

METAL WORKS INC.	WORK INSTRUCTION	Rev: H	Control Stamp
MANUFACTURING CAPABILITY INSTRUCTIONS		WK-27	

REVISION HISTORY

ISSUE DATE	DESCRIPTION OF CHANGE	REV
05/15/96	Initial Release	A
06/18/97	Added further information on bend angles and tolerance.	B
09/28/98	Updated format, and cover page.	C
11/24/98	Added finish classifications to capability instructions.	D
02/06/00	Changed section on Parallel and Compound Planes to tolerance of +/- .040.	E
01/06/01	Added masking and powder cost capabilities	F
01/09/04	Tightened up Bend to Hole tolerance and Hole to edge tolerance, both by .050. Added finish criteria for plated and cosmetic surfaces.	G
02/09/05	Added Section on Pre-plated metals and deburring.	H
Process Owner:		Approval:

STANDARD FABRICATION TOLERANCE

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FOR SHEET METAL PRODUCTS

This standard reflects the current process capabilities of the sheet metal industry. The tolerances specified in this document are the minimum available without specialized tooling or processes. It is strongly suggested that tolerances be made as broad as possible, while retaining high product quality and functionality. Focus should be on maintaining critical quality features.

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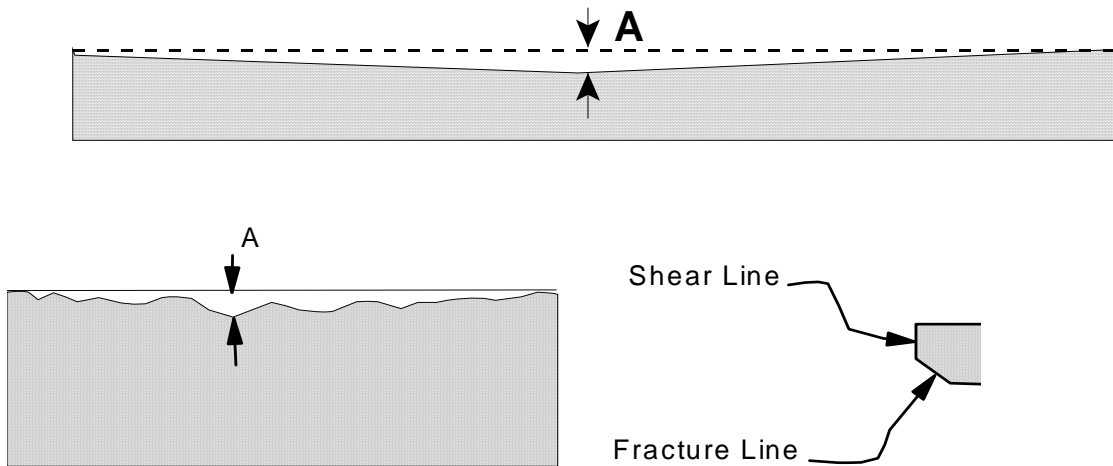
Flatness

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Surface Length in.	Flatness Tolerance (A) in.	Surface Length Metric (mm)	Flatness Tolerance (A) Metric (mm)
0" # 1.00"	0.005"	0 # 25 mm	0.127 mm
1.00" # 4.00"	0.005"/ linear inch	25 # 101.6 mm	5 μm / mm of length
> 4.00"	0.020" +0.004"/ in. of length	>101.6 mm	0.51 mm + 4 μm / mm of length

Straightness of Cut

When measuring the straightness of a cut edge, the maximum deviation from the theoretical straight edge is measured. The deviation (A) shall not exceed 0.005" per foot of cut length. The measurement is to be made along the shear line, and not the fracture line.



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Squareness

Formed and sheared sides shall be square within the tolerance requirements described in the table below.

SQUARENESS BETWEEN	SHEARED EDGE	FORMED EDGE
SHEARED EDGE	0.015" / ft.	0.020" / ft.
FORMED EDGE	0.020" / ft.	0.015" / ft.

