Subject: Sheet Metal, Miscellaneous Metal and Nonmetals

APPROVED BY Manager, Hardware Engineering

STATUS Maintenance Revision

PURPOSE Defines manufacturing practices and methods used primarily in the fabrication of sheet metal parts and miscellaneous metal and nonmetal parts. Offers information not generally defined on engineering drawings or operation records. This instruction also offers supplemental information to personnel involved in the fabrication of sheet metal as well as miscellaneous metal and nonmetal parts.

AFFECTED FUNCTIONS Hardware Engineering
Manufacturing

REFERENCES

LMS 6-2	Screw Threads
LMS 6-3	Machine Shop Practices
LMS 7-1	Arc Welding
LMS 9-1	Painting

DEFINITIONS

Burrs. The material that extends beyond the line of intersection of the two intersecting surfaces of a part, caused by machining or punching operations.

Dimpling. Stretching a relatively small, shallow indentation into sheet metal. Stretching metal into a conical flange for use of a countersunk rivet head or screw. Dimpling is substantially stronger than countersinking and should be performed on relatively thin panels.

Joggle. A step formed in material by two adjacent reverse bends.

Nibbling. The manufacturing operation for cutting sheet metal parts by means of a punch press.

Sheet metal. Any metal less than .250 inch thick.

INSTRUCTION

1. Requirements

1.1 Burrs.

a. Burrs shall be permitted on a part unless one of the following conditions exists:

(1) The drawing or operation record specifies their removal.

(2) The tolerance of either surface is exceeded.

b. When preparing the operation record, the Methods Engineer shall consider whether:

(1) A safety hazard exists.

(2) Burrs will interfere with succeeding operations.

(3) Burrs will interfere with proper operation of the part when assembled.

c. The general note on old drawing formats:

" REMOVE ALL BURRS .003- TO .020-INCH RADIUS "

is superseded by this instruction.

d. When deburring is specified on the manufacturing operation record, the resultant radius or chamfer shall be .003 to .020 inch (0.076 mm to 0.508 mm).

1.2 Flatness. The total deviation permitted shall be applied to all points on the surface in both the length and width directions. Maximum flatness deviation shall be as shown in Figure 1 and Table I.

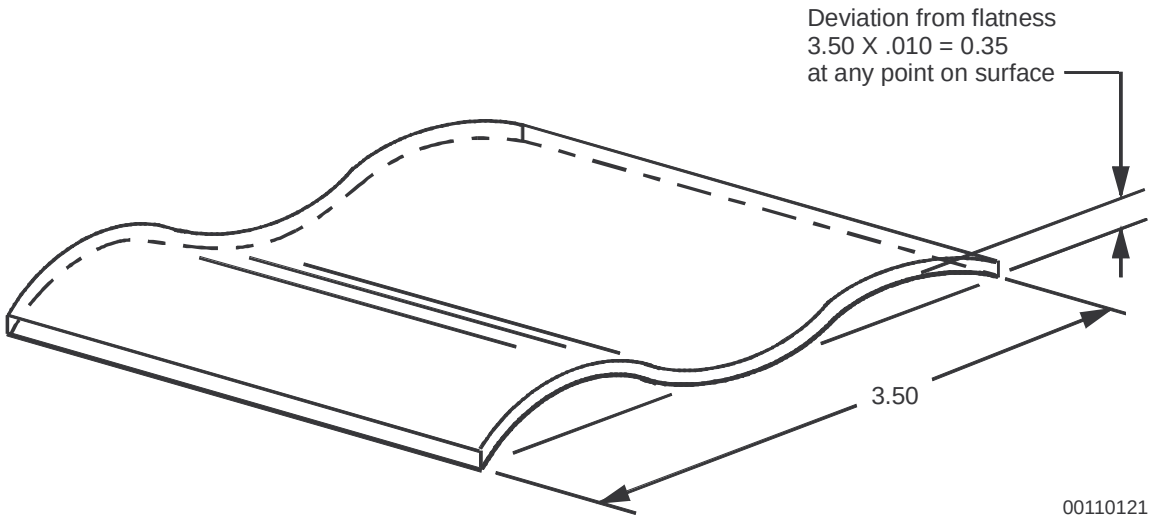


Figure 1 Flatness Tolerance

Table I Deviation

SURFACE LENGTH	DEVIATION FROM FLATNESS
Up to 1 inch (2.54 cm)	.010 inch (0.254 mm)
Over 1 in. (2.54 cm) and incl. 4 in. (10.16 cm)	.010 inch (0.254 mm) per linear inch
Over 4 in. (10.16 cm)	.040 +.008 inch (1.016 mm + 0.203 mm) per additional inch

