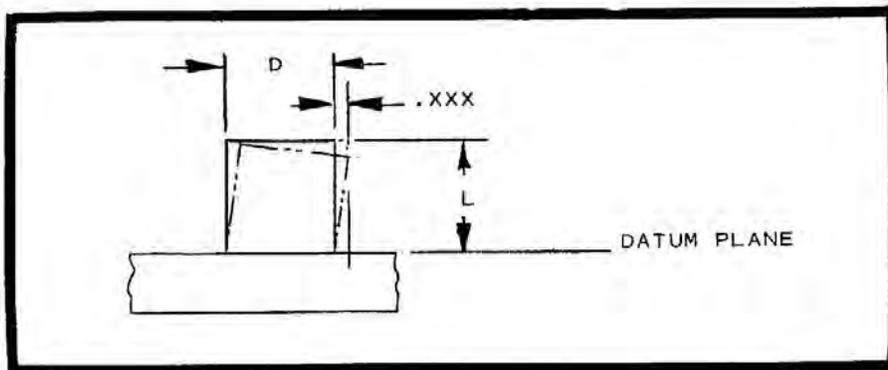


TABLE I

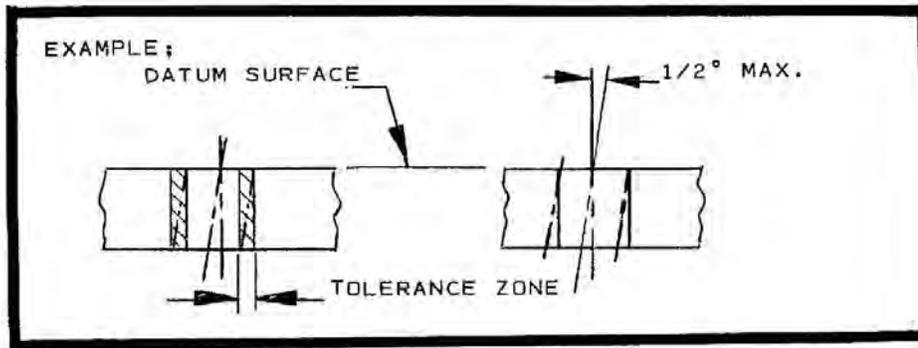
Length of Plane Surface (L)	.XXX = Tolerance Zone
0 to 1.0	.001
to 2.0	.002
to 3.0	.0025
to 5.0	.004
to 8.0	.005
to 10.0	.006
to 15.0	.007

15.2 The perpendicularity of projections shall be as follows:

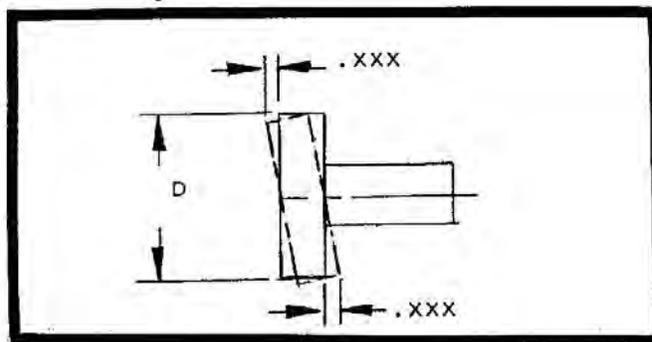


"L"	"D"	.XXX
0 to 1.0	to 1.0	.0025
to 2.0	to ½	.003
	to 1.0	.004
to 3.0	to ½	.004
	to 1.0	.005
to 5.0	to 2.5	.006

15.3 The perpendicularity of a single hole to a datum surface shall be governed by a tolerance zone formed by the locating dimensional tolerance or shall be held to 1/2 degree, whichever is less.



15.4 The perpendicularity of turned faces shall be as follows.

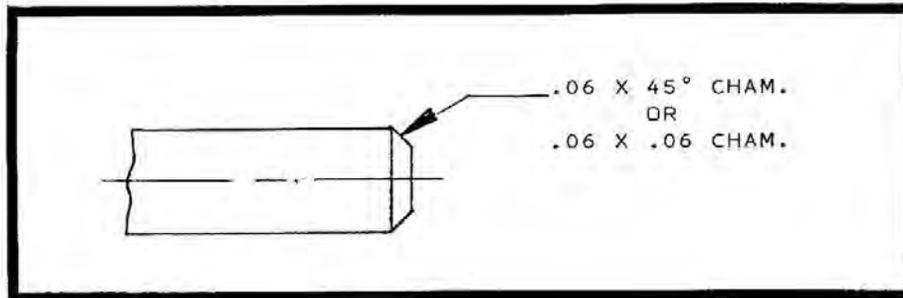


"D"	.XXX
0 to 1/4	.0020
to 1/2	.0025
to 1.0	.0030
to 2.0	.0035
to 3.0	.0040
over 3.0	.0050

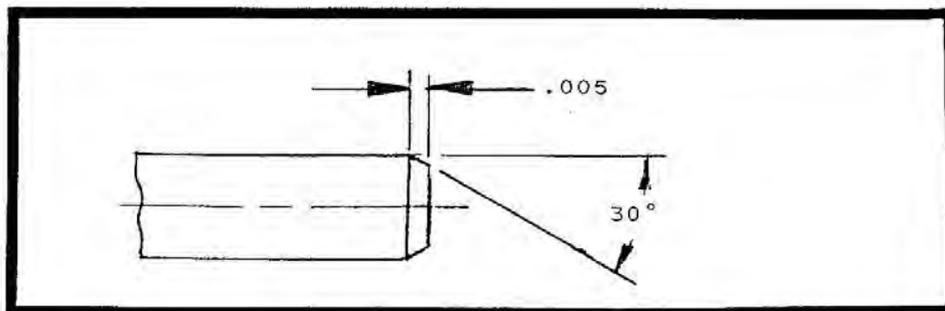
16.0 CHAMFERS

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 in the note. The dimension is the measurement along the length of the part, and not along the slope of the chamfer.

16.1 45° chamfers - may be called out on a drawing in either dimensional or not form because the size dimension may apply to either side because of equivalent dimensions.

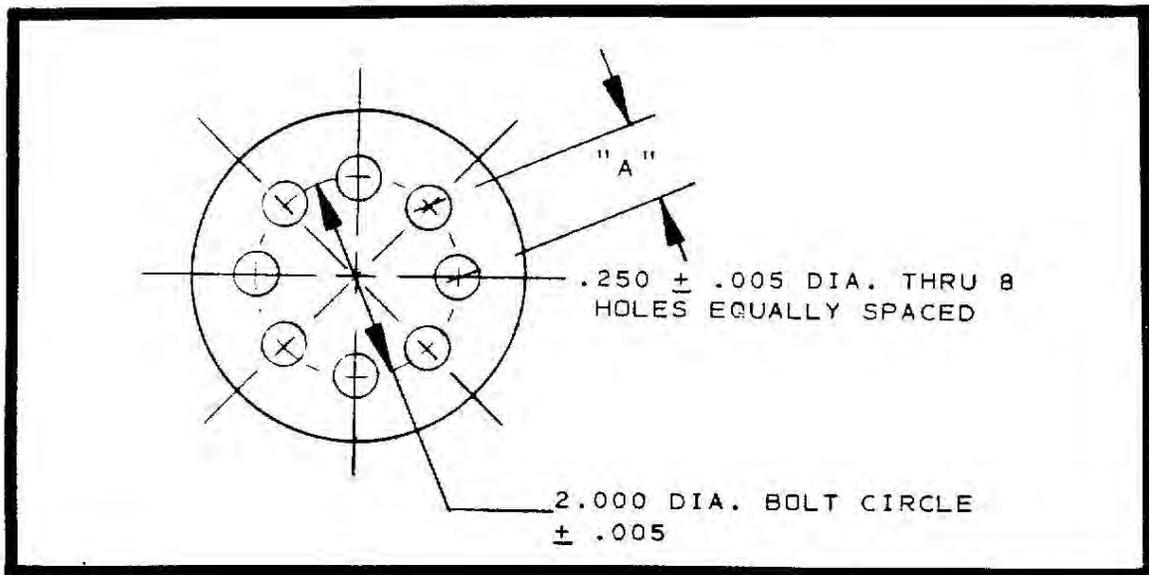


16.2 Chamfers greater or less than 45° - the size of the chamfer will be indicated for the side adjacent where the angle is shown.



17.0 REPETITIVE DIMENSIONS

Where a series of holes are spaced equally, dimensions may be applied by the notations "Equally Spaced" as illustrated in Figures 4, 5 and 6. When the notation "Equally Spaced" similar to the 2.000 diameter bolt circle appears as in Figure 4, 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 $\pm .005$ due to the decimal tolerance of the bolt circle diameter.