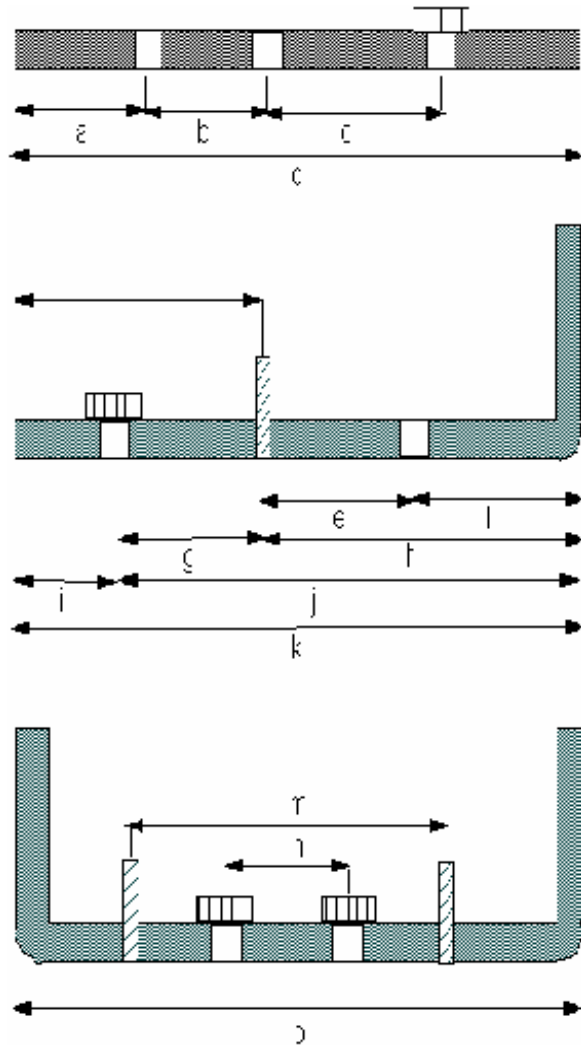
Edges and Burrs

Burrs and sharp edges shall be broken by a chamfer or radius up to 0.015" or 10% of material thickness, whichever is smaller. Localized projections caused by piercing, notching, nibbling, blanking or shearing are permissible but shall not exceed 0.006". A sharp edge is capable of cutting or scratching a bare hand. Sharp edges shall be removed to minimize handling danger.

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Features

Feature		Tolerances (+/-)	
		Inch	mm
Edge To Hole	a	0.005	0.127
Hole to Hole	b	0.005	0.127
Hole to SCF	c	0.010	0.254
Edge To Edge	d	0.010	0.254
Hole to Stud	e	0.010	0.254
Bend to Hole	f	0.010	0.254
SCF to Stud	g	0.015	0.381
Bend to Stud	h	0.020	0.508
Edge to SCF	I	0.015	0.381
Bend to SCF	j	0.020	0.508
Bend to Edge	k	0.010	0.254
Edge to Stud	l	0.015	0.381
Stud to Stud	m	0.015	0.381
SCF to SCF	n	0.015	0.381
Bend To Bend	o	0.020	0.508



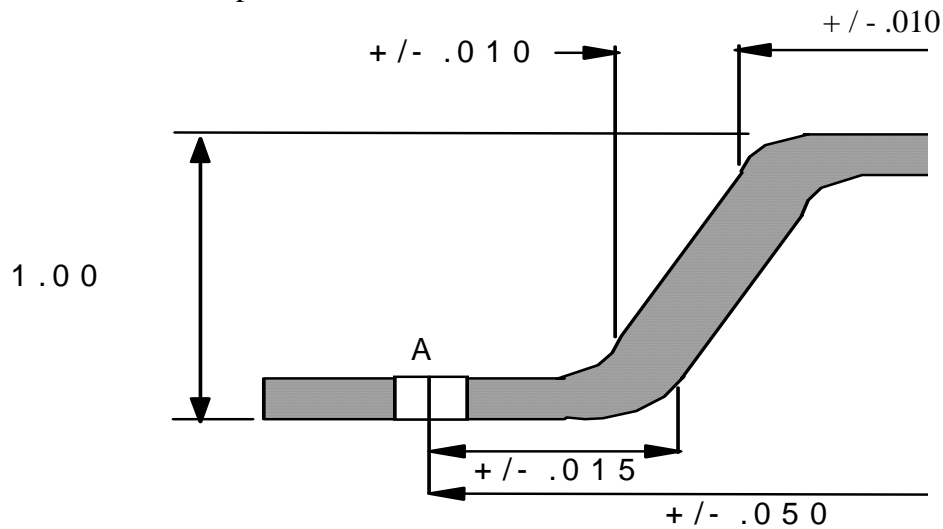
*SCF = Self Clinching Fastener

**Stud = Stud or Standoff

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Parallel and Compound Planes

