Federal Tool & Engineering, LLC

Introduction

To

Metal Stamping and Fabrication

Introduction to Metal Stamping and Fabrication

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Introduction to Metal Stamping and Fabrication

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Program Objectives

This introduction to Metal Stamping and Fabrication is intended to provide the user with a base knowledge in the following areas:

- Blanking, Cutting, Piercing, and Forming
- Assembly and Finishing
- Material Selection

Equipment Overview:
Blanking, Cutting Piercing, and Forming

- Shear
- Laser
- Turret Press
- Punch Press
- Press Brake
- Multi-Slide

Shear

Used Primarily to "Right Size" a sheet of metal for additional processing in CNC Lasers, Turret Presses, Punch Presses, and Press Brakes

CNC Laser

Industrial cutting lasers offer flexible "no tool cost" production of complex shapes. Extremely effective in low volume rapid turnaround applications.

CNC Turret Press

CNC Turret (Punch) Presses utilize standard tools to offer "low tool cost" start-up and production of low to medium volume parts. This manufacturing method will accommodate a wide range of parts. It not only punches out shapes, but will also perform minor forming.

Mechanical Stamping Press

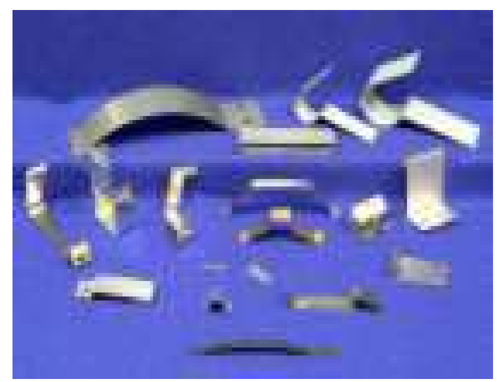
Mechanical stamping presses require medium to high cost tooling. Primarily used for medium to high extended life production where the per unit piece cost must be minimized.

CNC Press Brake

The CNC Press Brake offers "low tool cost" forming of low to medium production volume parts. It will accommodate a wide range of thicknesses and simple to complex bends.

Slide Forming Machines

Utilizing several cams, this “low tool cost” method of part production is suited for medium to high volume light gage sheet metal and wire parts. As no carrying web is needed it typically will use less material, but has limitations on deep drawn shapes

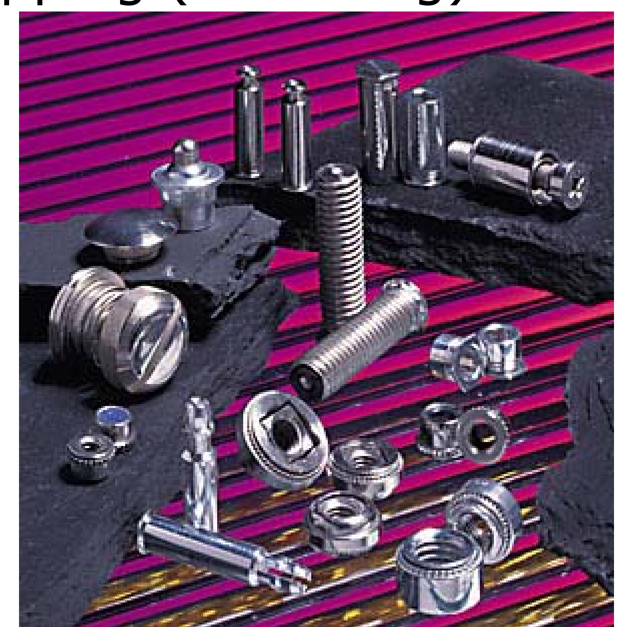


Application Matrix

	Laser	Turret Press	Punch Press	Press Brake	Multi-Slide
Lower Tool Cost					
Higher Tool Cost					
Shorter Lead Time					
Longer Lead Time					
Lower Unit Cost					
Higher Unit Cost					
Light Gage					
Medium Gage					
Heavy Gage					
Standard Burr				NA	
Less/No Burr				NA	

Hardware Insertion

Commonly known under the "PEM" name, there is almost an endless variety of inserts available. While insertion can be automated and costs kept low, the supplier should evaluate whether the insert can be eliminated through in press tapping (threading) of extruded holes.