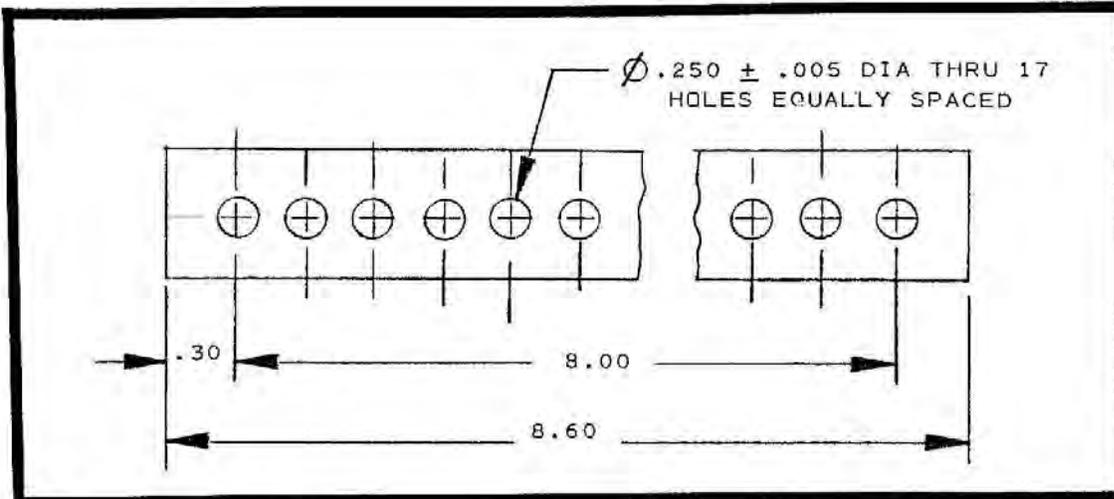


Figure 5

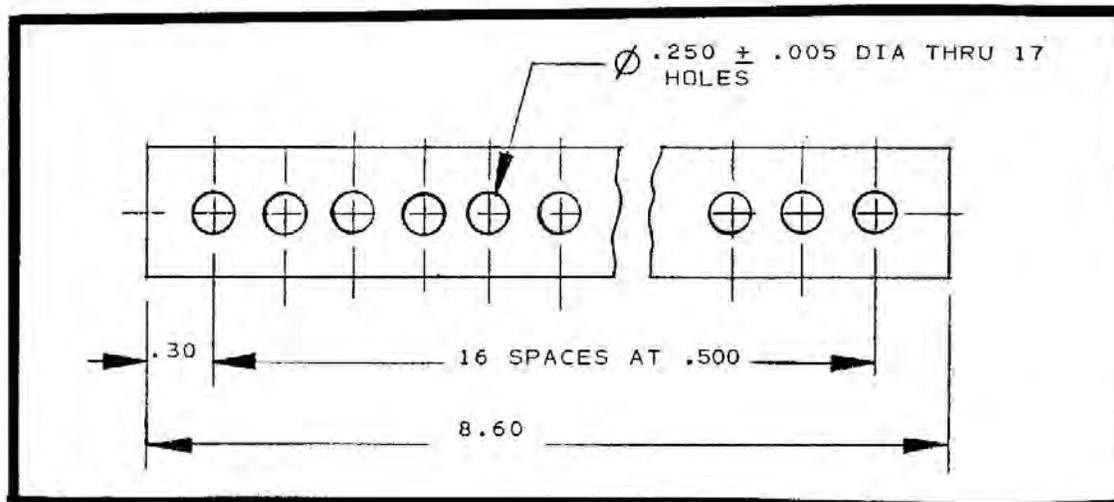


Figure 6

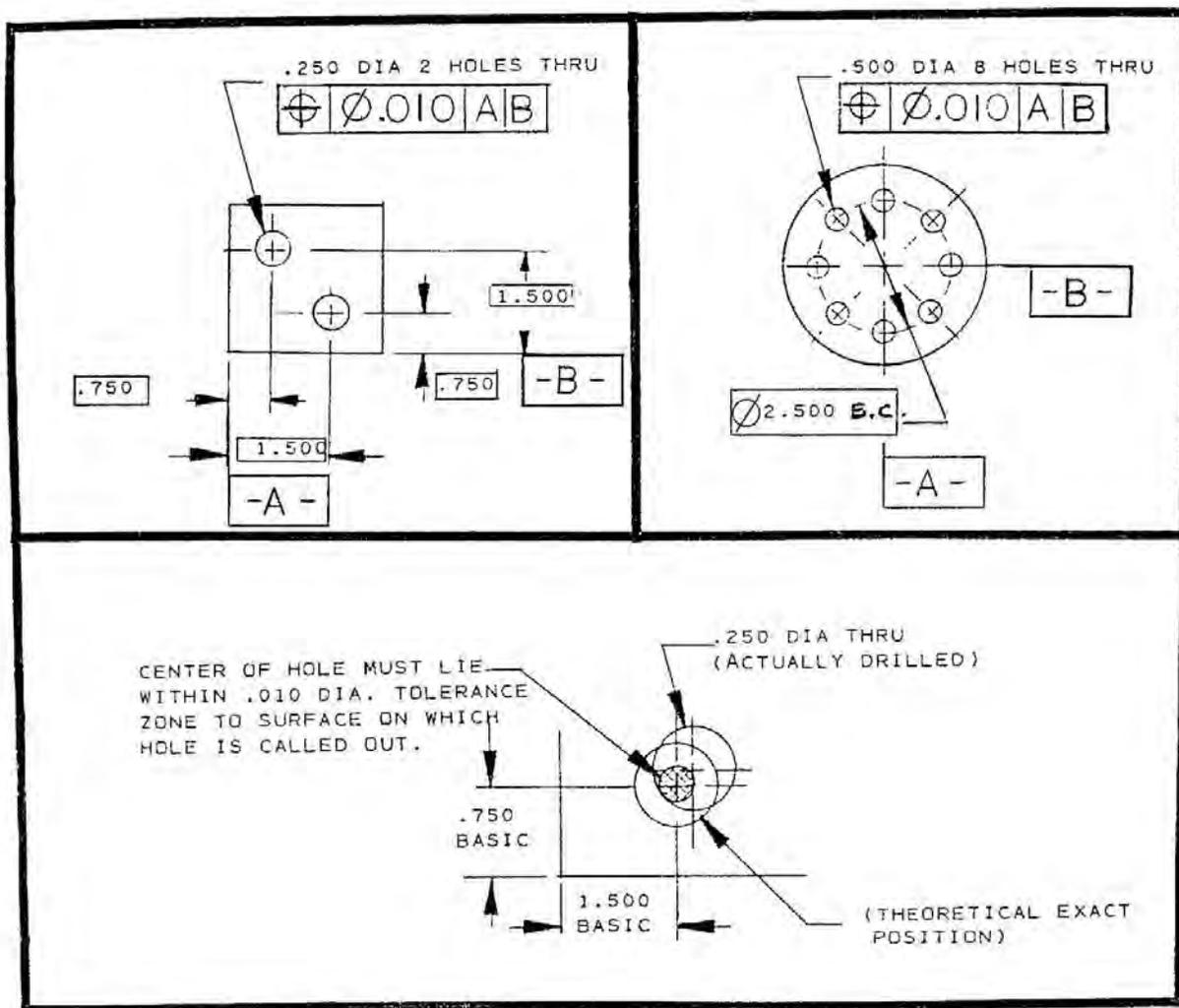
17.1 True Position

The basic location of each hole is given by the use of untoleranced dimensions. If further clarification is required refer to the specification entitled "True Position" Section 18 in this Fabrication Standard.

18.0 TRUE POSITION

When the symbol for true position $\text{⊕} \text{ } \boxed{.XXX}$ is shown on a drawing, the locatin 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 .XXX diameter.

Interpretations of other uses of true position tolerance shall be in accordance with ANSI Standard Y 14.5



18.1 Modifiers

A modifier is the term used to describe the application of the “maximum material condition” or “regardless of feature size principles”. The modifiers are maximum material condition (MMC) and regardless of feature size (RFS).

18.1.1 Maximum material Condition (MMC)

Maximum material condition is that condition of a part feature where in it contains the maximum amount of material, e.g. minimum hole size and maximum shaft size.

18.1.2 Regardless of Feature Size

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

18.2 Special Symbols

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

18.2.1 Projected Tolerance Zone

Projected tolerance zone is a tolerance zone applied to a hole in 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.

18.2.2 Least Material Condition

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

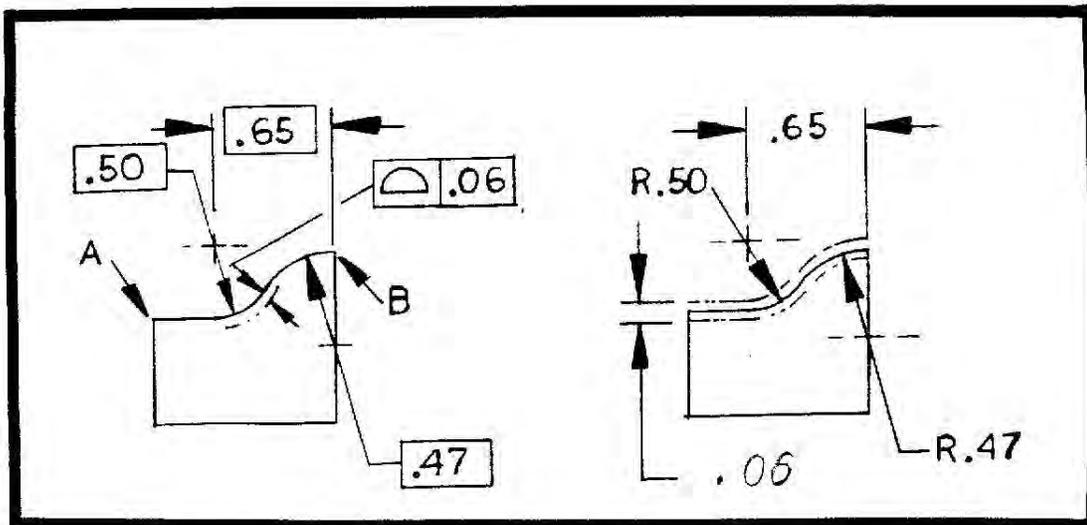
19.0 SURFACE ROUGHNESS

Surface roughness or surface finish is specified using the symbol $\sqrt{\text{RMS}}$ where the RMS value is defined as the maximum value of fine spaced surface irregularities.

It is standard practice that the surface roughness for parts fabricated for CPI shall not exceed a $\sqrt{.63}$, .00063 maximum tolerance. Deviations from this requirement shall be called out on the drawings. One specific deviation from the $\sqrt{.63}$ maximum surface condition, is the $\sqrt{.250}$ maximum surface roughness which is permitted for castings. Parts fabricated with a surface roughness less than $\sqrt{.63}$ are acceptable unless the drawing indicates otherwise.

19.1 Profile of Any Surface

Profile of any surface is the condition permitting a uniform of profile variation, either unilaterally or bilaterally, on a surface.



20.0 SURFACE FINISHES

20.1 Surface finishes are defined as platings, coatings or chemical conversions which physically cover or chemically change the surface of a part.

20.2 Unless otherwise specified by the drawing, dimensions apply to the finished part after the surface finishing process.

20.3 Suppliers shall provide with the completed parts, a Certificate of Compliance (C of C) or Process Certification (PC), from the supplier who performed the finishing process. See paragraph 29.3 for the minimum certificate contents. If a C of C is provided to certify a process, then it must also contain the process spec or standard, revision, and if applicable, the class and type.

20.4 All surface finishes shall be continuous and consistent without flaking, voids, pits, or damage.

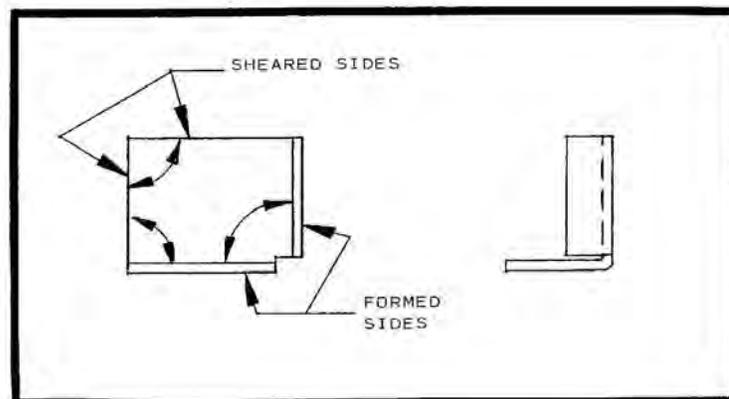
21.0 METAL STAMPINGS

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 CPI drawings for metal stampings.

21.1 Squareness/Perpendicularity of Sides

Between two sheared edges, two formed sides or a sheared side and a formed side, the squareness shall be within .003 in./in.



21.2 Flatness

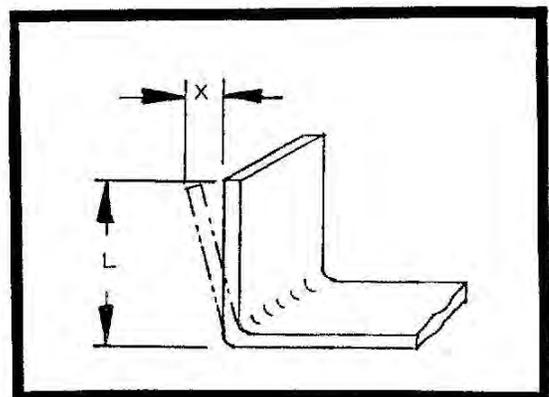
Deviation from flatness or sheet metal stampings shall conform to the following maximum values:

Material Thickness (Inches)	Length or Width				
	to 1"	to 3"	to 10"	to 20"	to 40"
0 to 1/64	.010	.020	.035	.050	.060
to 3/64	.010	.020	.035	.040	.050
to 1/16	.008	.015	.025	.030	.040
to 3/32	.005	.010	.020	.025	.030
to 1/8	.005	.008	.020	.020	.025
to 1/4	.005	.008	.020	.020	.025

21.3 Right Angle Bends

The formed side of the sheet metal shall be perpendicular to the flat within the tolerance indicated as follows:

Length of Formed Side "L"	Maximum Allowed Tolerance "X"
0 to 1 / 2	.010
to 1	.020
to 2	.025
to 5	.030
5 & up	add .005 in/inch



21.4 Bend Radii

Right angle bends shall have a minimum inside radius shown in the following table. For metals not included the bend radii shall, at minimum, be equal to the stock thickness.

TABLE 1 — AUSTENITIC STAINLESS STEELS

Steel	Condition	Thickness Range, in.	Bend Radius	Bend Angle, deg.
301, 302, 304	Annealed	All	½T	180
	¼ Hard	To 0.060	½T	180
		Over 0.061	1T	90
	½ Hard	To 0.060	1T	180
Over 0.061		1T	90	
Hard	To 0.030	2T	180	
	0.031 - 0.050	1½T	90	
316	Annealed	All	½T	180
	¼ Hard	To 0.050	1T	180
		Over 0.051	1T	90
	½ Hard	To 0.030	2T	180
0.031 - 0.050		3T	90	
Over 0.051	2T	90		
	Annealed	All	½T	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
3003 - 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 - 0.032	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

TABLE 4 — COPPER ALLOYS

Alloy	Temper	Nominal Thickness, in.	Minimum Suitable Radius of Punch, in.		
			Bend Perp to Roll Dir.	Bend 45 Deg. to Roll Dir.	Bend Par. to Roll Dir.
Copper	Half Hard	0.020	1/32	1/32	3/64
	Extra Hard	0.020	1/64	1/32	1/32
Red Brass, 85%	Drawing Anneal	0.005 - 0.064	Sharp	Sharp	Sharp
	Half Hard	0.020 - 0.050	Sharp	Sharp	Sharp
	Hard	0.040	1/64	1/32	1/32
	Extra Hard	0.040	1/16	1/32	1/32
	Spring	0.040	1/16	3/32	1/2
Low Brass, 80%	Hard	0.020	1/32	1/64	1/16
	Spring	0.020	1/32	1/8	3/16
Cartridge Brass, 70%	Half Hard	0.005 - 0.050	Sharp	Sharp	Sharp
	Hard	0.040	1/64	1/32	1/64
	Extra Hard	0.040	1/32	1/32	1/32
	Spring	0.040	1/16	< 1/4	< 1/4
	Extra Spring	0.040	1/8	< 1/4	< 1/4
Yellow Brass	Half Hard	0.005 - 0.090	Sharp	Sharp	Sharp
	Hard	0.040	Sharp	Sharp	1/32
	Extra Hard	0.040	1/64	1/8	3/16
	Spring	0.040	1/64	3/32	< 1/4
Medium Leaded Brass	Half Hard	0.040	Sharp	Sharp	Sharp
Phosphor Bronze, 5%	Half Hard	0.020 - 0.070	Sharp	Sharp	Sharp
	Hard	0.040	1/16	1/16	1/8
	Extra Hard	0.040	1/16	1/8	—
	Spring	0.040	3/32	—	—
Phosphor Bronze, 8%	Half Hard	0.005 - 0.064	Sharp	Sharp	Sharp
	Hard	0.040	1/32	1/8	—
	Extra Hard	0.040	1/64	3/32	< 1/4
	Spring	0.040	3/32	1/4	1/2
	Extra Spring	0.064	3/32	< 1/4	< 1/4
High Silicon Bronze	Hard	0.020	1/32	1/32	1/16
	Spring	0.020	3/64	3/32	3/16
Nickel Silver 65 - 18	Half Hard	0.040	—	1/64	1/32
	Hard	0.040	1/16	1/16	1/16
	Extra Hard	0.040	1/8	1/2	3/16
	Spring	0.040	3/32	1/16	3/32
	Extra Spring	0.040	3/32	3/32	1/4
Nickel Silver 55 - 18	Half Hard	0.040	1/16	1/16	1/16
	Hard	0.040	1/16	1/16	1/32
	Extra Hard	0.040	1/8	3/32	3/16

Source: Walkins and Bunn

21.5 Direction of Grain

Bends shall be made across grain or at 45 ° to the rolling direction. Bends parallel to the grain shall be avoided unless bends must be made. Microscopic inspection may be necessary to identify the direction of the grain.