1.3 Straightness and parallelism. The edge of a part may be irregular or slanted and still be acceptable if it is within the tolerance bandwidth limits specified on the drawing. (See Figure 2.)

1.4 Squareness. The edge of a part may be out of square with an intersecting edge, providing it remains within the tolerance bandwidth limits specified on the drawing. (See Figure 3.)

a. Squareness of formed angles. Unless otherwise specified, bend angles of 90 degrees, whether actually dimensioned on the drawing or merely shown as 90 degrees, shall be within the accuracy specified in Figure 4. Measurement shall be made from the bend lines.

b. Bend angles other than 90 degrees (whether obtuse or acute) shall be produced to accuracies of 2 degrees regardless of length “L” or radius “R”, unless otherwise specified.

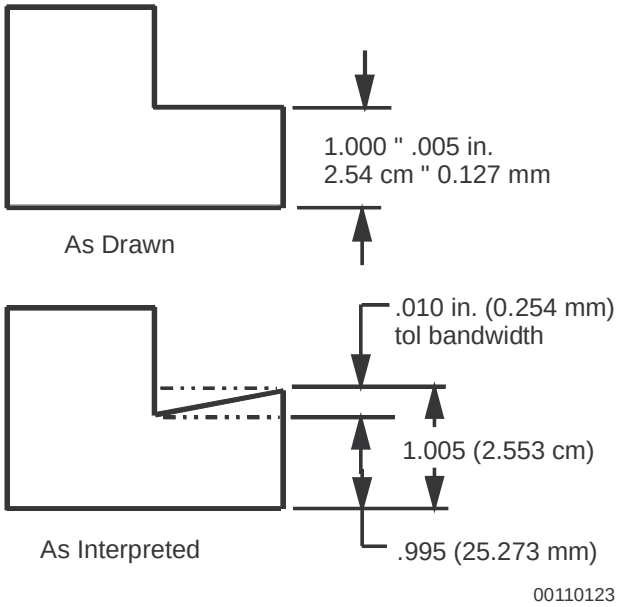


Figure 2 Parallel Tolerance

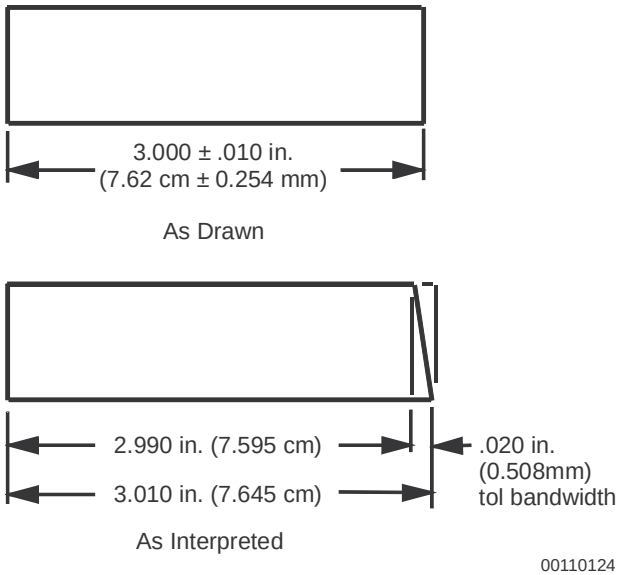
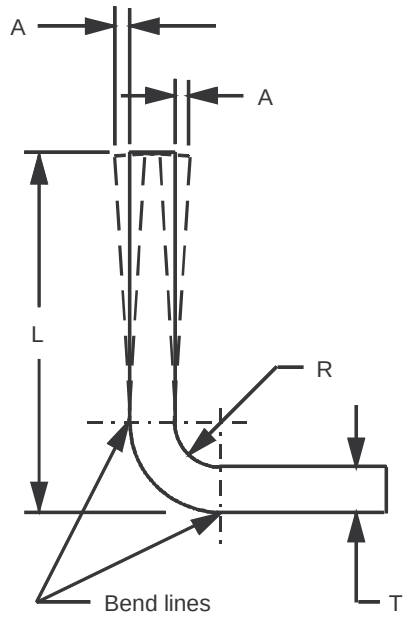