Mechanical Bonding

Mechanical bonding provides an inexpensive yet highly reliable alternative to welding or riveting. It should be viewed as a viable option.

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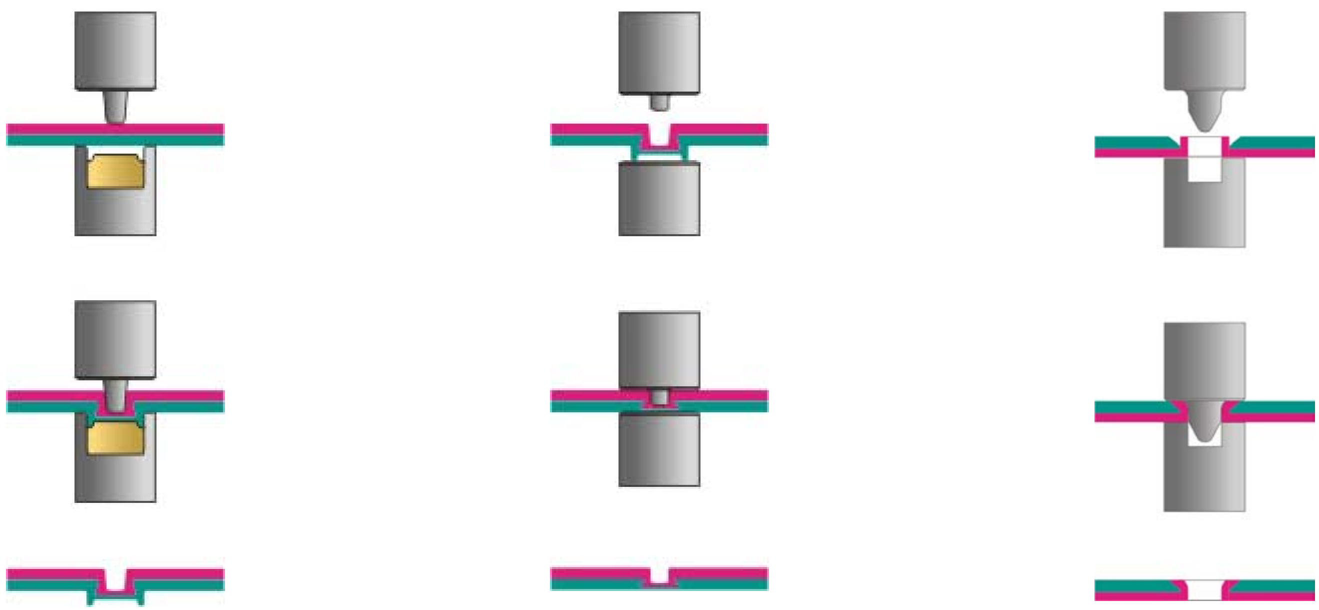

Round Joint

Flat Joint

Vario Joint II

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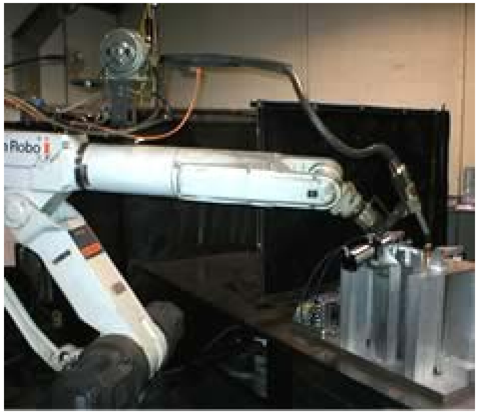
Welding

Due to the numerous approaches to welding and its multiple variables, it is always best to bring the supplier in at the beginning of the design process. Quite often weld type, size, etc. are over specified and dramatically increase cost. Additionally, part and assembly design may provide an opportunity for redesign into fewer components and/or alternate bonding methods.