21.6 Finish

Sheet metal which is punched, pierced, extruded or blanked is only partly sheared clean. The balance of the metal is torn by the pressure exerted. Therefore all formed sheet metal shall be deburred. Unless otherwise specified on the drawing the surface roughness shall not exceed $\sqrt{63}$ maximum on non-sheared surfaces and $\sqrt{125}$ on the sheared surface.

22.0 CASTING DEFINITIONS

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

22.1 Annealing

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

22.2 Blister

Defect on surface of casting appearing as a shallow blow hole with a thin film of metal raised over it.

22.3 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.

22.4 Buckle

Defect on a casting surface appearing as an indentation resulting from an expansion scab on the mold surface.

22.5 Cold Shut

A seam, lap or fold like discontinuity which is formed when two streams of molten metal approach each 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.

22.6 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 core into the casting cavity.

22.7 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.

22.8 Crack

22.8.1 Hot

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

22.8.2 Shrink

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

22.8.3 Stress

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

22.8.4 Quench

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

22.9 Draft

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

22.10 Ejection Pin Marks

Marks left on casting by ejection (knockout) pins.

22.11 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.

22.12 Gate

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

22.13 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 spurrs or risers.

22.14 Impregnation

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

22.15 Inclusions

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

22.16 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.

22.17 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.

22.18 Mismatch

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

22.19 Misrun

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

22.20 Micro Porosity

Extremely fine pores.

22.21 Parting Line

The mark left on the casting where the mold halves meet.

22.22 Permanent Mold

A long life reusable mold, usually iron.

22.23 Pin Hole Porosity

Pores which are larger than micro porosity.

22.24 Porosity

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

22.25 Run Marks or "Heat Check Lines"

Fine lines raised on the surface of the casting caused by heat degradation of mold materials, usually in die.

22.26 Sand Castings

Metal casting produced in sand molds.

22.27 Shrink Mark

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

22.28 Sponge

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

22.29 Surface Lap

A step in a surface of a casting.

22.30 Surface Porosity

Micro or pin hole porosity visibly apparent on the surface of the casting.

22.31 Voids

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

22.32 Weld Line

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

23.0 INVESTMENT CASTING

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 CPI Beverly vendor is responsible, where required, for furnishing certification and/or other substantiating evidence that castings procured have been inspected and meet the requirements per 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 as 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 or equal to

$250 \sqrt{\text{rms.}}$

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 CPI Beverly 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. Draft Shall be in accordance with good foundry practice.

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 castings 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 CPI Beverly Microwave 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 CPI Beverly Purchasing department.

23.1.9 Pre-Production Sampling (When Required)

- 23.1.9.1 Pre-production samples shall be specified by the CPI Beverly Purchase Order.
- 23.1.9.2 Pre-production samples shall be submitted to the CPI Beverly Purchasing department.
- 23.1.9.3 Approval will be based upon the inspection of samples by CPI Beverly Incoming Inspection department.
- 23.1.9.4 The casting vendor shall not pour production units until receipt of approval by the CPI Beverly Purchasing department.

23.2 Inspection of Casting

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

23.3 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 surface shall be called out on specific drawings.

Voids and gas holes greater than .040 diameter or .040 depth on the surfaces shall be cause for rejection other than those defined.

23.4 Material Segregation

Segregation of casting material shall be cause for rejection.

23.5 Surface Porosity

Casting shall be capable of meeting the specified surface finish of $\sqrt{250}$ unless called out differently in the field of the drawing.

23.6 Flatness

Flatness of cast surfaces shall not exceed .005 inch TIR per linear inch of length.

23.7 Parallel Sections

Two parallel sections shall be cast within \pm .005 inch per linear inch of separation, unless otherwise specified.

23.8 Corners, Edges, Fillets

Unless otherwise specified, radii shall not exceed .015 inch on both outside and inside corners, edges or fillets.

23.9 Sharp Edges

It shall be standard practice to remove all sharp edges. (Reference Section 1.0)

23.10 “Burr”

(Core Seam or Flash) – It shall be standard practice to remove all “Burr”. (Reference Section 1.0)

23.11 Additional Imperfections

- 23.11.1 Foundry tool marks
- 23.11.2 Warpage preventing further machining within tolerance.
- 23.11.3 Evidence of shrinkage
- 23.11.4 Omitted features.
- 23.11.5 Omitted or incorrect marking
- 23.11.6 Dimensional discrepancies
- 23.11.7 Improper packaging or parts which results to damage items.

24.0 FORGINGS

This specification sheet is to be used in conjunction with applicable forging drawings 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 Forgings to be free of unfilled areas, cold shuts, scale pits, flakes and mistrims.

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 1000°C and maintain vacuum integrity of a maximum leak rate of $(1 \times 10^{-6}$ torr liters/sec.) when subjected to a helium leak check.

24.1.5 CERTIFICATE OF ANALYSIS AND CERTIFICATE OF COMPLIANCE REQUIRED WITH EACH LOT SUBMITTED.

24.2 The following definition of words common to forging processes are to be used in conjunction with CPI Beverly Microwave Division 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 for 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 impressions.

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 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.

25.0 PERMANENT MAGNETS

This section is designed to compliment a magnet fabrication drawing to insure consistent tolerance's and quality of all CPI Beverly Microwave Division's purchased permanent magnets.

25.1 Physical Characteristics

25.1.1 Surface Conditions

All magnet surfaces shall be free of foreign materials which would tend to hold or collect extraneous particles of the magnet surface in the unmagnetized conditions.

25.1.2 Chips and Burrs

Magnets shall be free of loose chips and burrs. They shall be free of imperfections which will result in loose chips or particles under normal conditions of handling, shipping, assembly and service.

25.1.2.1 A chipped edge or surface shall be acceptable if no more than 10 percent of the edge or 5 percent of the surfacd is removed, provided no loose particles remain at the edge or surface, and further provided the magnet under examination meets the magnetic specificaliton as defined on the drawing or purchase order.

25.1.3 Other Physical Defects

Imperfections such as minor hairline cracks, porosity, voids, cold flow, shrinkage, pipe and others, all of the type commonly found in cast or sintered metallic magnets, or sintered ceramic magnets, shall be judged acceptable if the following conditions are met.

- 25.1.3.1 The magnet meets the minimum magnetic performance criteria as defined on the drawing on purchase order and as tested by the magnet manufacturer in concurrence with CPI Beverly Microwave Division.
- 25.1.3.2 The imperfections do not create loose particles or other conditions which will interfere with proper functioning of the end device.
- 25.1.3.3 In the case of visible cracks or imperfections, they do not extend through more than twenty-five percent (25%) of any cross section, fifty percent (50%) in the case of Alnico 9.

25.1.4 Other Conditions

Inspection methods such as the use of penetrants, magnetic particle analysis, ultrasonics, or x-ray shall not be acceptable methods for judging quality of cast or sintered Alnico magnets or sintered ceramic magnets, except as provided in 25.1.4.1 below.



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- 25.1.4.1 In cases where the magnet is expected to withstand abnormal conditions or stresses such conditions must be previously specified and a mutually acceptable service test devised to assure the magnet shall not fail under the specified service conditions. Such tests should duplicate service conditions with appropriate safety factors.
- 25.1.4.2 “Magnets made of Alnico 5-7 and Alnico 9 (Which are particularly crack-prone due to their columnar grain). Magnets made of these materials shall be judged acceptable if they maintain their physical integrity satisfactorily for the application “ (i.e., must withstand gaussing process).

25.2 Sheathed Magnets

25.2.1 Magnets requiring a cast sheathing must be free of sheathing separation from base magnet.

25.2.2 “Magnets requiring plastisol coating are to meet the following visual inspection”:

- a. Depressions, pits, inclusions, etc. that are coated and seal the surface are acceptable provided they cover less than 20% of the surface.
- b. Parts may be patched with the same type and color of plastic to seal the magnet surface, provides less than 5% of surface.
- c. Trapped air under the coating, which does not break the coating, is acceptable if the area is smaller than ¼” diameter and less than 2 per surface.

25.3 Dimensions & Tolerances (Individual Magnets)

Dimension shall be as specified on the drawings within the tolerances given therein. Tolerances not so specified shall be in accordance with the applicable Tables 1 and 2.

Table 1 — TOLERANCES, CAST METALLIC MAGNETS

		Conventional Sand Cast	Shell-Mold Sand Cast	Investment Cast
	Dimension (inches)	Tolerance (inches)	Tolerance (Inches)	Tolerance (inches)
Size:				
Unfinished Surfaces: (including Draft)	0 - 1	± .016	± .010	± .005
	1 - 2	± .031	± .016	± .010
	2 - 3	± .031	± .024	± .015
	3 - 4	± .047	± .030	± .020
	4 - 5	± .047	± .036	± .025
	5 - 6	± .062	± .042	± .030
	6 - 7	± .062	± .048	± .035
	7 - 8	± .078	± .054	± .040
	8 - 9	± .078	± .060	± .045
	9 - 10	± .094	± .060	± .050
	10 - 12		± .066	
Finished Surfaces:	Any Plane Ground Dimension:	± .005	± .005	± .002
	Center or Centerless Ground 0 to 1.5	± .002	± .002	± .002
	Over 1.5	± .005	± .005	± .002
Parallelism:	Finished Surfaces:	½ total tolerance between surfaces (degrees)	½ total tolerance between surfaces (degrees)	½ total tolerance between surfaces (degrees)
Squareness:	Between Two Unfin. Surfaces:	90° ± 1½°	90° ± 1½°	90° ± 30'
	Between One Fin. & One Unfin. Surface:	90° ± 1½°	90° ± 1½°	90° ± 30'
	Between Two Finished Surfaces:	90° ± 30'	90° ± 30'	90° ± 30'
Concentricity:				
Between Inside and Outside Surfaces:	Unfinished Surfaces: Hole dia. its length	.032 FIR	.032 FIR	*(see below)
	Finished Surfaces:	1.5xtotal OD TOL. FIR .007 FIR	1.5xtotal OD TOL. FIR .007 FIR	*(see below) .003 FIR
Roughness:	Unfinished Surfaces:	Within standard dimensional tol.	Within standard dimensional tol.	Within standard dimensional tol.
	Finished Surfaces:	63 microinches over at least 95% of surface.	63 microinches over at least 95% of surface.	32 microinches over at least 95% of surface.

* OD CONCENTRICITY

Over - 0.0 to 0.5 inch .005 FIR Over - 1.5 to 2.0 inch .015 FIR
Over - 0.5 to 1.0 inch .010 FIR Over 2.0 to 2.5 inch .025 FIR
Over - 1.0 to 1.5 inch .015 FIR Over - 2.5 to 3.0 inch .030 FIR

Table 2

Table 2 — TOLERANCES, SINTERED METALLIC MAGNETS

	DIMENSION (inches)	TOLERANCE
Size:		
Unfinished Surfaces: (Including Draft)	0 to .125 Over .125 to .625 Over .625 to 1.250	± .005 inch ± .010 inch ± .015 inch
Finished Surfaces:		
Plane Ground	Any	± .005 inch
Center Ground or Centerless ground:	0 to 1.5 Over 1.5	± .002 inch ± .005 inch
Concentricity:		
Between Inside and Outside Surfaces:	OUTSIDE DIAMETER	
Unfinished Surfaces:	0 to 0.5 Over 0.5 to 1.0 Over 1.0 to 1.5	.005 inch FIR .010 inch FIR .015 inch FIR
Finished Surfaces:	Any	.003 inch FIR
Squareness:		
Between Two Unfinished Surfaces:		90° ± 1°
Between One Finished, One Unfinished Surface:		90° ± 1°
Between Two Finished Surfaces:		90° ± 30'
Parallelism:		
Finished Parallel Surfaces		½ total tolerance between surfaces.
Surface Roughness:		
Unfinished Surface:		Within standard tolerances.
Finished Surface:		63 microinches over at least 95% of the ground surface.



GENERAL SPECIFICATION

PRINTED CIRCUIT BOARD

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GENERAL SPECIFICATION
PRINTED CIRCUIT BOARD
TWO SIDED/MULTILAYER

26.1 Scope:

This specification describes the requirements for the construction of rigid double sided and multi-layer printed circuit boards, interconnected by plate-through holes normally located on 0.025 inch grid intersections.

