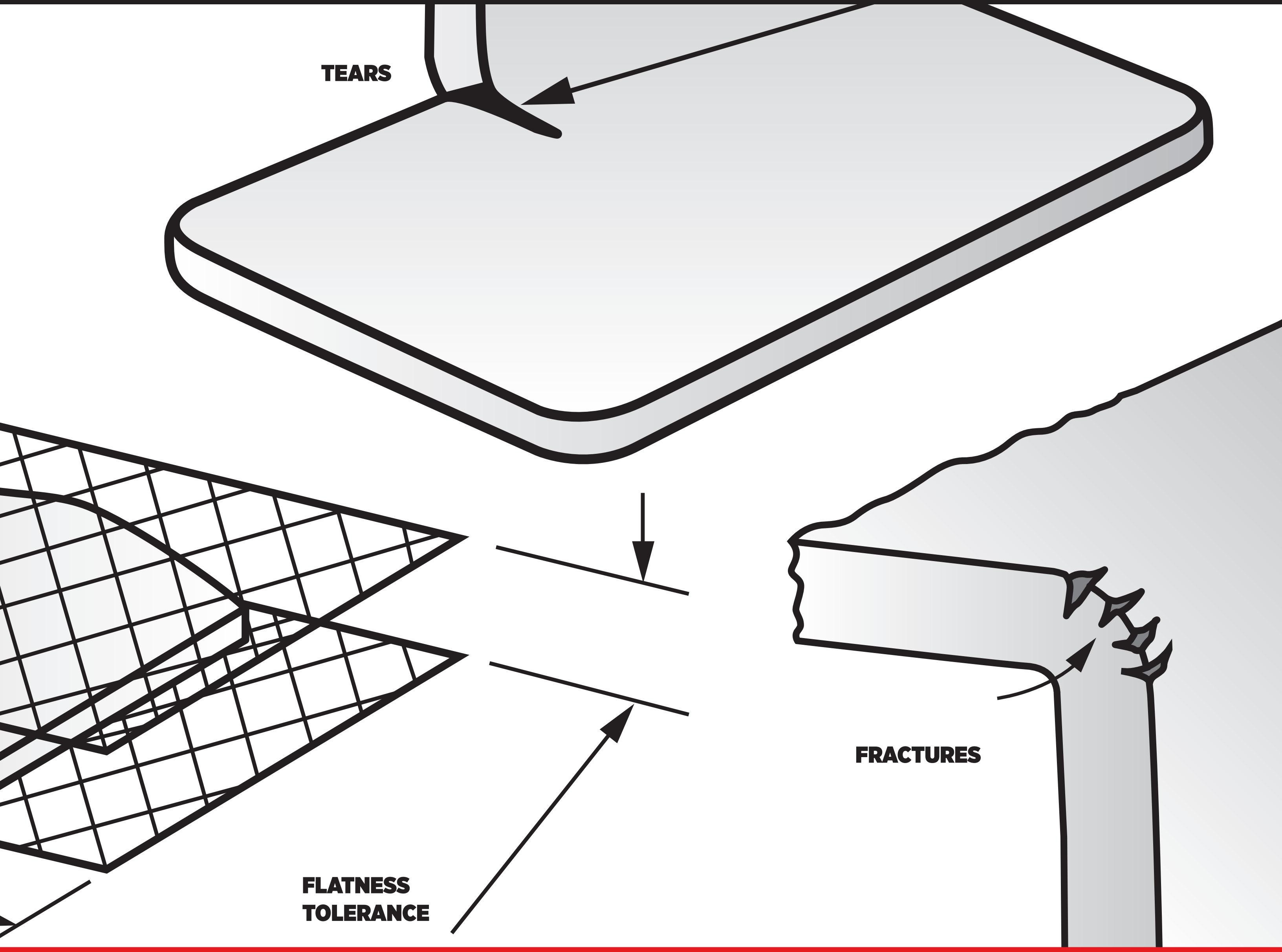
Design Guides

Metal Stampings & Fabrications



WRICO™
A Griffiths Company

Precision Stampings & Fabrications – There's a Difference!

Wrico Does It Better

A privately owned and operated business for over 30 years, Wrico is recognized nationally as the leader in Quality stampings, fabrications and superior customer service.

Adhering to an organizational perspective that focuses on exceeding customer expectations, Wrico has expanded to six full service manufacturing facilities strategically located throughout the United States. Wrico supplies high quality component parts and precision assemblies to the nation's leading OEM manufacturers in the hardware, electronics, appliance, automotive, lawn & garden, and recreational vehicle industries.

Whatever your stamping or fabrication requirements may be: large, medium, or small – Wrico can blank, pierce, punch, form, deburr, weld, stake, fasten, plate, and paint to your specifications on parts up to 48″ x 96″ and 1/2″ thick.

The contents of this booklet is intended to help you understand, design and buy metal parts more efficiently and economically. It does not contain all answers to all questions but rather basic rules of thumb Wrico has found to be important in making wise sheet metal part designs.

This design guide book is one of many special Wrico services, including seminars, plant tours, product evaluations and studies, to help you with your metal stampings & fabrications.

Wrico always welcomes your questions and comments as a means to improve its service to you, the customer.

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Over 500,000 Square Feet of Capacity

WRICO STAMPING OF MINNESOTA

WRICO STAMPING OF WISCONSIN

WRICO STAMPING OF ARIZONA

WRICO STAMPING OF NORTH CAROLINA

WRICO STAMPING OF TEXAS

WRICO STAMPING OF FLORIDA

When to Use Wrico for Metal Stamping & Fabricating

Wrico makes tooling in a fraction of the time required for permanent tooling. From the estimate to the delivery, the latest technology and equipment are utilized to meet your quality, low cost, fast turnaround production requirements.

Wrico's skilled Tool Makers and Engineers assist you in developing an appropriated part design by using CAD systems, special punches, dies, and existing fixtures from our extensive stock tool library. This process eliminates the time-consuming mounting and assembly requirements. Quality stampings and Fabrications are produced and commercially accepted tolerances are maintained – Closer tolerances can be maintained when needed.

Save Money

Wrico can save you up to 80% on the extremely low initial tooling costs compared to permanent dies. You can save additional money each time you modify the die since it can usually be altered at a fraction of the cost of the original short run tooling. Your Inventory requirements on these stampings can be kept at an absolute minimum as they can be produced and shipped to you JIT.

Our exclusive processes and technologies are designed to save the Customer money.

New Products

It's only logical to use less expensive, more quickly produced Wrico stampings & fabrications on new products. From prototype to production runs, Wrico has the capabilities to serve you better anywhere in the country.