The tolerance between features on two different planes is the sum of the tolerances between the first feature to the bend, the bend tolerances, and the tolerance between the bend and the second feature. An example is shown below.



- +/- 0.015Hole (A) to Bend
- +/- 0.020Bend To Bend
- ++/- 0.015Hole (B) to Bend

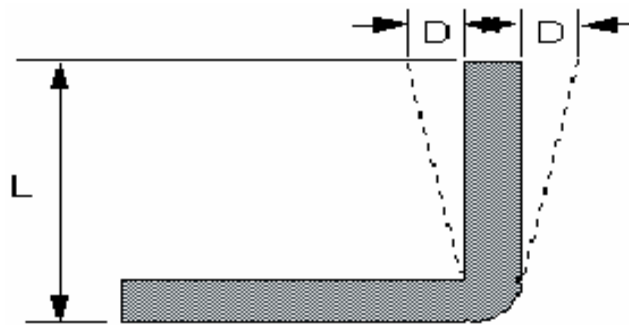
+/- 0.040 Tolerance between A and B

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Bending

Right Angles

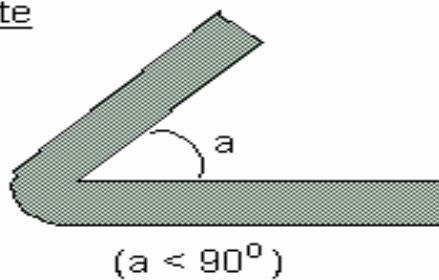
Angles that are not specified on the engineering drawing and appear to be 90 degrees are considered to be 90 degrees. The angular tolerance will be +/- 1 degrees. The position of material (D) at the end of a bend will vary according to the length of the bend (L).



Acute Angles

The tolerance for acute angles is +/- 1 degrees.

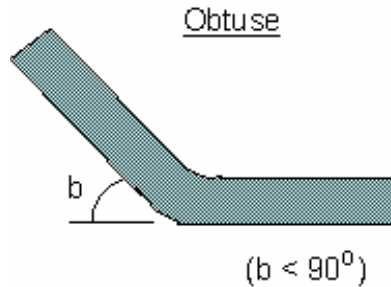
Acute



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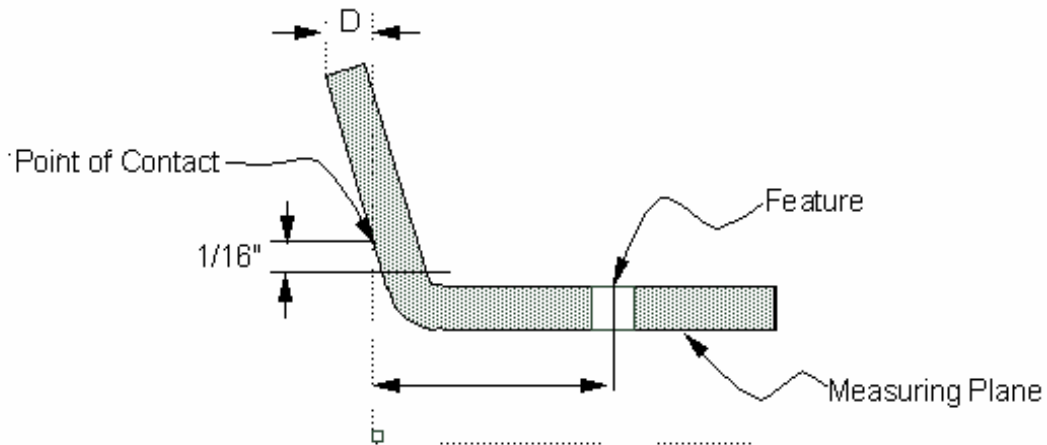
Obtuse Angles

The tolerance for obtuse angles is +/-1E.