26.2 Applicable Documents

The documents listed in paragraph 26.2.1 of this specification form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of invitation to bid shall apply. When a conflict of instructions occurs, the following order of precedence shall apply:

- A. The purchase order
- B. The engineering drawings
- C. The specification
- D. Applicable
- E. Documents listed in paragraph 26.2.1

26.2.1 Specifications and Standards

IPC-ML-950	Multilayer Board Performance Specifications
IPC-ML-975	Multilayer Board Documentation Specifications
IPC-A-600	Acceptability of Printed Wiring Boards

26.2.1 Specifications and Standards: (Continued)

IPC-TC-500 Copper Plated Through Hole, Two-Sided, Rigid

IPC-TC-550 The Design, Assembly and Testing of Fused in place Interfacial Connections in Rigid Printed Circuit Boards.

IPC-ML-910 Design and End Product Specifications for Rigid, Printed Circuit Boards.

IPC-L-110 Preimpregnated, B Stage Epoxy Glass Cloth for Multilayer Printed Circuit Boards.

IPC-4101 Specification for Base Materials for Rigid and Multilayer Printed Boards.

MIL-STD-275 Printed Equipment for Electronic Equipment.

MIL-STD-429 Printed Wiring & Printed Circuit Terms & Definitions

MIL-G-55636 Glass Cloth Resin Preimpregnated (B Stage) for Multilayer Printed Wiring Boards.

MIL-S-45204 Gold Plating, Electro Deposit.

MIL-P-13949 CANCELED, See IPC-4101

NOTE-Any CPI/BMD Drawing that references Mil-P-13949 should be disregarded and replaced with IPC-4101

MIL-P-55617 Plastic Sheet, thin Laminate, Metal Clad for Printed Wiring.

MIL-P-55110 Printed Wiring Boards.

MIL-C-14550 Copper Plating (Electronic Deposit)

MIL-P-55640 Printed Wiring Boards, Multilayer, Plated Thru Hole.

26.2.1 Specifications and Standards (Continued)

- QQ-N-290 Nickel Plating (Electro Deposited)
- QQ-S-571 Solder, Tin Alloy: Tin-Lead Alloy, lead Alloy
- U.L. 478 Standard for Electronic Data-Processing Units & Systems
- U.L. 796 Underwriters Laboratories Standard for Safety, Printed Wiring Boards
- U.L. 94 Underwriters Laboratories Standard Tests for Flamability of Plastic Materials
- Underwriters Laboratories Recognized Components Index (ZPMV2)
- FTMS 406 Federal Test Method Standard
- ASTM-B-53 Method for Chemical Analysis of Copper

26.3 Requirements:

26.3.1 Material:

Unless otherwise specified, the printed circuit board base material shall be of:

Laminated Sheet, Epoxy, Glass-Cloth Base

Flame-Retardant, Copper Clad

(Military Type GF, Nema Grade FR-4), having a U.L. Approval (Refer to Section 26.11)



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Unless otherwise specified on the applicable board machining drawing, materials and board thickness shall be as follows:

BOARD LAMINATE	FINISHED BD THICKNESS (2)	COPPER WT (1) BEFORE PLATING	TYPICAL APPLICATION
Single Sided Copper	.093, .125	1 oz., 2 oz	Power Supply
Double Sided Copper	.062	½ oz., 1 oz., 2 oz	General Use
	.093, .125	1 oz., 2 oz.	Back Plane & Power Supply
Multilayer (3/4 Layers)	.062	½ oz., 1 oz. (External Layers) 2 oz. (Internal Layers)	General Use

- NOTES:
- (1) 2 oz. Copper = .0028" Thickness
 - 2 oz. Copper = .0014" Thickness
 - ½ oz. Copper = .0007" Thickness
 - (2) All .0062" thickness boards mating with edge board connectors are finished to .062" ± .007"

26.3.1 Materials (Continued)

26.3.1.1 Single Sided Boards:

Shall be constructed as follows:

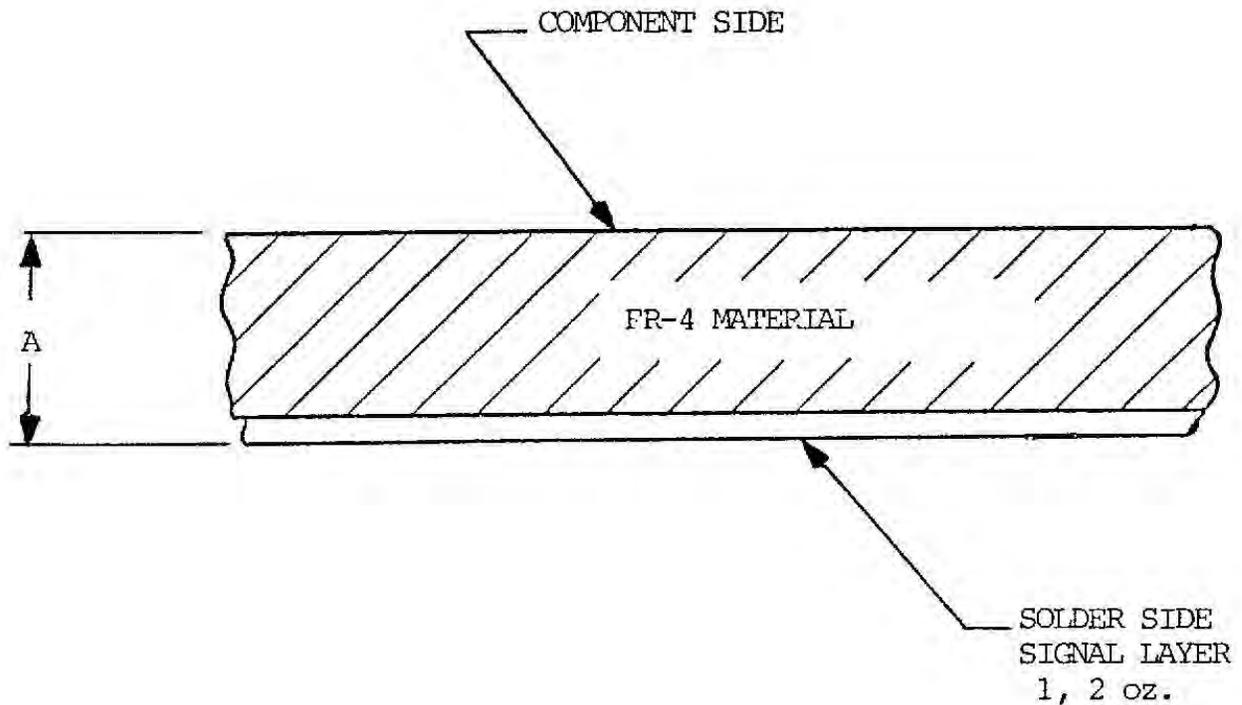


Figure 1

MATERIAL/COPPER THICKNESS	A
.093 1 oz.	.093 ± .007
.093 2 oz.	.093 ± .007
.125 1 oz.	.125 ± .012
.125 2 oz.	.125 ± .012

26.3.1 Materials (Continued)

26.3.1.2 Two Sided Boards:

Shall be constructed as follows

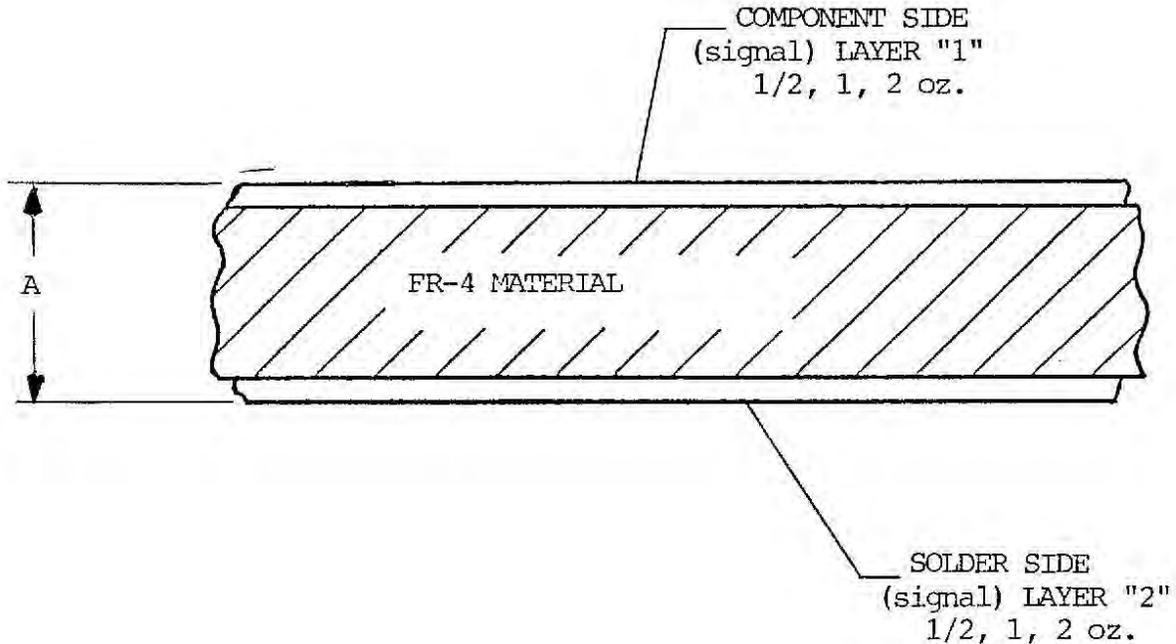


Figure 2

MATERIAL/COPPER THICKNESS	A
.062" Thick 1/2, 1, 2 oz.	.062 ± .007
.093 Thick 1 oz	.093 ± .007
.093 Thick 1 oz.	.093 ± .009
.125 Thick 1 oz., 2 oz.	.125 ± .012

NOTES: (1) Measured at connector finger area including copper, nickel and gold plate for .062"

26.3.1 Materials (Continued)

26.3.1.3 Multilayer Boards: (3 Layer Construction)

Shall be constructed as follows:

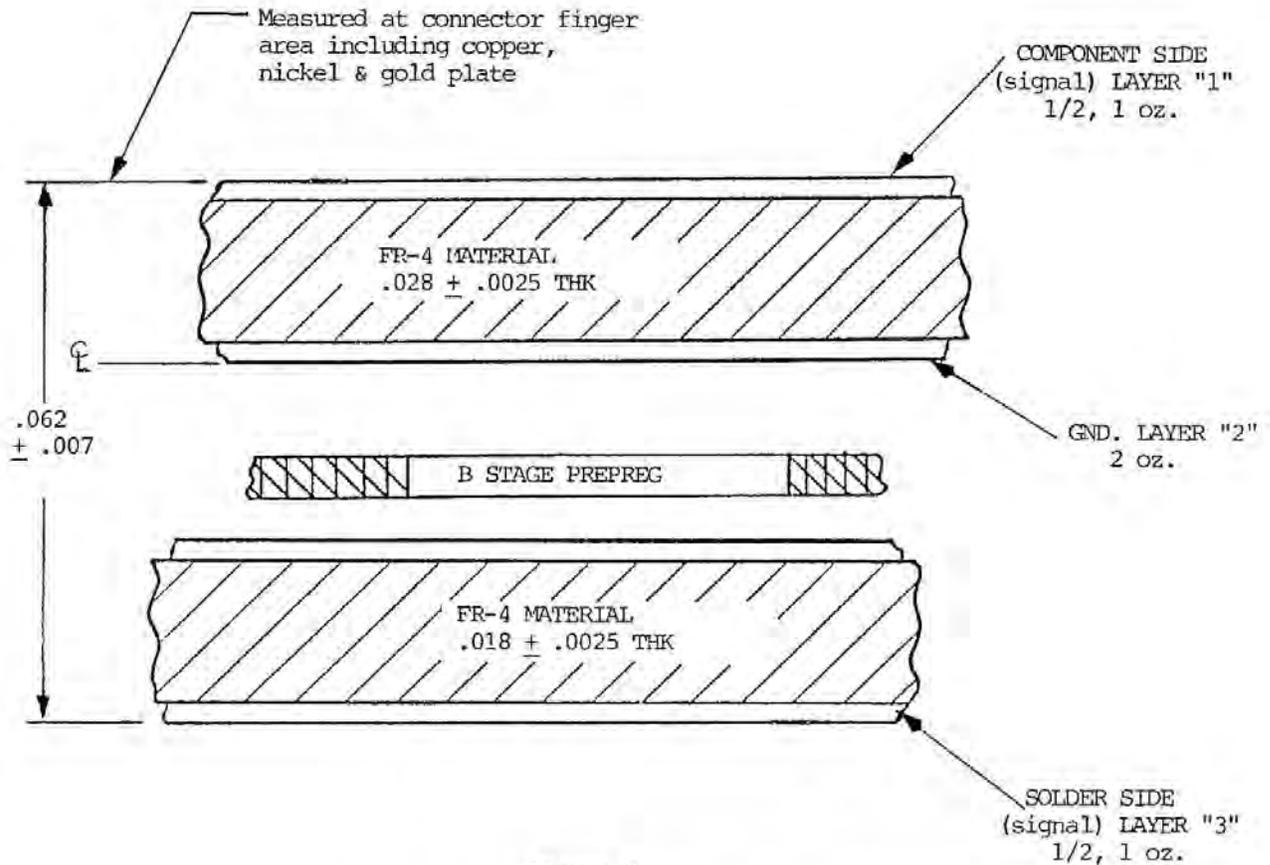


Figure 3

Other multilayer thicknesses (.093, .125) shall be detailed by machining drawings.