Market-Testing Products

Both new and modified products may be produced inexpensively and quickly for all types of tests, trade fairs, sales meetings, etc. No need to commit or freeze-in to full production.

Modifying Products

New product features can be made and checked quickly with Wrico Short Run Stampings.

Pilot Runs

Standardized parts can be produced using the Wrico Short Run or Laser Fabricating with an advantage over conventional dies and production techniques and at far less cost and time requirements.

Small But Important Markets

Low volume production runs can be made profitable to you by using short run stampings, or laser fabricating and yet quality will be up to commercial standards.

Experimental Study

Product performance can be more accurately studied using actual stampings than handmade parts. Stampings & Fabrications have consistent tolerances and finish characteristics for best overall product evaluation.

Replacement Parts

Short run stampings & fabrications can “save the day” on damaged equipment when replacement parts are obsolete or out of stock.

Improve Time Schedules

When a manufacturer is short of time, Wrico short run stampings & fabrications can help. A good way to get needed parts while permanent tooling is being made. Use Wrico as a backup source to shortcut possible delays or production breakdowns.

Substitute to Your Own Production

Wrico can be a better answer than setting up your own production. Setup & tooling costs are low. Deliveries fast. You may even cut your own personnel and inventory requirements.

Design Guides

The basic design of a particular stamping is important to its cost. The savings in time and money on a stamping depends on many factors relating to materials, quantities, tolerances and its overall general design.

To make your stampings as functional, efficient and economical as possible, the following guidelines are recommended.

01. Blanking Operation

Blanking of parts, by punch press operations, necessitates a punch and die combination, conforming to the part periphery. This operation requires clearance between the punch and die. **(See Illustration 1)**

This clearance causes the punch to "cut" through a portion of the material, and "break" through the balance of the material thickness. **(See Illustration 2)**

The punch as it enters the material, actually begins to "form" the surface of the material, prior to cutting. This "form" is referred to as pull-down. **(See Illustration 2)**

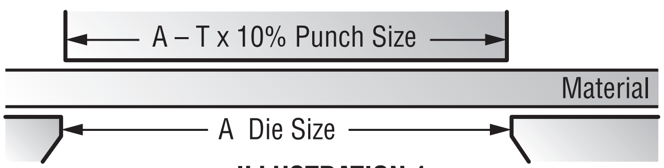

ILLUSTRATION 1

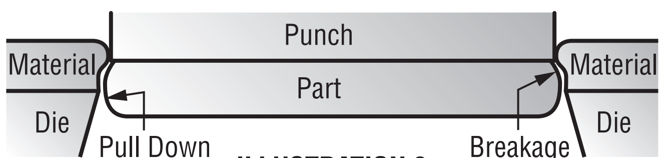

ILLUSTRATION 2

02. Pull-Down

The amount of pull-down is affected by three principal factors:

a) Temper of material. The softer the material, the greater the amount of pull-down.

b) Structure of material. Longer grained materials (i.e. Copper, Stainless Steel, etc.) will tend to flow, and will have a greater amount of pull-down.

c) Thickness. Thicker materials pull down considerably more than thinner materials.

03. Breakage

The amount of breakage occurring is affected by two principal factors:

a) Temper of material. As hardness increases (either by rolling or by heat treating) the amount of breakage increases.

b) Structure of material. Short grained materials (i.e. Aluminum, high carbon steels, etc.) will have a greater percentage of breakage.

04. Blank Design - Minimum Blank Sections

Minimum practical section “W” should never be less than 1-1/2 to 2 times material thickness in width and never less than 1/32″. Length of min. section should not be greater than 5 times width of section **(See Illustration 3)**

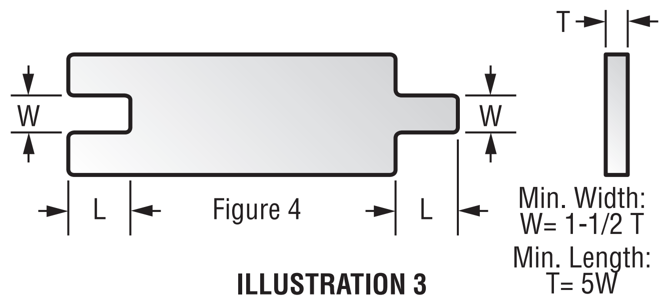

ILLUSTRATION 3

05. Corners

Corner radii should be a minimum of one half of the material thickness. Corners can be sharp, if the material thickness is 1/16″ or less. **(See Illustration 4)**

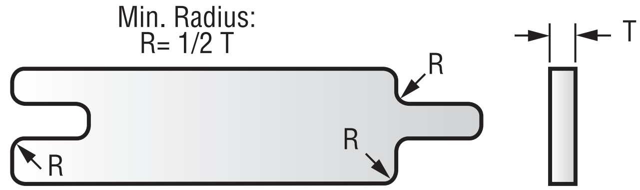

ILLUSTRATION 4

06. Notches

Should a notch require close size and/or location tolerances, give an option on the corner radii. **(See Illustration 5)** If included in the blank, maximum radius would be used. If included in a separate operation, a sharp corner would be required.

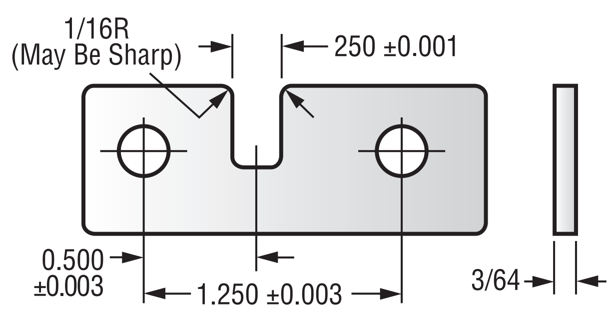

ILLUSTRATION 5

07. Specifying Cutoffs

Once the material blank has been sheared to correct width, there are several correct cutoffs to specify for economical stampings. **(See Illustration 6)**