Figure 3 Squareness Tolerance



Radius	Angular Tolerance	A Max in inches
less than 2T	± 1_	.063 (1.600 mm)
2T to 4T incl	± 2_	.125 (3.175 mm)
over 4T	± 3_	.188 (4.775 mm)

NOTES: Limit A takes precedence over the angular tolerance when L (short leg to the bend is 4 in. (10.16 cm) or greater.

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Figure 4 Squareness of Angle

c. Except as noted herein, material formed to 90 degrees or more shall have a radius equal to the thickness of the material. The tolerance range for these radii shall be minus .00 and plus the material thickness.

(For example: for $^1/_8$ material = R .12 $^{+.12}_{-.00}$,
for $^1/_4$ material = R .25 $^{+.25}_{-.00}$, etc.)

When design requires a radius less than the material thickness, the drawing shall specify grain direction to avoid potential fracturing or grain stretching. When stretch lines are visible on the exterior surface of the formed section, surface abrading in accordance with work order instructions may be used to remove those lines, providing a minimum of 75 percent of the material thickness remains at the radius area.

d. Special tooling or processes may be utilized when "tighter" radii are required for design purposes.

1.5 Punched or drilled holes. Table II indicates standard punched hole tolerances for general sheet metal work. (For drilled hole tolerances, refer to **LMS 6-3**, Machine Shop Practices.) Unless otherwise specified on the drawing, punched hole size tolerances shall be determined as follows:

a. A 3-place decimal hole size dimension, such as .250-inch (6.350 mm) diameter, shall be in accordance with the standard tolerances of Table II.

b. A 2-place decimal hole size dimension, such as .25-inch (6.35 mm) diameter, shall have tolerance of .03 inch (0.76 mm).

c. A fractional hole size dimension, such as 1/4-inch diameter, shall have a tolerance of .015 inch (0.381 mm).

1.6 Breakaway of holes. The Go Gage must pass entirely through the hole; the No-Go Gage must not pass. (See Figure 5.)

1.7 Internal corners. When a sharp internal corner of a punched hole or notch is shown with no radius specified, a radius to .015 inch (0.381 mm) maximum shall be permissible.

1.8 Distorted holes. Holes or slots may be distorted by subsequent operations, such as bending. Such distortion shall not cause the hole or slot to exceed specified tolerances. (See Figure 6.)