26.3.1 Materials (Continued)

26.3.1.4 Multilayer Boards (4 Layer Construction)

Shall be constructed as follows:

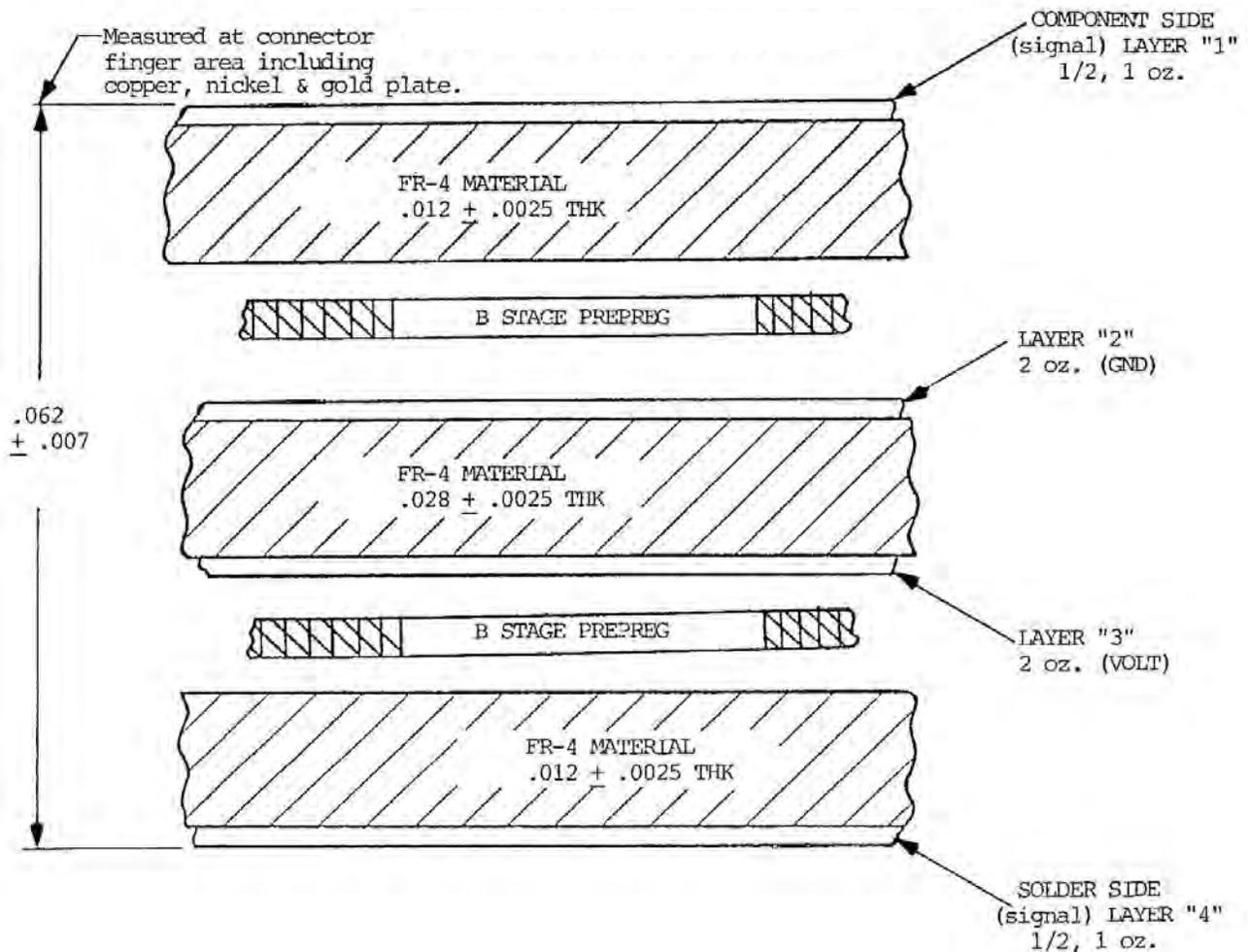


Figure 4

Other multilayer thickness (.093, .125) shall be detailed by machining drawings.

26.3.2 Artwork:

The master artwork (positive or negative) specified by the purchase order shall be furnished by CPI. All negative/positive files and screens shall be the property of CPI, and shall be treated as proprietary information. The mater artwork shall be returned to CPI at the completion of any order and shall be handled with maximum care. Precision photo reductions shall have a reduction tolerance of $\pm .003$ per artwork.

26.3.3 Plating:

Plating on the board surfaces and/or plated-through holes shall be copper with tin-lead (solder) over plate.
(Reference Figure 7)

26.3.3.1 Copper Plating:

All Copper electroplates shall have a minimum purity of 99.5% as determined by ASTM-B-53. Copper plating on the walls of the plated-through holes shall have an average minimum thickness of .001 inch based upon three measurements on each wall of three holes. No single measurement shall be less than .0007". Voids at the pad to hole wall interface are unacceptable. Voids which exceed 10% of the plated surface are unacceptable. Circumferential voids are unacceptable. Reference Figure 3.

26.3.3 Plating: (Continued)

26.3.3.1 Copper Plating: (Continued)

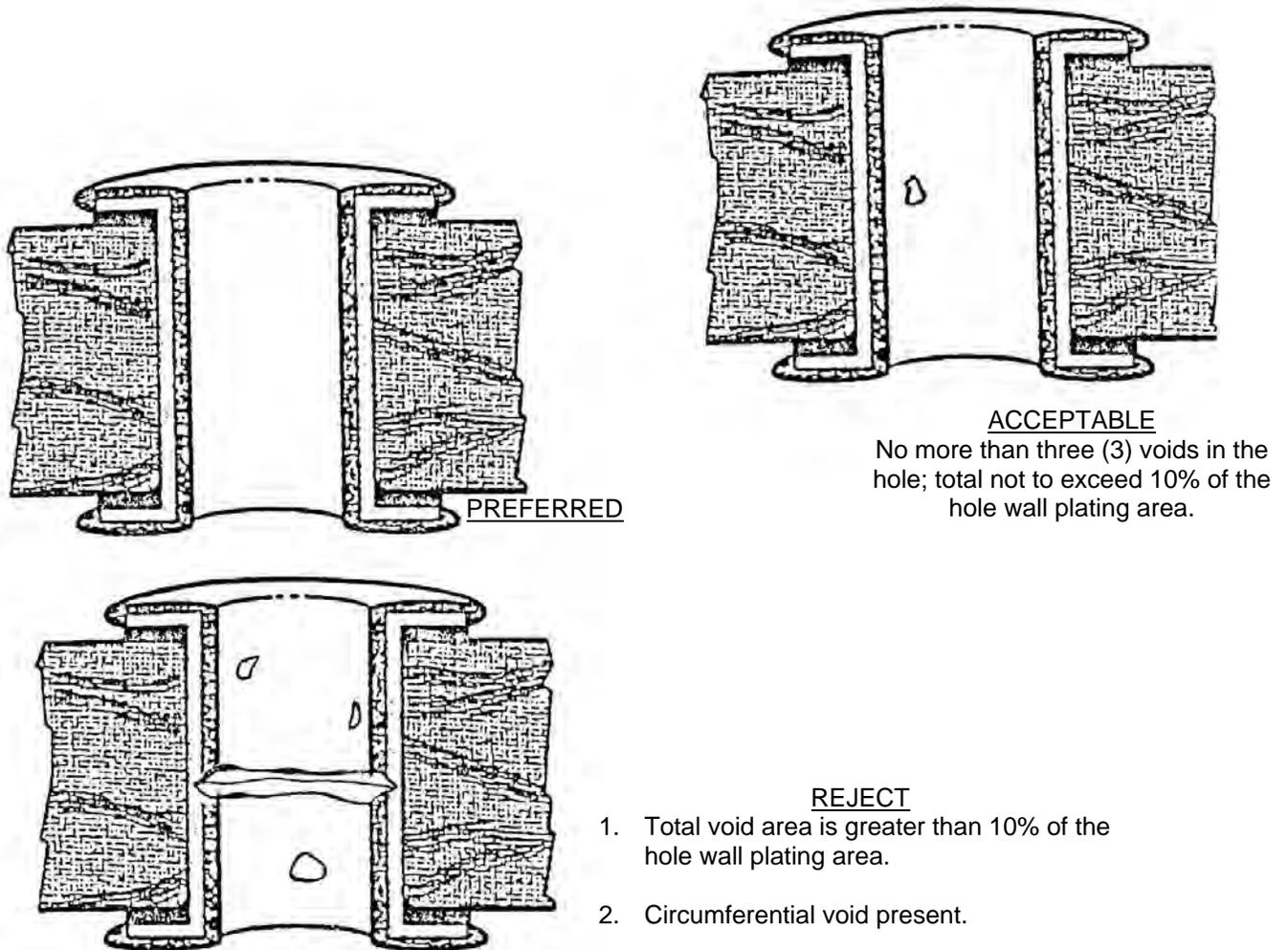


Figure 5

Nodules, burrs or excessive roughness in holes are rejectable if the minimum diameter is violated.

26.3.3 Plating: (Continued)

26.3.3.2 Nickel/Gold:

The connector fingers shall be nickel plated in accordance with QQ-N-290, (minimum thickness of 0.000100"/maximum of 0.000200) and overlaid with electro-deposited hard gold having a thickness of 0.000050 inch minimum. The connector finger's plating thickness and length shall be as defined in the detail drawings. There shall be no copper showing between the finger plating and the tin-lead allow. Imperfections such as pits, depressions, scratches or pin holes located on functional connector fingers will be considered cause for rejection. Gold plating should completely cover the entire connector finger and should not extend beyond the .020" max. limit line.

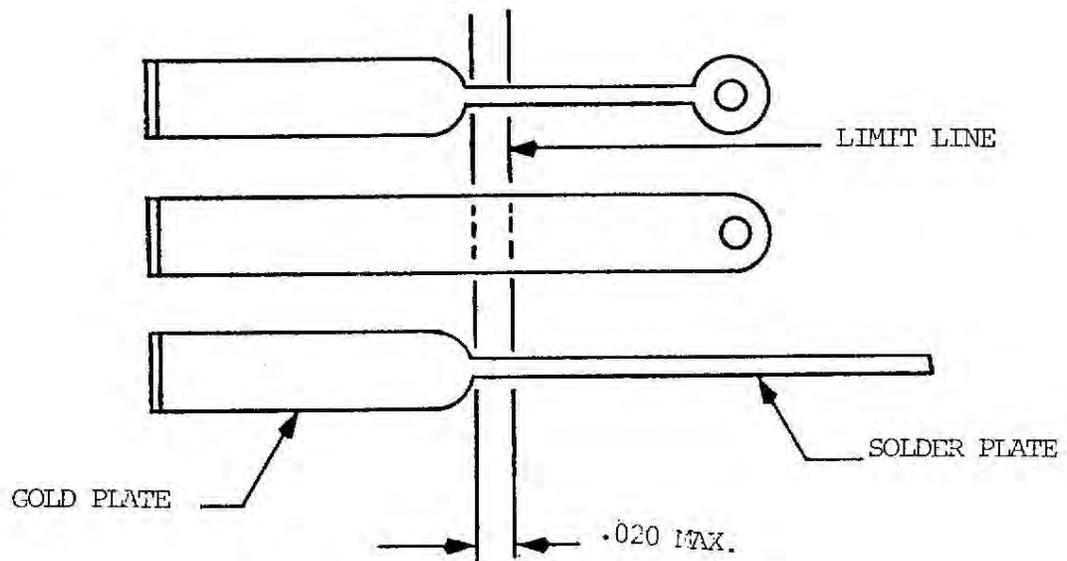


Figure 6

26.3.4 Solder Plating: (Standard Process)

All areas of the board except the connector fingers shall be finished with solder electroplate. Tin content of the solder plating shall be between 50% and 70% by weight. Unless otherwise specified, the minimum thickness of solder electroplating shall be 0.0003". Measurements shall be made within the plated-through hole.

26.3.5 Solder Reflow: (electroplated solder)

All solder plated PCB's must be reflowed by the manufacturer. Solder reflowing enhances the integrity of the circuit boards in two ways (Reference figure 7)

It reduces the probability of shorts due to solder slivers.

It enhances solderability at assembly due to an increased shelf life.