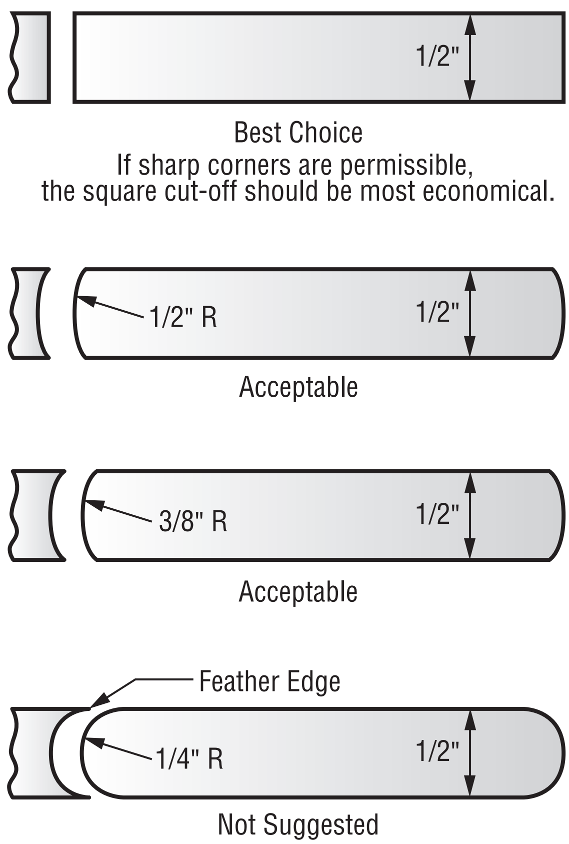

ILLUSTRATION 6

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08. Specifying Holes – Minimum Diameters

For general economy, remember this rule of thumb: hole diameter should be equal to or greater than the stock thickness. Holes less than stock thickness may be punched in soft aluminum or other soft materials, with the recommended minimum diameter increasing in direct ratio to the shear strength. Stainless steel usually requires a diameter equal to two times stock thickness. If the hole diameter is less than material thickness, (or less than 0.050 dia.) it must be drilled and the burr removed at added cost.

09. Hole Tolerance

Unless specified, tolerances shown on hole diameters are considered to apply to the punch side only. **(See Illustration 7)**

Breakage occurs in all punched holes. **(See Illustration 8)** This is due to the clearance between the punch and die. Breakage occurs with all materials and varies by material characteristics.

Smoothly finished holes add cost. Should they be required, the hole can be punched smaller than required, then reamed to its finished diameter. **(See Illustration 8)**

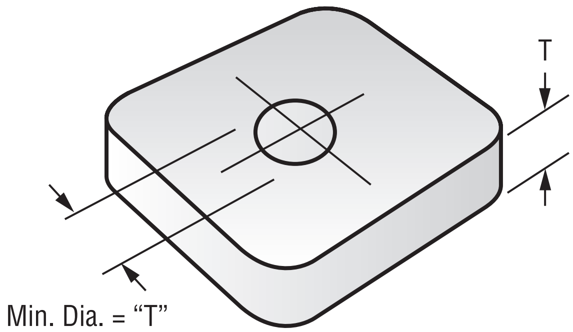


ILLUSTRATION 7

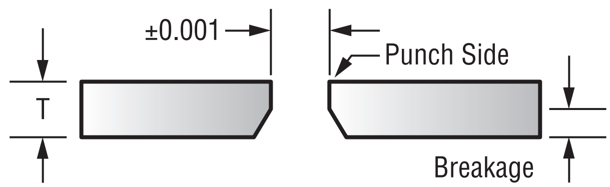


ILLUSTRATION 8

10. Specify Holes and Other Openings Near Blank Edge

The hole can be punched without causing a bulge if the web is a minimum of 1-1/2 the stock thickness. **(See Illustration 9)**

A bulge in the blank will result anytime the web is less than 1-1/2 times the stock thickness. **(See Illustration 10)**

Bulge conditions increase progressively as the web decreases, until there would be a complete break-through. The bulge is hardly visible until the web is reduced to less than 1/2 the stock thickness. These examples would also apply to a web between holes.

If some bulge is not permitted, a drilling and deburring operation may be necessary. This will add to your stamping costs. **(See Illustration 11)**

As a suggestion, if the web is too narrow, the profile of the blank could be changed by adding an ear of sufficient dimensions and shape to eliminate the problem.

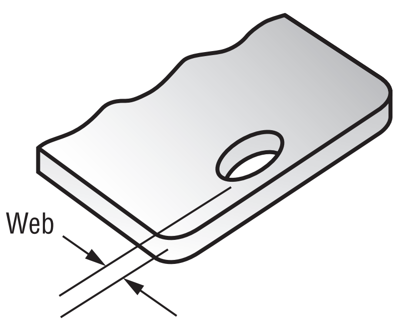


ILLUSTRATION 9

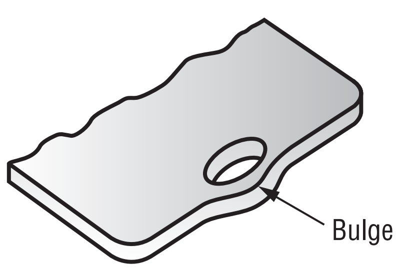


ILLUSTRATION 10

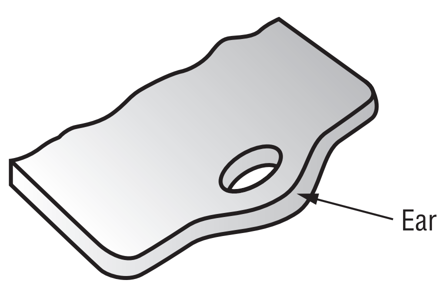


ILLUSTRATION 11

11. Notches May Be Hole Substitute

Another suggestion would be to change the contour of the blank to include the hole as a notch that could be punched **(See Illustration 12)** or the notch can be made wide enough so it could be included in the blank without a punching or notching operation.

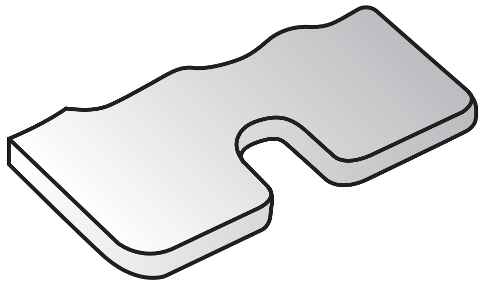


ILLUSTRATION 12

12. Specifying Holes and Openings Near Bends

The minimum inside distance required from the edge of a hole to a bend is 1-1/2 times the material thickness plus the bend radius. **(See Illustration 13)**

Distortion will result when punching the hole at a location less than the minimum distance required. If distortion is not acceptable, the hole must be punched after forming, in a separate operation. This will increase your stamping costs.

For economical stamping production, the following guidelines should be considered.