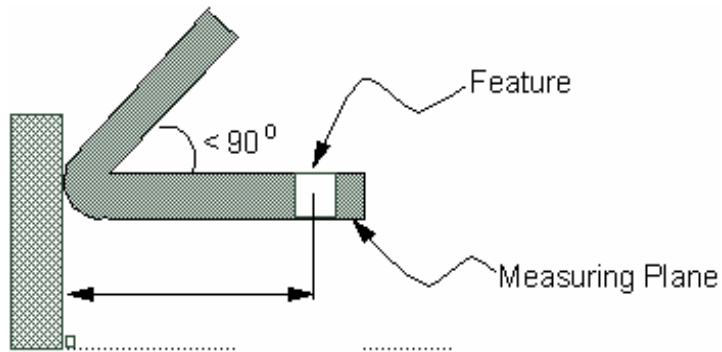
Measurements from a Bend

For right and obtuse angles, the measuring point of a bend shall be established 1/16" from the furthest point tangent to the radius. Features are to be measured from the vertical plane that extends from the contact point. This plane shall also be used to verify the angle of the bend.



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For acute angles, the position of a feature is measured using a straight edge or cylinder held perpendicular to the measuring plane.



Bends and Material Grain

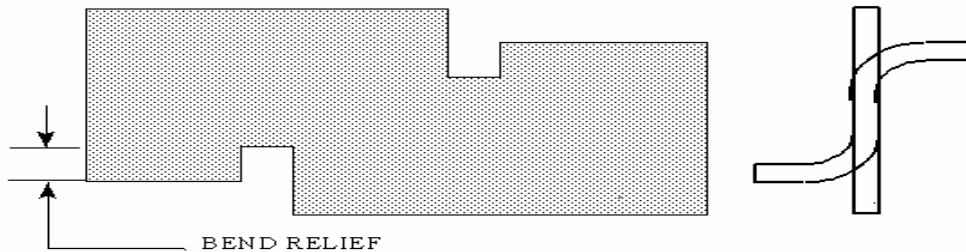
Whenever the bend configuration permits, a bend shall be made across the grain of the material, or at a 45 degrees to the grain direction. **Minimum Flange (Bend Length)**

The minimum recommended flange dimension should be at least 3.5 times the sum of the material thickness and the bend radius.

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Bend Relief

Where flanges extend over only a portion of a part, a notch or hole should be provided to prevent tearing (as shown). The minimum recommended bend relief will equal the sum of the material thickness and the bend radius.



Distance of a Punched Hole from a Bend

The minimum inside dimension from a bend to the edge of a punched hole should be 1.5 times the sum of the material thickness and the bend radius. Punched holes located closer to a bend will have a tendency to distort and may lead to cracking of the material.

Material Thickness and Hole Size

Generally minimum hole size is limited to the thickness of the material.

Distance of a Punched Hole from Edge of Blank

To avoid distortion in sheet metal, holes must not be too close to an edge. For sheet metal 1/32 inch or less in thickness, all holes should be at least 1/16 inch from the nearest edge. The minimum distance from an edge for thicker material should be twice the thickness, but not less than 1/8 inch. The minimum distance between two punched holes should be at least twice the thickness of the material.

If the holes are to have inserts, studs etc. pressed in the manufacturer's recommendations for minimum distances should be observed.

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PRE-PLATED METALS AND DEBURRING:

There are numerous pre-plated metal products on the market today. MWI has worked with all of them, the most common are:

- Tri-Clear - Appealing cosmetic finish, but the least available of pre-plated metals.
- Galvanized - Less expensive metal solution, most often requested with min spangled.
- Galvaneal - Painting and powder coating
- Loc AF - Good for anti finger print finish.

It is important when choosing pre-plated material to access the environmental exposure the product will be subject to. All of these materials caution against deburring, and can not be run through timesaver or stroke sander. However in the office environment where most of the products manufactured by MWI end up the risk of sharp edges leading to personnel injury is a much bigger concern than the threat of contamination.