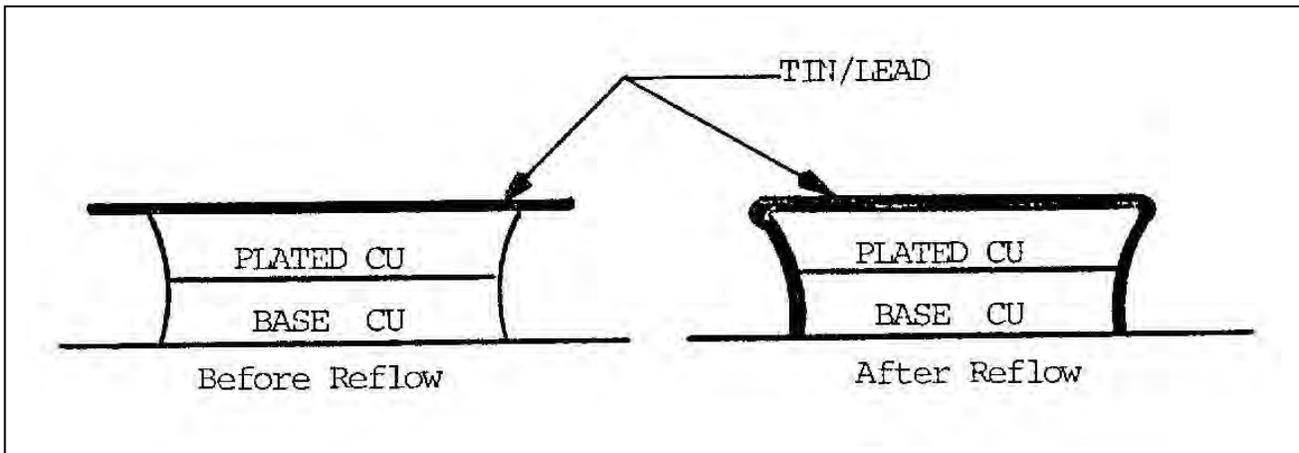


Figure 7

26.3.6 Solder Mask Over Bare Copper Process (SMOBC):

Solder mask registration must allow for total coverage of the solder mask over all etch runs.

The application of solder must be done using the solder dip method, i.e.: Gyrex, Hollis, etc. Electroplating is unacceptable for this process.

Solder must not show signs of de-wetting.

Solder buildup inside plated thru holed due to poor solder leveling is unacceptable when the minimum hole size is violated.

26.3.7 Plating Adhesion (Solder Plate):

All surface plating must be capable of withstanding the plating adhesion tests of IPC-ML-950, CLASS A, PARA. 3.4.1.3. Reflowed boards should exhibit a lustrous surface finish. Non-reflowed boards exhibit a darker non-lustrous finish. A tape test should be performed on questionable boards using the following method:

Apply a strip of 1" "High Tack" cellophane tape to the surface using firm pressure to assure adhesion.

Pull up sharply at a 90° angle to the surface. Inspect the tape for evidence of solderplate removal.

Lack of reflow will be evidenced by removal of thin strips of solder plate (slivers). This is unacceptable and cause for rejection.

26.3.8 Plating Adhesion (Gold Plate):

Gold plated connector fingers must withstand the same test as specified for solder plate. (ref. Para. 26.3.7)

On gold plated fingers, a slight flaking condition directly at the gold/solder interface is acceptable. All other areas of peeling or flaking are unacceptable.

26.3.9 Solderability:

Solder must flow readily on the solder surface of the board and show a maximum limit of 10% “de-wetting”.

The solder coating inside of the holes shall be smooth and continuous. “Non-wetted” areas on the surface or in the holes are cause for rejection.

26.3.9.1 Heat Endurance

The board shall be capable of withstanding a wave or dip solder operation at a solder temperature of 500 ± 10 °F and a maximum solder contact period of 12 seconds, no delamination, electrical discontinuity or visible blistering shall result.

26.4 Mechanical:

26.4.1 Configuration:

The mechanical configuration shall be in accordance with this specification and the appropriate board machining drawing.

26.4.2 Printed Connector Area:

The printed connector (finger) area shall be in accordance with the details shown on the appropriate board machining drawing.

26.4.3 Beveling:

The board edge containing the connector fingers shall be bevelled as shown below:

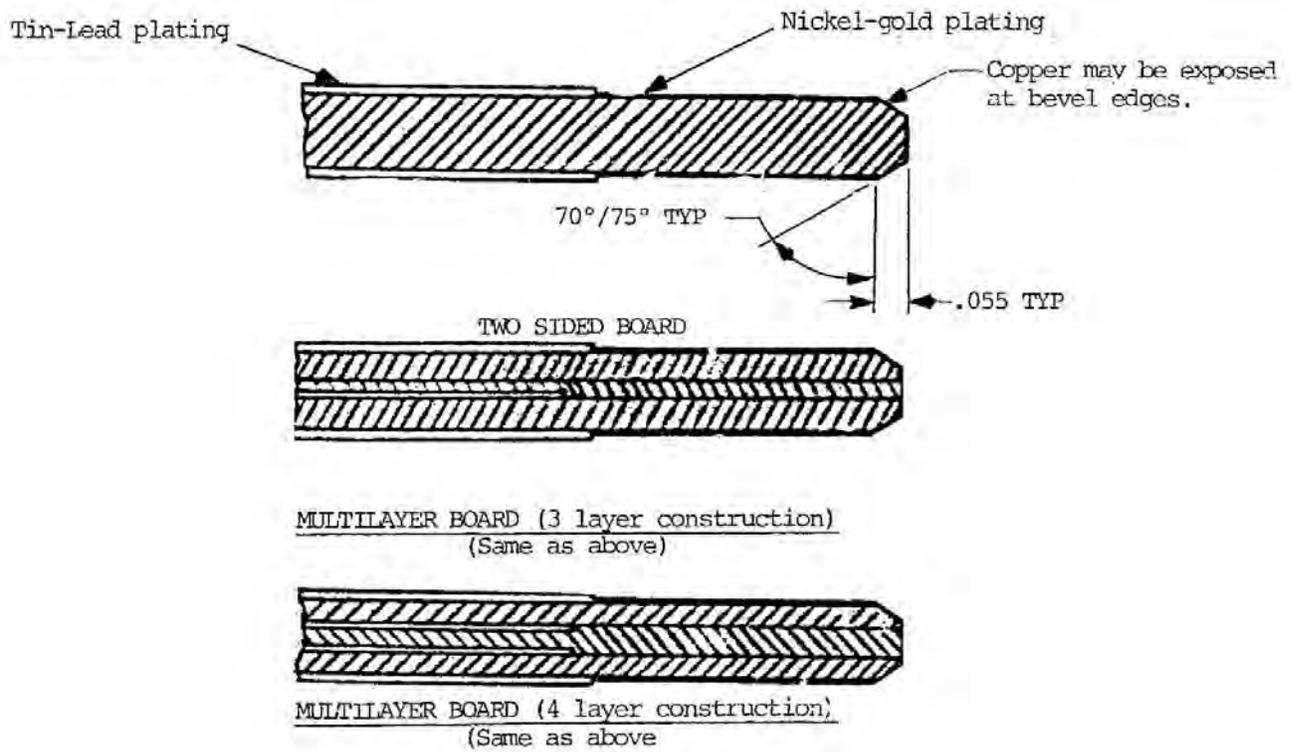


Figure 8

Internal layers shall not be within $.060''$ of any edge, and not extend under connector fingers.



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26.4.4 Conductor Width/Spacing:

Conductor lines may be reduced to a minimum of .006 on the finished board where the design artwork is less than .015. Where the design artwork is greater than .015, the conductor lines may be reduced by a maximum of 30%.

Artwork (1:1) Nominal Line Width	Specified Copper Foil Thickness	Finished Board Line Width
.012"	2 oz.	.009 ± .003"
.012"	1 oz.	.010 ± .003"
.012"	½ oz.	.011 ± .003"

Insulated nicks/cuts in circuitry cannot reduce the line by more than 30%. The number of defects do not exceed one per linear inch of conductor path length.

24.4.4.1 Requirements:

Spacing requirements are as follows:

Line to line = .008 minimum

Line to pad = .006 minimum

Pad to pad = .006 minimum

Isolated projections cannot reduce line to line spacing to less than .006.

26.4.5 Drilling:

For manual generated artwork all holes may be drilled with reference to the pad centers. The diameter of all holes shall be in accordance with the individual board machining drawing. A drill tape maybe supplied with CAD generated artwork from VBMD. It is the vendors responsibility to set offsets, feeds and speed per processors used. The diameter of all holes shall be in accordance with the individual board machining drawing.

For thru-plated holes the diameter given is for the finished hole after plating and must be free of all debris to facilitate rapid insertion of component leads.

26.4.6 Annular Ring:

The minimum annular ring is the minimum distance between the edge of functional land and the edge of a drilled or etched hole. Minimum annular ring for internal and external layers is listed below:

Internal Layer .002"

External Layer .003"

26.4.7 Registration, External Layer:

26.4.7.1 Hole to Pad:

Hole to pad misregistration occurs when the artwork on one side of the board does not line up with the opposite side. This results in one side of the artwork not aligning with the plated thru holes.

26.4.7.2 Break Out:

Hole break out is allowed when in a direction away from the circuit/pad interface and no more than 30% of the hole extends beyond the pad edge. The plating requirements described herein still apply.

26.4.7.3 Circuit Path:

In ceases where misregistration causes the hole to be in the direction of a circuit path the following applies:

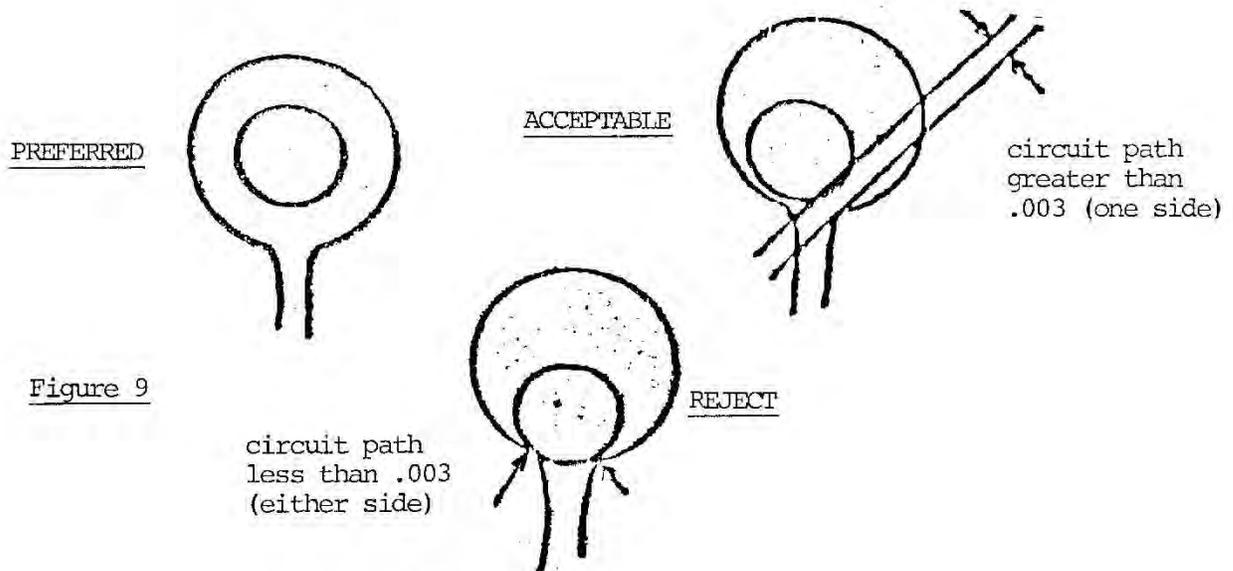


Figure 9

24.4.8 Registration Internal Layer:

26.4.8.1 Minimum Clearance:

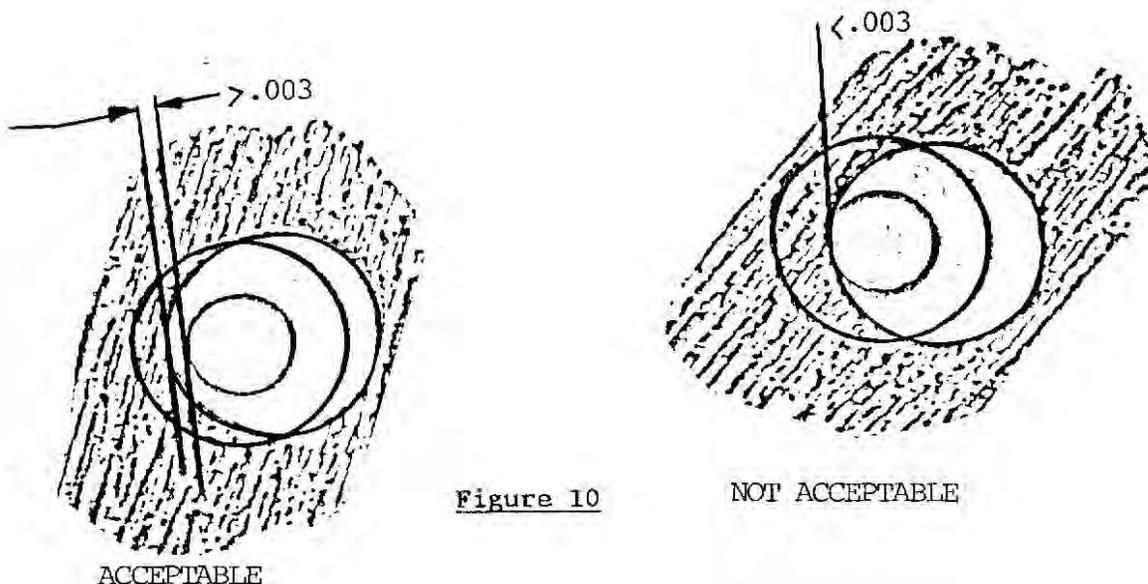
Internal layer registration must be such that a minimum clearance of .010 will result between the plated hole and the inner layer conductor not requiring continuity.