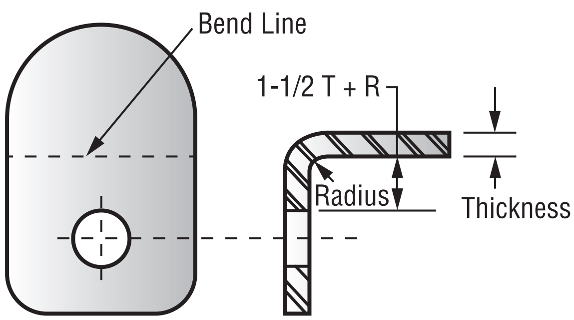


ILLUSTRATION 13

13. Minimum Requirements

When “L” is up to 1″, “H” = 2T + R
When “L” is 1″ to 2″, “H” = 2-1/2T + R
When “L” is 2″ or more, “H” = 3T to 3-1/2T + R

The function of these holes or openings should determine the degree of simplicity or complexity of tooling and operation. Be sure you give complete information for the most economical price.

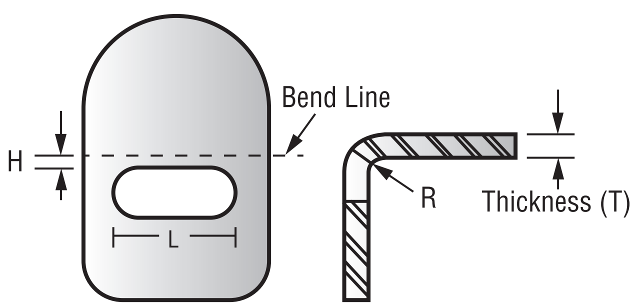


ILLUSTRATION 14

14. Specifying Internal Tabs

Careful analysis of your tab needs can hold your stamping costs down. A slot can be punched around the entire tab to permit bend relief. However, this requires an additional operation. If other punched openings are required, this relief slot can be punched at the same time. **(See Illustration 15)**

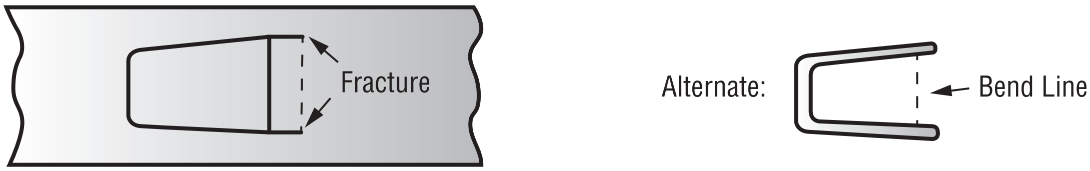


ILLUSTRATION 15

15. Specifying Bends

It is necessary to take special care in designing bends in your stamping to avoid material tearing. To avoid this, design the blank profile to allow offset relief where possible. If the part is under stress, this tear will likely cause fatigue failure. Stock tooling cannot be adapted because the flat area adjacent to the form must be held in position during forming. This will increase your stamping expense. **(See Illustration 16)**

A similar case exists in **Illustration 17**. The form is just outside the blank profile. The tear itself runs into the center of the required bend radius.

Solution to the tear is illustrated **(18 and 19)** by changing the blank profile which provides relief for the bend. This eliminates fatigue under stress and it is then possible to use Stock 90 degree punches and dies. The result is higher quality and a lower tool/engineering price.

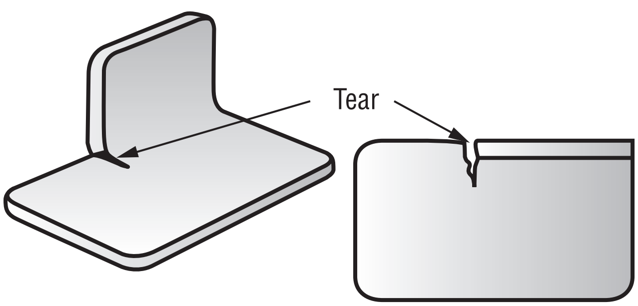


ILLUSTRATION 16

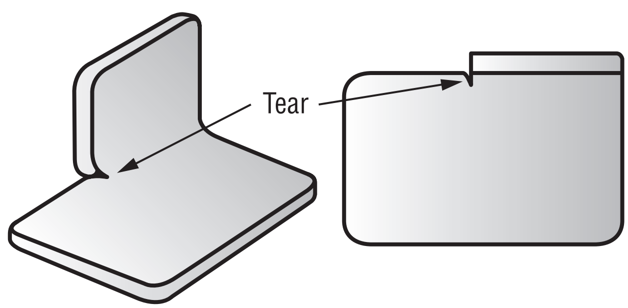


ILLUSTRATION 17

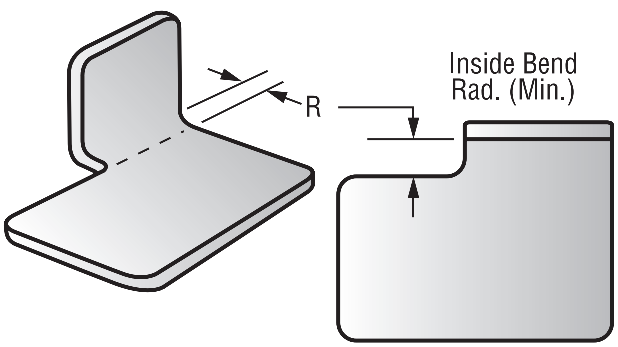


ILLUSTRATION 18

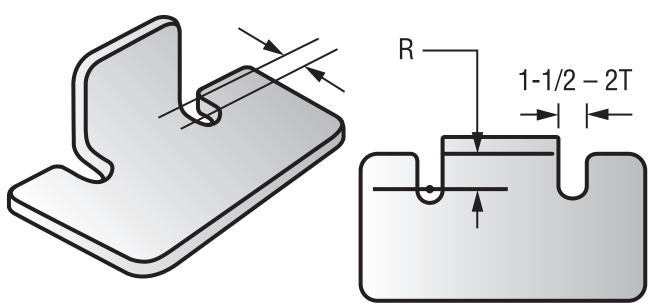


ILLUSTRATION 19

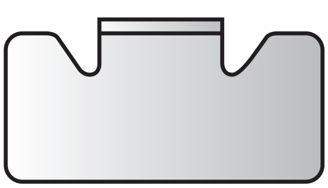


ILLUSTRATION 20

*Relief notch width in the above illustrations should be at least 1-1/2 to 2 times the material thickness. If designed as the relief in **Illustration 19**, they can be included in the blanking operation at very little or no extra cost for tools.*

15. Specifying Bends (continued)

Problem forming is shown in **Illustration 21**. A 90 degree bend is made with insufficient material height to form right.

Therefore, sufficient material must be added so the form is high enough (H) and then trimmed. This is an extra operation which means added stamping costs.