Hand MIG/TIG



Robotic MIG/TIG

Hand Resistance/Spot

Drilling, Machining, and Deburring

Secondary operations can account for a large percentage of the total part cost. Question your supply base on whether operations such as deburring, chamfering, reaming, etc. can be eliminated through alternate tool design or manufacturing processes to save costs

Design Considerations

- Budget: Engineering Cost vs. Unit Cost
- Time: Start-up, Ramp-up, Life
- Volume
- Application
  - Strength and Weight
  - Corrosion Resistance
  - Cosmetics
  - Validation and Testing

Budget: Engineering Cost vs. Unit Cost

While not always the case, a good rule to design by is:

"Lower engineering costs yield higher unit costs"

Time: Start-up, Ramp-up, Life

Depending on the quantities needed, uncertainty of market acceptance, the ramp-up time to reach production volumes, etc. it may be beneficial to begin production with a different, more economical, process than that used for on-going production. Too often, programs are looked at in an "all-or-nothing" scenario. It may be prudent for the decision maker to take a tiered approach to program implementation.

Time: Start-up, Ramp-up, Life

Accurately estimating the life of the product at the design stage is critical to building the lowest cost, yet effective, tooling and process. The type of tool steels and coatings, the number of processes, the level of automation employed, the type of equipment used, etc. will have a tremendous impact on engineering and unit cost.

Volume: Life and Annual

From material sourcing to tool and process design, accurately estimating the annual and life volume of a part is critical.

<u>If volumes are underestimated the unit and tool maintenance costs will be far greater than need be</u>. The tool and process engineer will look to minimize upfront tool charges by using less robust tool steels, coatings, and may sacrifice tool complexity in favor of more operations. The savings generated through lower initial tooling and process costs will be swallowed-up quickly.

<u>If volumes are over estimated, the unit and tool maintenance may be low, however the upfront tool charges will far exceed the unit cost savings</u>. Long life high wear tool steels and coatings, much more expensive, will be utilized to ensure that the tool will hold up to the wear and tear of high volume production that never occurs. The payback on the investment will not be offset by the lower unit cost over the life of the program.

Application: Strength and Weight

Is this an application that is load bearing or where the weight of the part is an important factor?

The advent of high strength low alloy steel can result in a 20%+ reduction in weight and cost over commercial grade heavier gage steel or heat treating. In addition, adding reinforcing gussets allows for using a thinner gage material yet retaining needed strength.

Application: Corrosion Resistance

- Don’t over-specify for corrosion protection. Take time to understand the environment where the part will be used and the wide range of options for protection.
- Understand the difference between barrier and sacrificial coatings.

Lower Cost	**Higher Cost**
Pre-coated hot dipped galvanized steel	300 series stainless steel
Pre-coated electro galvanized steel	Pre-painted carbon steel
Post zinc plated carbon steel	Post anodized aluminum
Post nickel plated carbon steel	Post painted carbon steel
Post black oxide plated carbon steel	Brass
	Copper

Application: Cosmetics

- Do not over specify surface finish requirements. If the part in use is not visible, do not specify scratch free, surface critical, etc. it only adds cost and time.
- If the part is cosmetic in nature be sure to state a qualitative and quantitative metric for compliance and a method for verification.
- Address packaging requirements and methods at the design stage to ensure protection and to help in minimizing costs.

Application: Validation and Testing

While it is important that all critical call-outs are clearly stated on the print, it is equally important that there is an agreement between the customer and supplier on how the parts will be measured for dimensional and cosmetic conformance.

The review and subsequent agreement should take place early in the design/quote process. Prototyping of the parts/assemblies is encouraged to insure manufacturability and process capability.

If available (needed), the customer should supply a DFMEA to the supplier and request that the supplier provide a PFMEA. This will help to eliminate process failures and minimize future problems.

Material Overview: Carbon Steel

Type	Cost	Strength As Rolled	Strength Heat Treated	Formability	Corrosion Resistance	Availability
Carbon Steel						
1008	1	2	NA	5	1	6
1020	2	2	NA	3	1	5
10B38	2	3	5	3	1	3
1045	2	3	5	2	1	3
1080	2	4	6	1	1	2
50Yield HSLA	2	3	NA	3	1	4
70Yield HSLA	2	4	NA	3	1	4
80Yield HSLA	2	5	NA	2	1	4

1 = Low to 6 = High

Material Overview: Aluminum

Type	Cost	Strength As Rolled	Strength Heat Treated	Formability	Corrosion Resistance	Availability
Aluminum						
1100	5	1	NA	3 - 6	3	5
3003	5	1	NA	3 - 6	3	6
5052	5	1	NA	3 - 6	3	6
6061	5	1	2	2 - 5	3	5