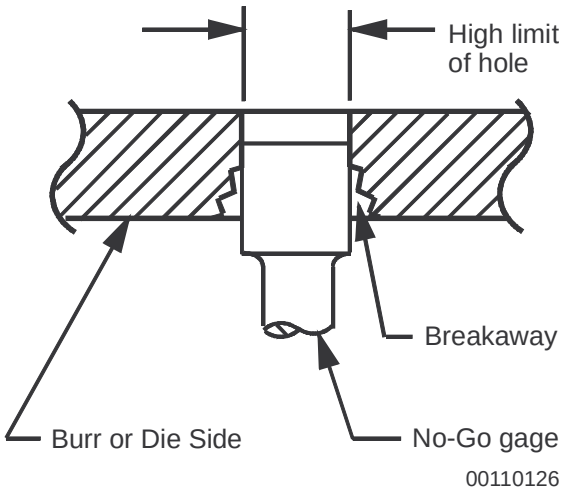

Figure 5 Distorted Hole

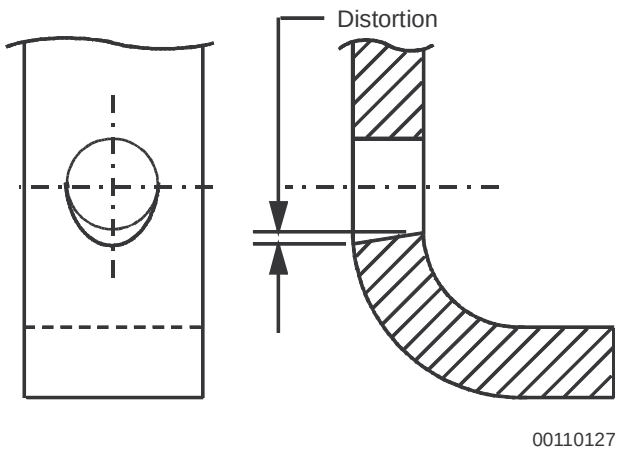

Figure 6 Distorted Hole

Table II Standard Punched Hole Tolerances

HOLE DIA inches (mm)		MATERIAL THICKNESS IN INCHES (mm)					
		METALLIC			NONMETALLIC		
OVER	TO	.001 (0.025) Thru .032 (0.813)	.033 (0.838) Thru .092 (2.337)	.093 (2.362) Thru .187 (4.750)	.001 (0.025) Thru .032 (0.813)	.033 (0.838) Thru .092 (2.337)	.093 (2.362) Thru .125 (3.175)
.0469* (1.1913)	.093* (2.362)	+.002 (0.051) -.001 (0.025)	+.002 (0.051) -.001 (0.025)	+.003 (0.076) -.002 (0.051)	+.005 (0.127) -.003 (0.076)	+.008 (0.203) -.005 (0.127)	+.010 (0.254) -.008 (0.203)
.093* (2.362)	.250* (6.350)	+.005 (0.127) -.003 (0.076)	+.005 (0.127) -.003 (0.076)	±.005 (0.127)	+.005 (0.127) -.003 (0.076)	+.010 (0.254) -.008 (0.203)	+.012 (0.305) -.010 (0.254)
.250* (6.350)	1.000 (2.54 cm)	+.008 (0.203) -.005 (0.127)	+.008 (0.203) -.005 (0.127)	±.010 (0.254)	+.008 (0.203) -.005 (0.127)	+.012 (0.305) -.010 (0.254)	+.015 (0.381) -.012 (0.305)
1.000 (2.54 cm)	3.000 (7.620 cm)	+.010 (0.254) -.008 (0.203)	+.012 (0.305) -.010 (0.254)	+.015 (0.381) -.010 (0.254)	+.015 (0.381) -.012 (0.305)	+.018 (0.457) -.015 (0.381)	+.020 (0.508) -.018 (0.457)

NOTES:

1. "Roundness" tolerance shall be within hole size tolerance.
2. Above tolerances do not apply to tap-punched holes; see tolerances on tapped holes in LMS 6-2.
3. Surface roughness in holes shall be 250 microinches (0.006 mm) maximum.
4. Tolerances for holes over 3.000-inch (7.620 cm) diameter shall be governed by general drawing tolerance.

* Punched hole diameters usually are equal to or exceed metal material thickness.

1.9 Countersunk holes. Unless otherwise specified on the drawing, countersink tolerances shall be in accordance with **LMS 6-3**.

1.10 Dimpling. Dimpling shall be in accordance with the diameter and angle specified on the drawing and the following:

a. When pilot holes are required, they shall be present prior to dimpling.

b. Dimples shall be free of cracks.

c. Unless otherwise specified on the drawing, the tolerance for the diameter of a dimple shall be +.03 inch, -.00 inch (+0.76 mm, -0.00 mm).

1.11 Irregular shaped holes. (See Figure 7.)

a. Maximum height of "Y" shall not exceed tolerance "A".

b. Total length of slot must allow passage of minimum plug gage diameter consistent with tolerance "A".

c. Multiple steps in any one slot shall not be accumulative in one direction in excess of tolerance applied to the dimension locating the slot.