26.4.8.2 Break Out:

Where a plated hole must contact the inner layer, registration of the hole to inner layer pad must not result in break out.

24.4.9 Registration Solder Mask:

Solder mask is screened onto PCB's in order to retard the wetting of solder over areas of the circuitry which do not require solder over areas of the circuitry which do not require solder as well as to add protection from shorting due to loose metal particles. The solder mask must not cover the circuit pads which do require solder with the following exceptions:



26.4.9.1 Plated Holes:

Solder mask must not be visible inside the plated thru holes. this is unacceptable and cause for rejection.

26.4.9.2 Adhesion:

Solder mask must adhere to the PCB without showing signs of flaking off. Per IPC-SM-840A.

26.4.10 Weave Exposure:

This condition exists when the woven glass cloth is not uniformly covered by resin. This is unacceptable. Since the glass cloth may be visible under other acceptable conditions a test must be performed to verify exposure. When the glass cloth appears to be near or above the resin surface, place a pin or paper clip on the surface and very lightly drag the point of it across the questionable area. If the weave is exposed a slight tugging will be felt.

26.4.11 Warp and Twist:

26.4.11.1 Allowance:

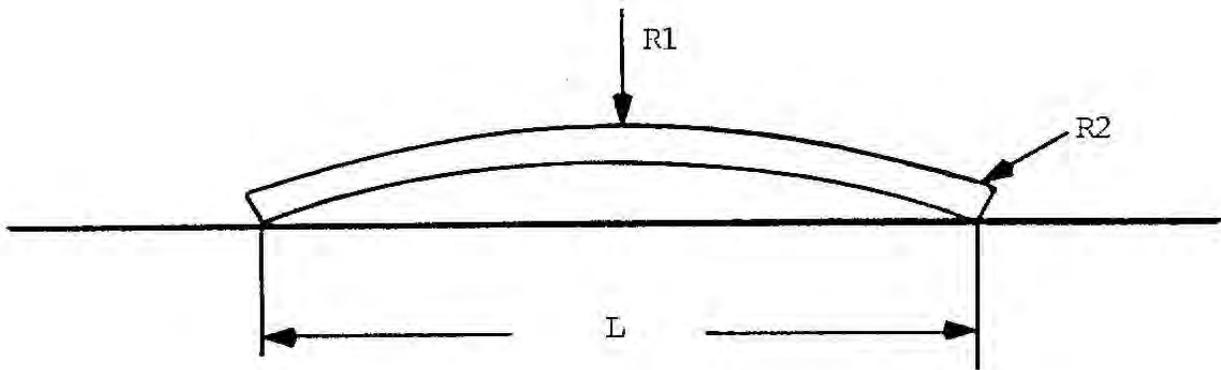
The maximum allowable warp and twist is .010 in/in.

26.4.11.2 Warp:

Warp shall be measured along the edge having the largest bow. the board shall be placed on a flat horizontal surface (surface plate) with the convex surface of the board upward. Both corners of the edge must contact the surface plate. If necessary one corner may be lightly weighed to establish a true plane. Using a height dial indicator gage, measure the highest point at the edge projection above the surface plate. Subtract the board thickness from this vertical displacement and divide the result by the length of the board edge to obtain the inch per inch or millimeter warp. this value multiplied by 100 converts the expression to percent.

26.4.11.3 Twist:

Twist shall be determined by placing the board on a flat horizontal surface (surface plate) with the convex surface of the board upward. If the board does not rest on three corners by its own weight, one corner shall be lightly weighted to establish a true plane. Using a height dial indicator gage, measure the highest point on the board projection above the surface plate. Subtract the board thickness from this vertical displacement and divide the result by the length of the board diagonal to obtain the inch per inch or millimeter per millimeter twist. This value multiplied by 100 converts the expression to percent.



R1 = Highest Point Measured With Dial Indicator

R2 = Board Thickness

L = Length Board

$$\text{PERCENT WARP} = \frac{R1 - R2}{L} \times 100$$

26.5 Electrical:

26.5.1 Shorts:

No shorts shall be permitted between electrically isolated points. Reference Section 26.12.1 Test and Inspection.

26.5.2 Continuity:

All circuit lines and associated plated through hole interconnections must be capable of carrying a minimum of one ampere of current for a period of no less than one minute.

26.5.3 Insulation Resistance

The insulation resistance between any two electrically isolated conductors or between layers shall be no less than 500 megohms with 500+10% VDC applied for one minute. There shall be no flashover or disruptive discharge.

26.6 Workmanship:

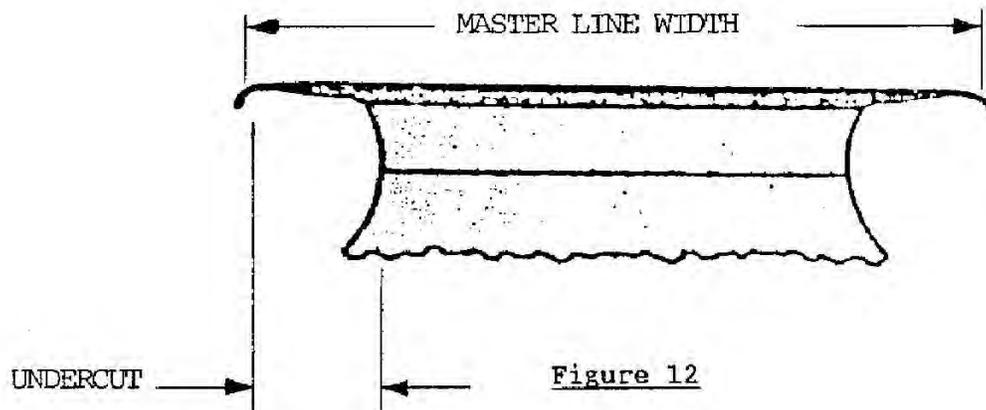
The printed circuit boards shall be processed in a manner consistent with good commercial practices. In addition to the requirements stated herein, the following undesirable workmanship items will be cause for rejection.

26.6.1 Base Material:

Delaminated areas caused by shearing, routing or drilling, extending more than .032 inches from machined edges (other than the printed contact edge) or delaminated areas at the printed contact edge will not be allowed.

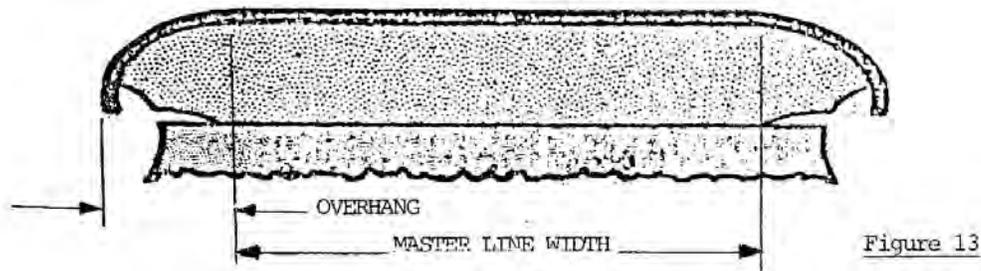
26.6.2 Undercutting:

Undercutting of a given circuit line shall not produce an actual cross section which is less than 85% of a rectangular section of the same base and height dimensions.



26.6.3 Plating Overhang:

Over plating shall not extend more than 0.001" beyond the base of the circuit line on either side.



26.6.4 Spurs and Flecks:

Any combinations of superfluous conductors, flecks and edge roughness shall not reduce the clearance between the normal outline of conductors to less than the specified in Section 26.4.4.1.

26.6.5 Voids in Circuit Path:

There shall be no reduction in the effective conductor cross section by more than 20% due to voids, notches, nicks, cuts, cracks or scratches or any combinations of these defects.

26.6.6 Delamination:

Internal delamination to any degree is unacceptable.

26.6.7 Etchback Multilayer:

Etchback of resin material must be assured a solid bond of copper hole plating to inner layer conductors requiring continuity. Epoxy smear at the interface of the PTH and inner layer conductor is unacceptable.

26.7 Artwork Alterations:

The vendor shall not alter artwork film unless specifically authorized in writing, by responsible CPI personnel.

Improvement of file quality, i.e.: minor touch up of pin holes, limited increased in line width etc., is expected to be performed by the vendor when necessary to fabricate an acceptable board.

26.8 Repair of Boards:

With certain exceptions, the vendor shall not alter or repair finished boards unless authorized by responsible CPI personnel. The exceptions are the repair to remove shorted etch and ultrasonic welding to repair opens.

26.9 Silkscreen Marking:

Marking must be capable of withstanding the conditions of section 26.3.9.1 of this specification without evidence of functional degradation. All marking is to be done with yellow non-conductive ink approved by CPI.

26.10 Board Identification

26.10.1 Etched Identification:

Each board type shall be clearly marked in etched copper derived from the artwork.

26.10.2 Date Code:

Each vendor will apply a four digit date code (year plus week) to each printed circuit board. The height of the letters shall be 0.125" and they shall be enclosed in a rectangle provided on artwork. See Figure 14.

26.10.3 Vendor Code:

Each vendor will apply a vendor's identification and/or UL marking code to the artwork. this marking code is to be placed in a convenient and conspicuous location and/or as otherwise specified and is to be copper etched on board.

26.11 U.L Requirements:

All printed circuit boards shall comply with the flammability requirements of UL478, Para. 3.3.6 Flammability Classification UL94 FLAM. CLASS. the flammability classification of the PCB shall be no mor flammable than 94V-1 when tested according to UL94.

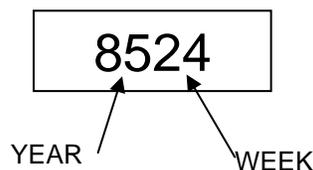


Figure 14



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26.12 Quality Assurance:

26.12.1 Test and Inspection:

The board manufacturer has the responsibility to initiate and maintain inspection and test procedures which will insure strict compliance with all requirements of the engineering drawings and this specification. CPI reserves the right to witness any such inspection or testing.

26.12.1.1 Requirements:

Electrical Test – All boards that have passed visual inspection shall be electrically tested for continuity, opens and shorts. The electrical test shall be performed by a computer based automatic tester. The tester would be constructed upon a “bed of nails” vacuum or pneumatic type test head for receiving the board to be tested. The tester should have the following parameters set for the board testing:

0 Test Voltage	=	50V typical
0 Test Current	=	10 ma typical
0 Continuity	=	50 ohms maximum
0 Short (Hi Res.)	=	100K ohms minimum

A maximum of five (5) open repairs are allowed per board. Repairs are to be done per Sec. 26.8, no solder etch repairs are allowed. Boards that successfully pass electrical test shall be stamped “TESTED” and protectively packaged for shipment. Per section 26.13.2



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26.12.2 Qualification:

Prior to the production of any board in conformance with this specification, a qualification, a qualification process must be completed. The qualification process requires that the potential supplier be surveyed by a CPI team consisting of members from the Quality and Materials departments. As part of the survey, the product manufactured by the supplier shall be reviewed for compliance to this specification.

26.12.3 Process Changes:

Once a vendor has been qualified, CPI must be notified of any major change which is likely to affect the quality; price; delivery or change in process of the products purchased from the vendor.

26.13 General:

26.13.1 Purchase Order:

Unless otherwise specified in the CPI purchase order, the provisions specified herein shall apply to all deliveries of printed circuit boards.

26.13.2 Packaging:

Each printed circuit board shall be individually bagged in a 3 mil bag and not sealed. Any alternate package must be approved by CPI.

26.13.3 Shipping:

Packing shall be done in such a way as to prevent damage during transit and storage. Shipping containers shall be suitable sized and shall conform to the requirements of the applicable carrier.

26.13.4 Marking:

Shipping containers shall be durably marked in a legible manner. The markings shall be applied in such a way that they will not be destroyed or rendered illegible when the container is opened. In addition to any special markings that might be required by the CPI purchase order, the markings shall provide at least the following:

- A. Part Number
- B. Purchase order number
- C. Quantity of items in the container

27.0 PACKAGING AND LABELING

27.1 Packaging

27.1.1 All parts and components shall be packaged and cushioned when necessary to provide protection from damage, contamination and corrosion during shipment and transportation from place of origin to place of destination. Critical surfaces, fragile items, precision parts, etc., shall receive special care cushioning and/or special mounting when required. Suppliers may request the buyer's advice in devising acceptable packaging.