Therefore it is MWI policy to deburr pre-plated edges that are determined to be sharp to ensure safety of the product unless otherwise stipulated by the customer. MWI requires an understanding of the environmental exposure for the product and if traditional methods of deburring will risk contamination of the product during its lifecycle. A Scotch-Bright Belt is a more expensive alternative to deburring with less risk of metal contamination. Here again the use of Scotch-Bright Belt for deburring is a concern for contamination if the product will be exposed to the elements. If the product will be exposed to the elements, no deburring is recommended in the manufacturing process.

FINISH CAPABILITIES:

Paint Masking:

From an edge of a part + / - .020 is the minimum that can be held without a special fixture. Masking in the middle of the part is held normally to + / - .060 without a special fixture.

In general it is preferred that masked areas be specified on powder coat instead of general over-spray restrictions, as commonly done with paint. This is due to the nature of powder vs. paint to migrate to any or all unmasked areas. The heat sensitivity of the curing process limits masking jigs & materials. Masking large areas is more costly for powder than it would be for paint.

Powder Coating:

Cosmetic conditions such as hiding hardware studs is very difficult in powder coat applications. These desired cosmetic conditions and should be avoided or it is recommended the finish be changed to a wet paint process. Products on the market to fill voids etc., do not hold up in the

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high heat curing process. In addition these fillers tend to disrupt the grounding required for the powder coat application.

Metal Works Finish Classifications:

Class "A" Products

Decorative or highly visible part. Pre-finished material must be free of scratches, digs, brake marks, etc. Special handling is required for material movement and packaging. Product to be stacked between cardboard, tissue paper is to be used when a particular surface is specified as scratch free.

Class "B" Products

Semi decorative finish. Pre finished material can have light fabrication marks which can be covered during the finishing operation. Light fabrication marks are those which cannot catch a fingernail when running across the mark.

Class "C" Products

Customer specifications have not called for decorative characteristics. No special handling requirements are expected.

If no class is specified by the customer, the part is considered to be a **Class "C"**.

Unless otherwise noted on the prints or routing, parts will be viewed or inspected at arms length for 5 – 10 seconds.

Cosmetic Finish Standard for Painted and Finish Plated Surfaces

	Class 1	Class 2	Class 3
1) Class –General Examples	Front of a chassis, enclosure or control panel	Rear of a chassis or enclosure	Interior surfaces of a chassis or enclosure
2) Acceptance Criteria			
Bare metal (unmasked areas)	None	None	None
Scratches (Are not acceptable if through to bare metal)	None	No more than 2 scratches, and not to exceed 1 inch in	Not to exceed 1 inch in length.

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		length per surface.	
4) Slug Marks	None	No more than 2	Not Critical
3) Coating			
a) Runs	None	1 – 2 small	Not Critical
b) Blemishes	Slight	Slight	Not Critical
c) Blisters	None	None	None
d) Specks	No more than 2 in a 6x6 area	No more than 4 in a 6x6 area	Not Critical
e) Coating build-up in corners	None	Slight	¼” max.
f) Build up on edges	None	Slight	Not critical except in areas that may interfere with assembly.
4) Silkscreen			
a) Coverage	Complete	Complete	Legible
b) Line Definition	No rough edges	Slight roughness	Moderate roughness
5) Miscellaneous			
a) Hardware	Outline may be visible	Outline may be visible	Outline may be visible

Cosmetic Finish Standard for Uncoated and Pre-plated Surfaces

	Class 1	Class 2	Class 3
1) Class	Front of a chassis, enclosure or control panel	Rear of a chassis or enclosure	Interior surfaces of a chassis or enclosure
2) Acceptance Criteria			
Scratches	None	No more than two scratches, and not to exceed 1 inch in length.	Not Critical
Dings	None	Not to exceed 10% of the material thickness.	Not to exceed 20% of the material thickness.
Blemishes	None	Slight	Not Critical
Corrosion	None	None	None
Abrasions/Scuff Marks	None	No more than 1 inch in length.	Not Critical
Slug Marks	None	No more than 2	Not Critical

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Brake Marks	None	Minimum brake marks allowed. Marks must be straight.	Not Critical
Burrs	None	None	None large enough to allow personal injury.
Sharp Edges	None	None	None allowed in an area that may cause personal injury.