A good rule of thumb to follow **(See Illustration 22)** in allowing material for bends-determine the inside height "H" which in this case equals 2-1/2 times the material thickness (T) plus the required bend radius (R) for economical tooling and production.

This guideline is reproduced in chart form below. These recommended minimum formed height dimensions are approximate. They cover most variables of design, size, material types, tempers and thicknesses and still permit the most economical tooling and production. Easily formed materials such as Aluminum, Brass,Copper and Mild Steel may be formed with approximately 20% lower minimum inside formed height.

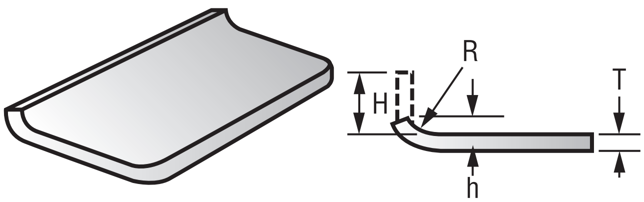


ILLUSTRATION 21

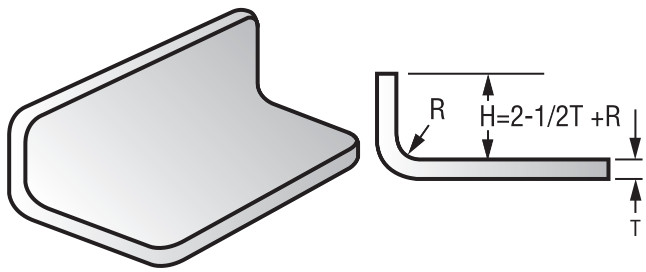


ILLUSTRATION 22

Minimum Inside Height of Form "H"					
"T" Stock Thickness	Inside Bend Radius				
	Sharp "R"	1/32 "R"	1/16 "R"	3/32 "R"	1/8 "R"
1/32	5/64	7/64	9/64	11/64	13/64
1/16	5/32	3/16	7/32	1/4	9/32
3/32	15/64	17/64	19/64	21/64	23/64
1/8	5/16	11/32	3/8	13/32	7/16
5/32	25/64	27/64	29/64	31/64	33/64
3/16	15/32	1/2	17/32	9/16	19/32

16. Bending

A distorted condition that occurs in forming is shown in **Illustrations 23 and 24**. It is a particularly noticeable distortion when heavy material is bent with a sharp inside bend radius. It is hardly noticeable on material thicknesses less than 1/16" or when the inside forming radius is large in comparison to the material thickness.

Material on the inside of the bend is under compression which results in this bulge condition on the edges. The edges on the outside of the bend are under tension and tend to pull in.

Such a bulge or distorted condition is usually of no concern and is accepted as standard practice. But, if this bulging will cause any interference with a mating part, then this should be referred to on the print so a secondary operation can be considered to remove the interference. This extra operation will add to the cost of the stamping.

16. Bending (continued)

If width dimension (W) must be held across the form, indicate this condition by showing relief notches. **(See Illustration 24)**

The enlarged section in **Illustration 25** indicates a fracture condition that occurs when the burr side of the blank is on the outside of the bend. This would be particularly noticeable when heavy material is formed with a sharp inside bend radius. It is hardly noticeable on material thicknesses of less than 1/16" or when the inside forming radius is large enough in comparison to the material thickness, type and temper.

This fracture condition occurs because the burr side of the blank on the outside of the bend is under tension, and causes the minute fracture on the sharp edge to open up and in extreme cases, become visible.

A blank is usually produced so the burr side will be on the inside of the bend which is under compression like the lower form. However, when print requirements prevent this, or when a bend is in an opposite direction, like the upper form, fractures may occur.

Tumbling or deburring before forming can minimize the fracture in most cases. On extra heavy material with a very sharp inside bend radius, or on materials difficult to form, such as SAE 4130, tumbling well before forming may not be adequate and it may be necessary to hand file, or disc sand a radius on the sharp edges. Such secondary operations will add to the cost of production to varying degrees.

Therefore, for the most economical production, where the design will permit, designate ample inside bend radii when the burr side of the blank must be on the outside of the bend.

When slight fractures are permissible, the print should be so marked.

Any tempered aluminum alloys necessitate much larger bend radii than steel alloys do.

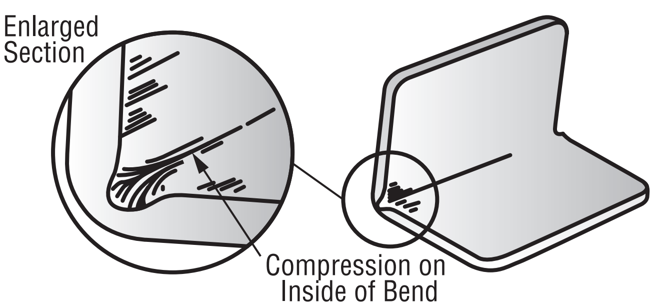


ILLUSTRATION 23

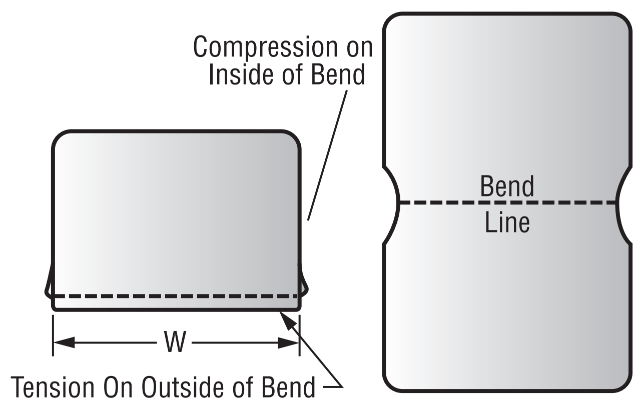


ILLUSTRATION 24

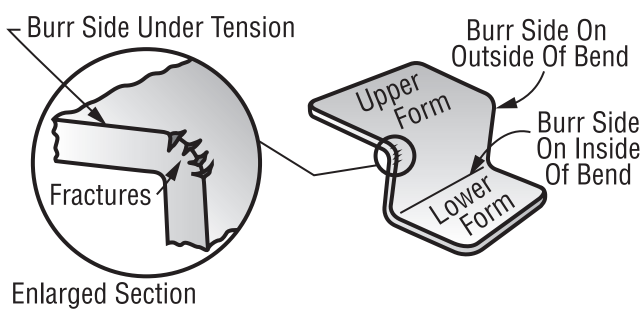
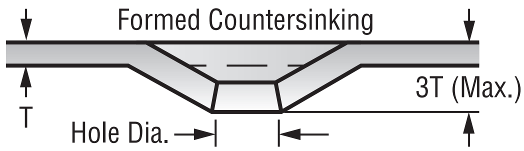


ILLUSTRATION 25

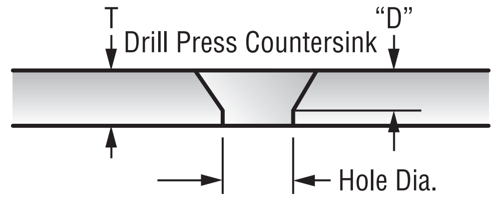
17. Specifying Countersinking

There are two types of countersinking shown above. **(See Illustration 26 and 27)** Method specified is governed by the particular application. Formed countersinking is the stronger of the two methods and usually the most economical.