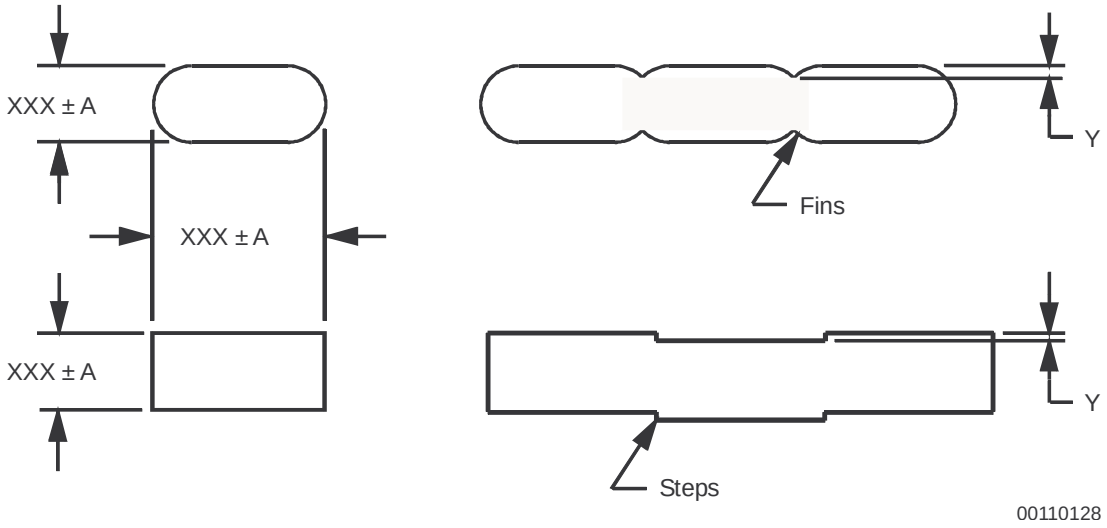

Figure 7 Irregular Shaped Hole Tolerance

1.12 Optional construction of sheet metal parts and nonmetal parts. These instructions apply to the manufacture of galvanized sheet metal parts such as air ducts, protective covers, drip pans, etc., when the drawing specifies "optional construction."

a. Optional joint and seam construction. When the note "optional construction" is specified, manufacturing shall use one of the methods defined below and illustrated in Figure 9, to fabricate the joints and/or seams of sheet metal parts.

(1) Acme/grooved seam. Seam construction that shall be used for large OD pipe.

(2) Standing seam. Seam construction that shall be used in end or top cap applications typical of air-condition ducting.

(3) "S" slip, drive slip, and end slip. Seam construction that shall be used for duct sections. End slip specifically used in thin gauge applications.

(4) Pittsburgh seam. Seam construction that shall be used for straight-sided ducting.

(5) Lap joint (flat and curved). Seam construction that shall be used typically in drip pan construction.

b. Construction method.

(1) Riveting shall be used as the method of fastening joints or seams.

(2) Soldering shall be used as the method of sealing joints or seams when "leakproof seams" are required, as specified by the drawing note "seams shall be leakproof." Soldering may be used as a method of fastening joints or seams when specified on the drawing.

c. Plain butt or angle sheet metal joints (Figure 8) that rely only on solder for the joint strength are not acceptable. These joints are permissible, however, if the joint is brazed or welded.

Figure 8 Joints

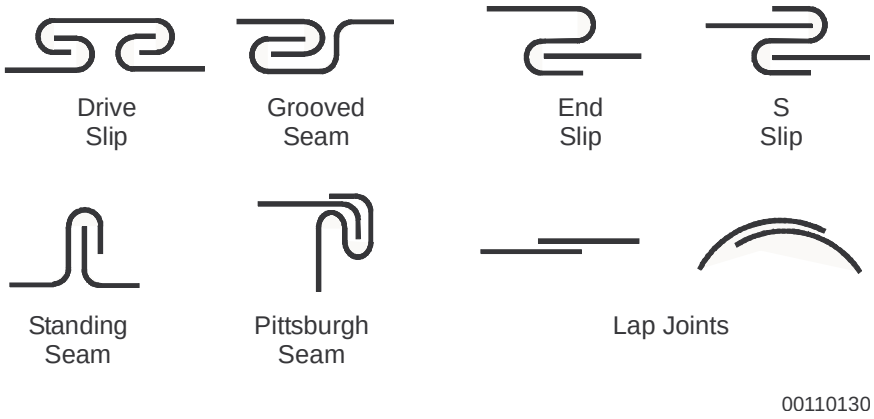

Figure 9 Acceptable Sheet Metal Joints

d. Joggle construction. Joggles at angles shall be accomplished by the following construction:

(1) Provide a saw cut the length of the materials to be joggled.