27.1.2 All parts shall be packed for shipment in such a manner that they will conform to all general requirements and requirements of the individual drawings as well as the following:

Sulphur free paper and containers are to be used in packaging parts or materials of the following composition:

- 27.1.2.1 Copper
- 27.1.2.2 High Copy Alloys Containing over 95% Copper
- 27.1.2.3 Silver
- 27.1.2.4 Silver Alloys
- 27.1.2.5 Parts plated with Silver or Copper

27.1.3 Fragile items and precision parts, with critical surfaces shall be cushioned as necessary with material such as air cap, microfoam, plastic pellets, corrugated paper boards, polyurethane foam, Kimpack wadding or tissue paper. Excessively dusty and linty materials such as excelsior, sawdust, vermiculite, or shredded paper shall not be used.

27.1.4 When a large shipment of any one part is to be made, it is advisable to pack these small lots in individual boxes, and over pack individual packages in shipping cartons. Individual boxes shall be packed so that they will not be damaged in transit. Carton sizes and shipment weights shall be selected to allow ease of handling and conform to box manufacturers maximum weight limit.

27.1.5 Where use of a particular container or packaging method is required and specified, such containers shall be used for shipment of parts.

27.1.6 Package ESD sensitive items in ESD protective material for handling and shipment. ESD protective packaging should be marked in accordance with EOS/ESD S8.1 or MIL-STD-2073-1 requirements.



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27.2 Labeling

27.2.1 To facilitate handling in receiving and inspection, a legible label (preferably printed or typewritten) would be securely attached to each package and/or container. Each container shall contain the following information:

27.2.1.1. Name of Supplier

27.2.1.2 Purchase Order number

27.2.1.3 Complete part Number and Revision Letter

27.2.1.4 Amount (number of pieces and/or weight, or any other units which would indicate the quantity of pieces).

Fragile labels shall be used when the item is of a delicate nature.

27.3 Packing Slips

Each shipment should contain a packing slip attached external to the package. Packing slips should identify item part number, quantity shipped, description/model type and the CPI purchase order number.

28.0 USE OF OXYGEN-FREE HIGH CONDUCTIVITY COPPER (OFHC)

- 28.1 This specification sheet is released for the purpose of informing suppliers of the uses of oxygen-free copper (OFHC). All OFHC copper used at CPI must comply with CDA-101 Class 3 or better including ASTM-F68.
- 28.2 Copper for the construction of microwave devices is usually of the OFHC type with oxygen contents held to less than .0007% during the melting and casting processes. No additional elements are added. This is in contrast to deoxidized coppers containing active scavengers which react with and remove oxygen from solution.
- 28.3 The main reason OFHC copper is used in the production of microwave products is that hydrogen atmospheres are used in processing. Other types of copper contain enough oxygen in the form of copper oxide to form voids and intergranular cracks when fired (900°C). The hydrogen combines with the oxygen to form steam that in turn builds up tremendous pressures in microscopic cavities and forces the copper to open up between grains. This often results in leaks through the material.
- 28.4 Some advantagss of OFHC Copper are:
- 28.4.1 Hydrogen embrittlement will not occur which is an aid in brazing.
- 28.4.2 OFHC copper remains soft, therefore preventing a seal from fracturing. Other types of copper become work hardened.



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28.5 Conclusion

28.5.1 The use of OFHC copper is mandatory in the machining of microwave parts. Whenever a CPI Beverly print specifies the use of OFHC copper, under no conditions must the material be substituted.

28.5.2 If material is supplied by CPI, and a supplier requires additional stock the CPI purchasing agent should be contacted.

28.6 Certification and Test Samples

28.6.1 Piece parts machined from OFHC copper purchased by the supplier will require a Certification of Chemical and Physical Analysis showing the heat number to be shipped in with the first lot. Subsequent lots delivered against the same purchase order will require a Certificate of Conformance.

28.6.2 When required by the part drawing and/or purchase order test samples of the raw material will be sent in with each lot submitted. The minimum size of the sample piece is 2" long x 1/4" wide x 0.81" thick. Larger size samples are acceptable and raw material thickness under 0.81" thick is acceptable when the basic sheet stock is under that thickness.

29.0 WORKMANSHIP & QUALITY REQUIREMENTS

29.1 Inspection of Parts

CPI will inspect parts that are fabricated and submitted by suppliers, outside contractors, and CPI machine shops.

Parts shall be rejected which do not meet the requirements of the purchase documents, defined as the drawing, purchase order, shipping instructions, referenced documents, etc.

29.2 Rejection of Parts

When parts are rejected, CPI may at its own option:

- a) Return the parts, and require that they be corrected or remade at no cost to CPI.
- b) Return the parts and cancel the contract without payment.
- c) Rework the parts at CPI and deduct labor plus overhead cost from the supplier's invoice.

29.3 Certifications

29.3.1 The supplier shall fabricate the part(s) using the material specified by purchase documents.

29.3.2 The supplier shall provide a Certificate of Conformance (C of C) when required by purchase documents. The C of C shall be titled and enclosed, with all lots, in the same shipping container as other documentation. It may be a separate document or included as part of the packing slip. Where multiple shipping containers are required, the one containing the C of C and other documentation shall be clearly identified. The minimum contents of the C of C shall be those in the following list:

- a) Certificate title
- b) Suppliers name
- c) CPI purchase order number
- d) CPI part number and revision
- e) Part quantity
- f) Part serial numbers (if applicable)
- g) Statement of conformance
- h) Name, title and signature of the certifier.

29.3.3 The supplier shall provide a chemical or physical Certificate of Analysis (C of A) when required by purchase documents. The C of A shall be titled and enclosed in the shipping container with other documentation. The minimum contents of the C of A shall be those in the following list:

- a) Certificate title
- b) Name and address of certifying company
- c) CPI purchase order number
- d) Material quantity
- e) Conforming data specific to the material's physical or chemical properties
- f) Statement of conformance
- g) Production heat lot traceable to the original melt.
- h) Name, title and signature of the certifier

If a C of A is unobtainable, the supplier and CPI Beverly Procurement shall agree on other acceptance criteria. Examples of which are the following: a C of C from a testing lab or material samples submitter for analysis to CPI Beverly.

29.3.4 The supplier shall provide a Process Certification (PC) when required by purchase documentation. The PC shall be delivered with all lots submitted to CPI Beverly. The minimum contents of the PC shall be those in the following list:

- a) Certificate title
- b) Process supplier's name and address
- c) Process name
- d) Process spec or standard, revision, class and type
- e) CPI purchase order
- f) CPI part number
- g) Part serial numbers (if applicable)
- h) Name, title and signature of the certifier

29.3.4.1 Special Processes

The special processes requiring certification will be called out on the purchase documentation. Special processes such as welding will require a copy of the welders certification to that specification called out on the part drawing and/or purchase order.

Special processes include, but are not limited to: Welding, heat treating, cleaning, plating, anodizing, chemical, films, chemical films, impregnation etc.

29.3.5 A C of A is not required when the supplier uses CPI Beverly material for parts fabrication. In this case, the supplier shall still provide a C of C and include the material-for-resale (MFR) number on the packing slip.

29.3.6 Failure of the supplier to supply the above documents or failure of the material received to meet physical or chemical properties as documented in material specifications will result in the rejection of same.

29.4 Workmanship

Parts shall be thoroughly cleaned (See Paragraph 31) and free from all contaminants before shipment to CPI.

Gouges, nicks, scratches or other types of surface flaws may be cause for rejection.



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CPI reserves the right to visit supplier's plant to survey supplier quality control and quality record system.

30.0 RESUBMISSION OF REJECTED MATERIAL

This specification sheet is issued and is to be used as a guide to CPI Beverly suppliers and subcontractors in the resubmission of previously rejected lots or shipments.

30.1 It is mandatory that this specification be adhered to as resubmitted lots must be inspected using different criteria than original lots.

30.1.1 In fairness to CPI Beverly suppliers and subcontractors, resubmitted lots are inspected under different sampling plans and are not included in the evaluation and rating of suppliers.

30.2 Specific Requirements

30.2.1 All defective lots returned to suppliers and subcontractors will be accompanied by a CPI Beverly Discrepant Material Report (DMR). Form QAR-170 (Exhibit A)

30.2.2 Upon satisfactory correction of the lot discrepancy, the supplier or subcontractor will resubmit the lot to CPI Beverly, along with the Supplier Corrective Action Report, QAR-173 (Exhibit B) when required.

30.2.3 The following information must appear on the supplier's or subcontractor's shipping papers accompanying the resubmitted material.

30.2.3.1 CPI Beverly Debit Memo Number

30.2.3.2 CPI Beverly DMR number

30.2.3.3 CPI Beverly Lot Identification

30.2.3.4 The supplier's or subcontractor's packing slip shall clearly identify the material as being "resubmitted".

30.2.3.5 The above information is available on the DMR as received from CPI Beverly.



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EXHIBIT A



DISCREPANT MATERIAL REPORT

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beverly microwave division
150 Sohier Road
Beverly MA 01915-5595

**SUPPLIER: An immediate faxed response is required
or material will be shipped without RA #
fax # 978-921-4770**

11/10/99

DMR #

Supplier Name - Address - Zip Code		V/C #	PURCHASE ORDER #		LINE #	DMR DATE	LOT #
		PART NUMBER	REV	QTY RECEIVED		DATE REC'D	
		PART DESCRIPTION					
RA#	Planner Code	BUYER		DELIVERY STATUS INFORMATION			
				on time	<input type="checkbox"/>	late	<input type="checkbox"/>
				days late			

ITEM #	INSPECTION PLAN			CHARACTERISTICS	ZONE	DISCREPANCY	REJECT QTY	# OF	
	A.Q.L	N=	C=					QTY	OCC

INSPECTOR

DATE

VENDOR Q. A.

DATE

TOTAL ACCEPT

TOTAL REJECT

Consumption Rate

Replacement Need Date

Priority Rating

IRB - MRB DISPOSITION CODES (DC) A = NO FAULT V = RETURN TO SUPPLIER X = USE AS IS B = REWORK AT CPI-BMD S = SCRAP

QUALITY CONTROL	DATE	ENGINEERING	DATE	CUSTOMER - GOV'T	DATE	OTHER	DATE

SUPPLIER CORRECTIVE ACTION REQUESTED YES NO

COMMENTS - INSTRUCTIONS

SHIP MATERIAL TO:

Above

Other

Other:

SHIPPING INFORMATION

EXAMPIE

Place Shipping Label Here

ACCOUNTING SECTION

Material Value	
Freight Out	
Total Debit	
Memo	

Pick Up Signature/Date

RA #

Request Ship Via

Original
Shipping
Accounts Payable
Accounts Receivable
CAR

QAR-170 Rev E 3/9/98

EXHIBIT B

Communications & Power Industries beverly microwave division 88236		DOC NO. QAR-173 REV. B PAGE 1 OF 1
SUPPLIER CORRECTIVE ACTION REQUEST To be completed by the supplier. Request for Supplier Corrective Action must be completed and returned to Supplier Quality Assurance, Box 3 within 2 weeks after receipt.		
Fix: 		
Root Cause: 		
Corrective Action: <div style="text-align: center; font-size: 4em; opacity: 0.5; font-family: sans-serif;"> EXAMPLE </div>		
Corrective Action Implementation Date: _____		
Supplier Evaluation By (Signature)	Title	Date
Supplier Quality Assurance Approval	Signature	Date
<input type="checkbox"/> Yes <input type="checkbox"/> No		
COMMENTS: 		

31.0 COOLANTS, LUBRICANTS, AND SOLVENTS

31.1 Coolants, lubricants and solvents used in fabricating parts for CPI Beverly must be free from chlorides, sulfur or sulfur containing compounds or not to exceed the maximum's listed below.

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

31.1.2 All parts should be wiped clean of excess oils & lubricants prior to delivery to CPI Beverly Microwave Division.

31.2 The following parameters define the acceptability of coolants, lubricants and solvents for use in manufacturing CPI Beverly Microwave Division parts.

31.2.1 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.

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

31.2.3 Coolants, lubricants and solvents which contain chloride greater than 1 ppm are not to be used.

31.2.4 Total active sulfur content shall not exceed .01%.

31.2.5 Total sulfur content shall not exceed .03%.

31.2.6 All lubricants must be free of high vapor pressure materials, i.e., the concentration of Hg, Cs, K, P, Na, S, Mg, Li, Sb, Cd, Zn, Te, Sr, Ca, Pb, and Mn shall not exceed .01% individual concentrations.



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32.0 CUPRONICKEL MATERIAL (CUNI)

- 32.1 Cupronickel material used to fabricate piece parts must be certified to comply with a maximum manganese content of 0.5% as per the CPI, P3-10 specification.
- 32.2 When cupronickel raw stock is not supplied by CPI/BMD, then a chemical and physical certification copy must accompany the first lot delivered on each purchase order.