Edge of hole is formed to shape of screw heads, results in raised portion on reverse side. Specify countersink dia., angle and minimum hole dia.

ILLUSTRATION 26



"D" (max.) = T – 0.005 in all cases. Hole dia. on thinner materials may have to be increased beyond clearance hole sizes.

ILLUSTRATION 27

18. Spot Weld Tips

When welding a flange to the main body of the part, the minimum width of the flange should be 1/2" in order to secure a good weld. Flanges of less than 1/2" require special tips and do not always yield the strongest weld.

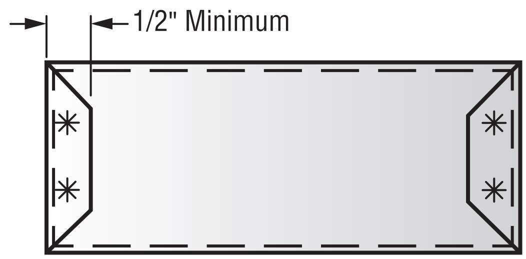


ILLUSTRATION 28

19. Dimensioning

Whenever dimensioning to a form the dimensions should be given to the inside of the material whenever possible. This precludes the variation in material thickness affecting the dimension and robbing the manufacturer of tolerance. This is especially true on a drawn part where you also have some thinning of the material.

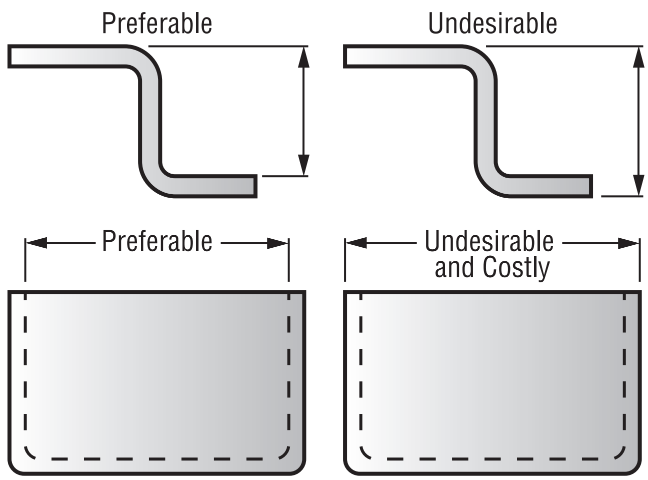
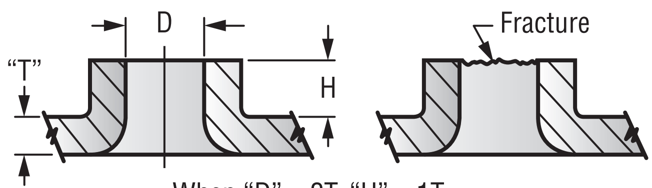


ILLUSTRATION 29

20. Extrusions

The function of an extrusion is to increase the material thickness to achieve more bearing surface or more threads in case of tapping. Maximum height to be expected is usually 1 material thickness. Anything over 1 material thickness will generally show a fracture or tearing condition, increasing in severity proportional to height increase. Decreasing "D" in Illustration will decrease "H" to about "1/2 T" in most cases.



When "D" > 2T, "H" = 1T
When "D" <2T, "H" decreases rapidly to 1/2T

ILLUSTRATION 30

21. Embossed Stampings

* Reduce to 2T for commercial grades of steel, one-quarter hard tempers, and alloys of aluminum.

**Reduce to 0.5 (R1 + R2) for commercial grades of steel, one-quarter hard tempers, and most alloys of aluminum.

Exceeding the maximum depth limits of embossed stamping for various metals increases rejects and stamping cost.

(The Precision Metal forming Association published portions of the above guidelines.)

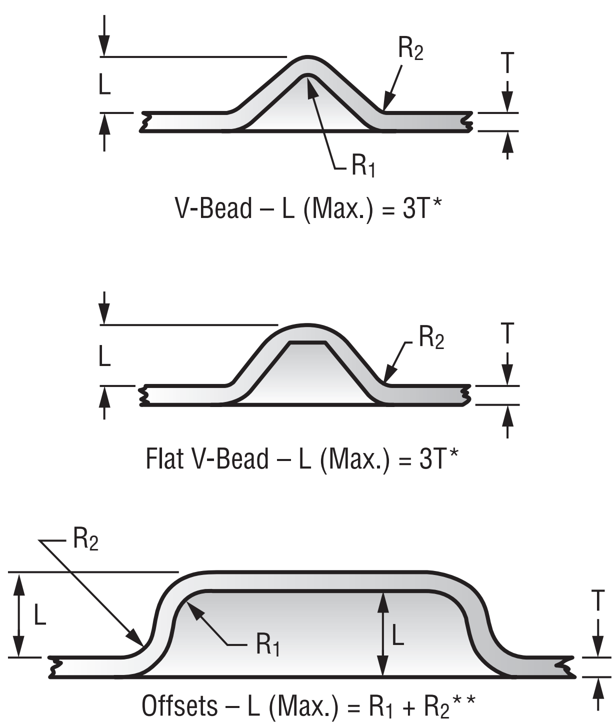


ILLUSTRATION 31

22. Burr Removal

All metal stampings have varying degrees of burrs on the stamped edges. They are ragged, sometimes sharp edges of the stamped part. The usual rule of thumb to follow on burrs is to allow for 10 percent of the stock. Wrico normally includes tumbling or sanding on all parts when requested and whenever practical to do so. Special edge treatments are available at additional cost.