(2) Joggle that portion.

(3) Weld the remaining slot closed.

(4) Grind smooth the outside corner.

1.13 Surface finishing. The mechanical finishing of sheet metal joints (closed by welding) similar to those shown in Figure 8 shall not reduce the thickness of the adjacent material in excess of the allowance limits shown in Table III. The surface condition and appearance (forming or grinding marks, etc.) of the base metal will be governed by the final surface finish grade specified on the drawing or operation record. Paint-finished surface grades are defined in **LMS 9-1**, Painting.

Table III Allowances

ALLOWANCE FOR FINISHING	
MATERIAL THICKNESS RANGE IN INCHES	% ALLOWANCE
.000 THRU .099	20
.100 THRU .199	10
.200 & UP	7

1.14 Nibbling. At the discretion of Manufacturing, nibbling may be used in the fabrication of sheet metal parts. The Methods Department shall coordinate with the Engineering Department prior to specifying the nibbling operation to assure that there are no design considerations which may prohibit nibbling. The dimensions and tolerances specified on the engineering drawing must be maintained and shall be applied to the maximum material condition. (See Figure 10.) Maximum depth of the "scallops" or "fins" shall be in accordance with Figure 7.

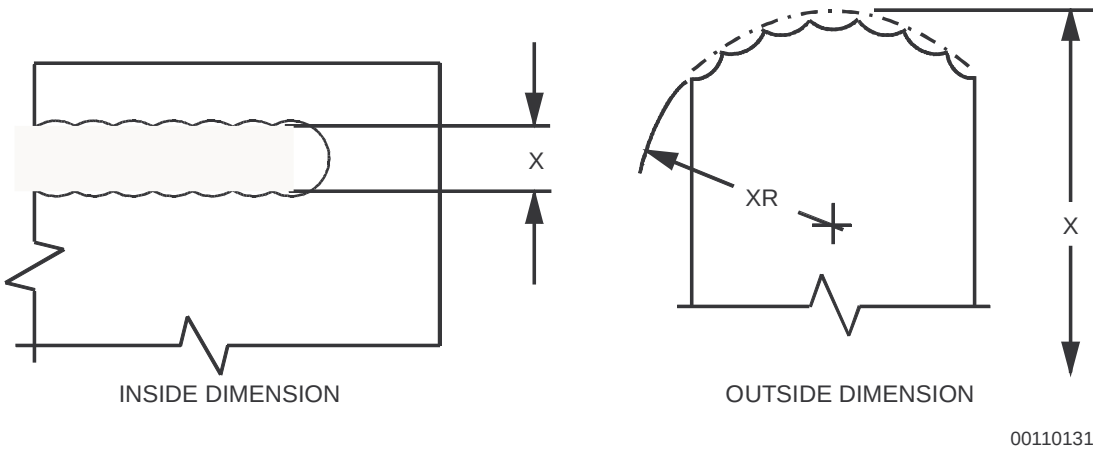

Figure 10 Nibbling

1.15 Laminated shim stock. Partial delamination of parts stamped or cut from laminated shim stock shall be permissible. Complete delamination and separation of the layers shall not be permissible.

1.16 Bend reliefs. Unless otherwise specified on the engineering drawing, bend reliefs may be used to prevent fracturing or cracking during bend formations. See **LMS 7-1** for conditions when bend reliefs may be filled with weld material.

2. Quality Assurance Requirements

2.1 The Quality Assurance Organization shall assure that the fabrication of sheet metal parts meets the requirements of this instruction.

2.2 In-process inspection of fabricated parts shall be performed as required to assure that the operations consistently produce parts conforming to the drawing and/or operation record sheet. When utilizing first-run (or revised) tooling or numerical control tapes, the first fabricated part shall be submitted to inspection to verify the integrity of that tool or NC tape prior to continuance of the operation (or subsequent operations) of that lot.

3. Preparation For Delivery (Not Applicable)