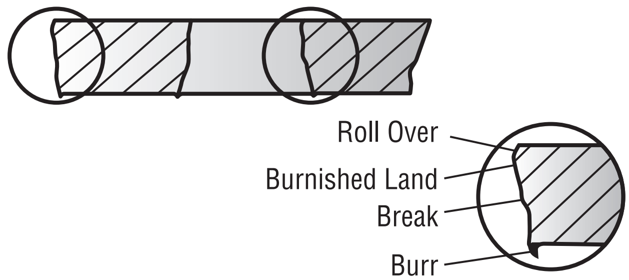


ILLUSTRATION 32

23. Flatness

No stamping has perfectly flat surfaces. Flatness requirements beyond the tolerances that follow will increase the cost of your stampings.

If the surface length is from 0″ to 1″, allow ±0.005″ tolerance. Over 4″, allow 0.020″ plus 0.004″ for each inch of additional length.

Special flattening operations to better these tolerances are available at additional cost if so requested.

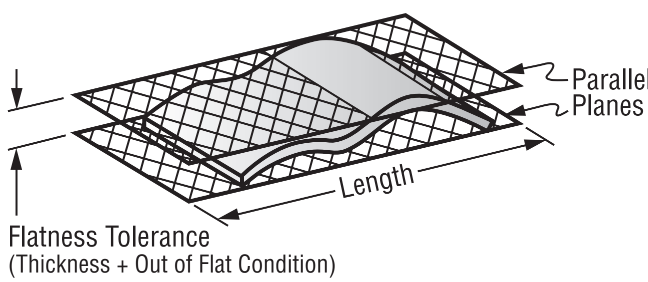


ILLUSTRATION 33

24. Surface Finish On Stamped Parts

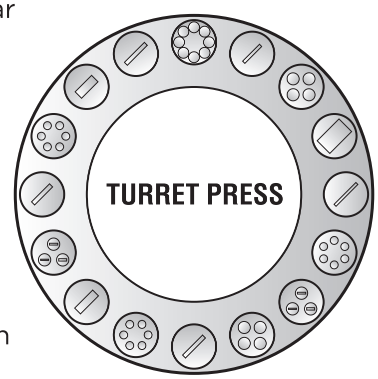
Dull, Semi Luster, Bright

The rule of thumb to follow here is the brighter the finished stamping, the higher the cost.

Raw metal stock varies in finish. Usually the finer (brighter) the finish, the higher its basic price is.

The stamping process may alter the metal finish greatly. So it is important to determine minimum finish requirements of the stamped part in order to maximize savings.

25. Turret Press Dimensioning



Detailed part drawings should accompany your explanation of a particular punching project. Good communication with accurate drawings and descriptions will ensure a quality, cost-effective result by following these three steps:

Start with choosing a fixed starting point on the part. Properly locating this datum at the hole center is best rather than at the edge or part corner referring to these measurements:

Following this method will avoid part clamping distortion and part misalignment. A hole datum also is more accurate than an edge measurement if material taper exists. Also, it makes inspection easier with fewer tolerance reference points.

Next, just one dimension should link to the general datum or starting point. Related hole patterns should be within this dimensional pattern to ensure desired quality and part function.

And, be sure to highlight all significant dimensions by calling out critical dimensional relationships that effect part function.

26. Press Brake Dimensioning Best Practices

Formed sheet metal parts on a press brake can be challenging. That's because angular tolerances and material flatness interact with single plane dimensions due particularly to thinner gauge material flexibility. Consistent measuring practices are required by multiple operators from project to project. Following is an easy-to-follow standard:

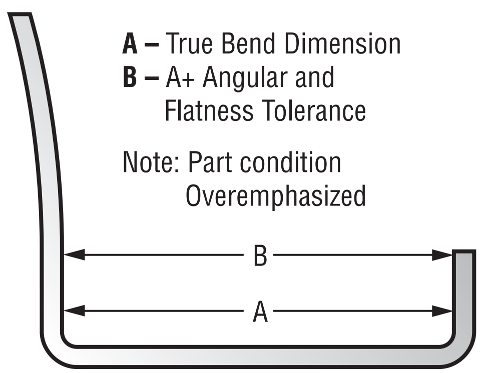


ILLUSTRATION 34

The above illustration below shows how form dimensions are properly accomplished. Always measure next to the bend radius. This prevents adding flatness and angular discrepancy.

Always dimension the part in a single direction whenever possible. This controls tolerance accumulation through the sequential operation of the forming process. Remember, dimensional variation occurs at each bend and must be accounted for in order to achieve an accurate and quality end result.

Another important consideration is clamping and/or fixturing parts according to specification. The standard above is appropriate for thin sheet metal parts when they are properly held in position through the forming process thereby controlling accumulated tolerances.

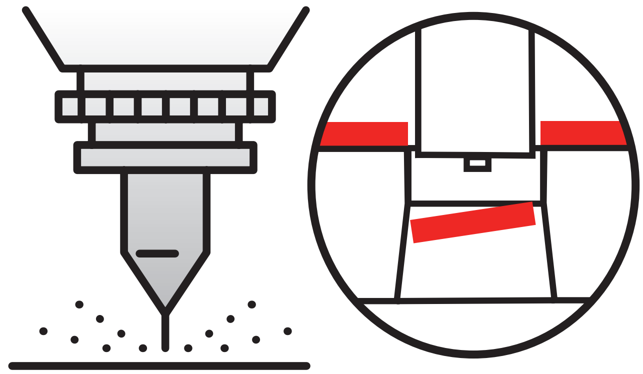
Avoid feature-to-feature dimensioning particularly in two planes. It is preferable to dimension a feature to an edge. This may require clamping fixtures and gaging. Remember that tolerances shown in a part drawing title block may be too restrictive for specified angles and dimensions while sufficiently appropriate for others.

27. Laser Cutting Combined With Turret Punching

Laser cutting has become an integral process in the fabrication of metal parts. Where limited product life cycles, shorter part runs and just-in-time manufacturing are now the norm, laser cutting systems have by design evolved to enhance these trends.

Turret presses and laser system capabilities can either be combined using stand-alone machines or with integrated laser turret press systems. Since both processes are very fast and accurate, both complex hole patterns and irregular cut profiles can be fabricated with accuracy and at high speeds.

It always necessary to evaluate a machine's capabilities so that it is suited for the project at hand particularly where punching and cutting are combined to achieve a satisfactory result.



LASER TURRET COMBO MACHINE

28. Designing Parts For Laser Processing

Through feature size minimum. Piercing and blanking limits with a punch press, including the relationship between minimum hole size and material thickness or the distance between features to avoid part distortion, are not applicable for laser cutting.

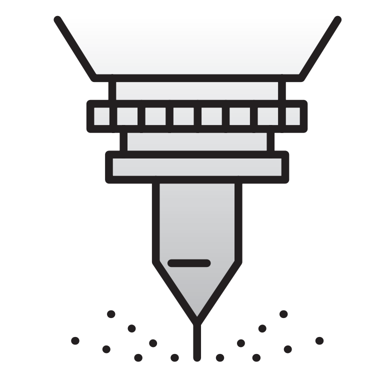
An average laser's cutting beam focuses at about 0.010 inch (0.2mm) and can cut holes and other features with a radii of about 0.030 in. (0.76 mm)

Accuracy of edge taper. The laser is most accurate where the laser beam penetrates the part. The hole size is smaller at the point of beam entry with a slightly larger diameter at the exit point. An edge condition results from the laser beam heat somewhat similar to a pierced or sheared operation which may require a secondary finishing operation. Also, knowing final use of the part is important so as to select the correct side of the part for laser cutting.

Micro tabs hold parts in the sheet during processing. This cost-saving feature allows positioning these tabs at areas where later removal is not needed. Micro tabs usually measure between 0.25mm – 5mm and require little or no force for material removal thus avoiding part distortion. Many applications apply for this useful feature including tightly spaced vents.

Metal heat affected zone. Heat generated by the laser beam melts and vaporizes the metal material which can cause problems depending on the material selected. It is important to remember that heat treated metal will become case hardened in the laser processed area. Similarly, laser cut holes in stainless steel and steel alloys that require later reaming or counter-sinking may prove difficult. Also, utilizing the laser to case-harden a part area may add needed wear resistance to the final product and its life cycle.

The part designer needs to remember that laser processed parts accumulate tolerances like all other punched, cut and bent parts. To achieve optimal quality cost effectively, it is important to emphasize and communicate what functional dimensions are most critical to the best end result.



LASER PROCESSING

MILLIMETER AND DECIMAL EQUIVALENTS

Fraction	DECIMALS	MILLIMETERS
1/64	0.015625	- 0.397
1/32	.03125	- 0.794
3/64	.046875	- 1.191
1/16	.0625	- 1.588
5/64	.078125	- 1.984
3/32	.09375	- 2.381
7/64	.109375	- 2.778
1/8	.1250	- 3.175
9/64	.140625	- 3.572
5/32	.15625	- 3.969
11/64	.171875	- 4.366
3/16	.1875	- 4.763
13/64	.203125	- 5.159
7/32	.21875	- 5.556
15/64	.234375	- 5.953
1/4	.2500	- 6.350
17/64	.265625	- 6.747
9/32	.28125	- 7.144
19/64	.296875	- 7.541
5/16	.3125	- 7.938
21/64	.328125	- 8.334
11/32	.34375	- 8.731
23/64	.359375	- 9.128
3/8	.3750	- 9.525
25/64	.390625	- 9.922
13/32	.40625	- 10.319
27/64	.421875	- 10.716
7/16	.4375	- 11.113
29/64	.453125	- 11.509
15/32	.46875	- 11.906
31/64	.484375	- 12.303
1/2	.5	- 12.700

Fraction	DECIMALS	MILLIMETERS
33/64	0.51625	- 13.09
17/32	.53125	- 13.494
35/64	.546875	- 13.891
9/16	.5625	- 14.288
37/64	.578125	- 14.684
19/32	.59375	- 15.081
39/64	.609375	- 15.478
5/8	.6250	- 15.875
41/64	.640625	- 16.272
21/32	.65625	- 16.669
43/64	.671875	- 17.066
11/16	.6875	- 17.463
45/64	.703125	- 17.859
23/32	.71875	- 18.256
47/64	.734375	- 18.653
3/4	.7500	- 19.050
49/64	.765625	- 19.447
25/32	.78125	- 19.844
51/64	.796875	- 20.241
13/16	.8125	- 20.638
53/64	.828125	- 21.034
27/32	.84375	- 21.431
55/64	.859375	- 21.828
7/8	.8750	- 22.225
57/64	.890625	- 22.622
29/32	.90625	- 23.019
59/64	.921875	- 23.416
15/16	.9375	- 23.813
61/64	.953125	- 24.209
31/32	.96875	- 24.606
63/64	.984375	- 25.003
1	1.000	- 25.400

MM	INCHES	MM	INCHES
.1 -	.0039	46 -	1.8110
.2 -	.0079	47 -	1.8504
.3 -	.0118	48 -	1.8898
.4 -	.0157	49 -	1.9291
.5 -	.0197	50 -	1.9685
.6 -	.0236	51 -	2.0079
.7 -	.0276	52 -	2.0472
.8 -	.0315	53 -	2.0866
.9 -	.0354	54 -	2.1260
1 -	.0394	55 -	2.1654
2 -	.0787	56 -	2.2047
3 -	.1181	57 -	2.2441
4 -	.1575	58 -	2.2835
5 -	.1969	59 -	2.3228
6 -	.2362	60 -	2.3622
7 -	.2756	61 -	2.4016
8 -	.3150	62 -	2.4409
9 -	.3543	63 -	2.4803
10 -	.3937	64 -	2.5197
11 -	.4331	65 -	2.5591
12 -	.4724	66 -	2.5984
13 -	.5118	67 -	2.6378
14 -	.5512	68 -	2.6772
15 -	.5906	69 -	2.7165
16 -	.6299	70 -	2.7559
17 -	.6693	71 -	2.7953
18 -	.7087	72 -	2.8346
19 -	.7480	73 -	2.8740
20 -	.7874	74 -	2.9134
21 -	.8268	75 -	2.9528
22 -	.8661	76 -	2.9921
23 -	.9055	77 -	3.0315
24 -	.9449	78 -	3.0709
25 -	.9843	79 -	3.1102
26 -	1.0236	80 -	3.1496
27 -	1.0630	81 -	3.1890
28 -	1.1024	82 -	3.2283
29 -	1.1417	83 -	3.2677
30 -	1.1811	84 -	3.3071
31 -	1.2205	85 -	3.3465
32 -	1.2598	86 -	3.3858
33 -	1.2992	87 -	3.4252
34 -	1.3386	88 -	3.4646
35 -	1.3780	89 -	3.5039
36 -	1.4173	90 -	3.5433
37 -	1.4567	91 -	3.5827
38 -	1.4961	92 -	3.6220
39 -	1.5354	93 -	3.6614
40 -	1.5748	94 -	3.7008
41 -	1.6142	95 -	3.7402
42 -	1.6535	96 -	3.7795
43 -	1.6929	97 -	3.8189
44 -	1.7323	98 -	3.8583
45 -	1.7717	99 -	3.8976
		100 -	3.9370

Metric Dimension ÷ 25.4 = Decimal Equivalent | .001" = .0254 MM | 1MM = .03937"

NOTES

NOTES

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