1 = Low to 6 = High

Material Overview: Stainless Steel

Type	Cost	Strength As Rolled	Strength Heat Treated	Formability	Corrosion Resistance	Availability
Stainless Steel						
302	5	3	NA	2	6	5
304	5	3	NA	2	6	6
316	5	3	NA	2	6	5
410	4	2	NA	2	5	5
430	4	2	NA	2	5	5

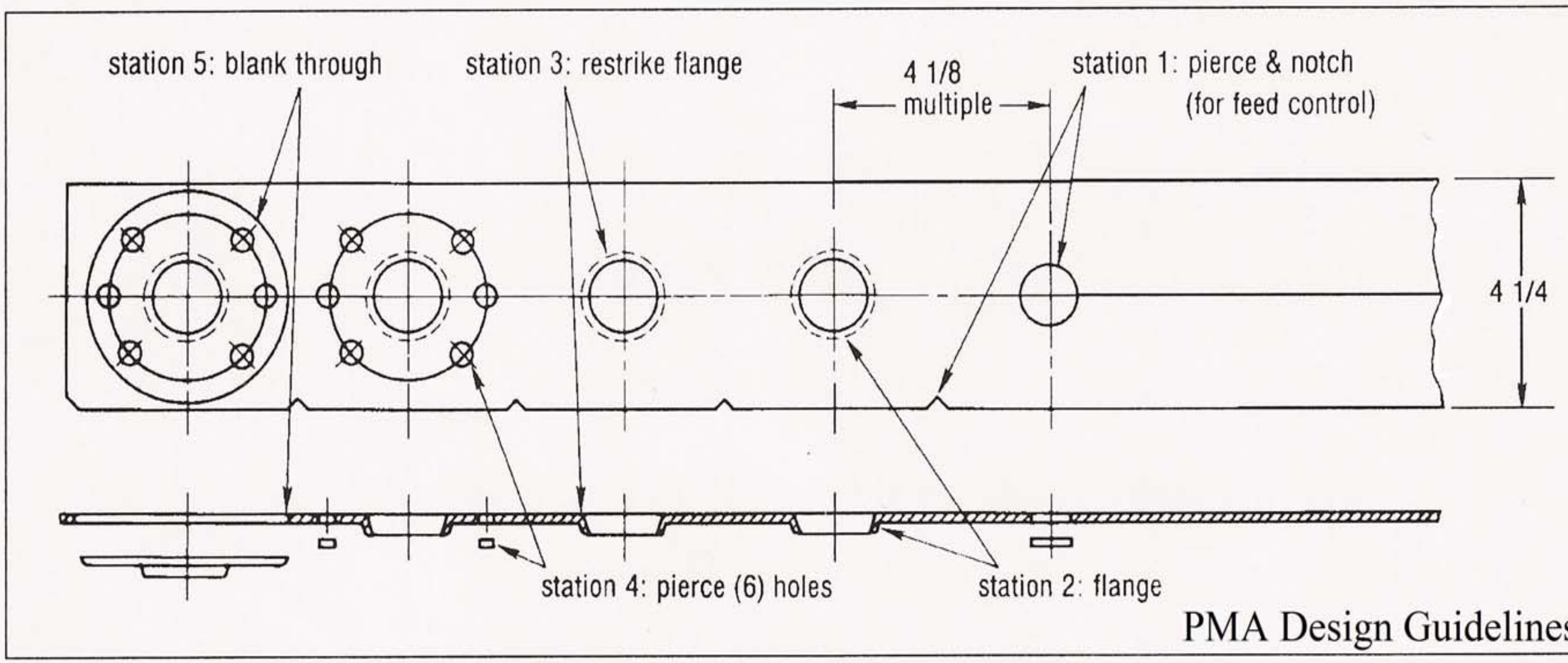
1 = Low to 6 = High

Material Overview: Brass and Copper

Type	Cost	Strength As Rolled	Strength Heat Treated	Formability	Corrosion Resistance	Availability
Brass/Copper						
260	6	1	NA	6	6	6
110	6	1	NA	6	6	6

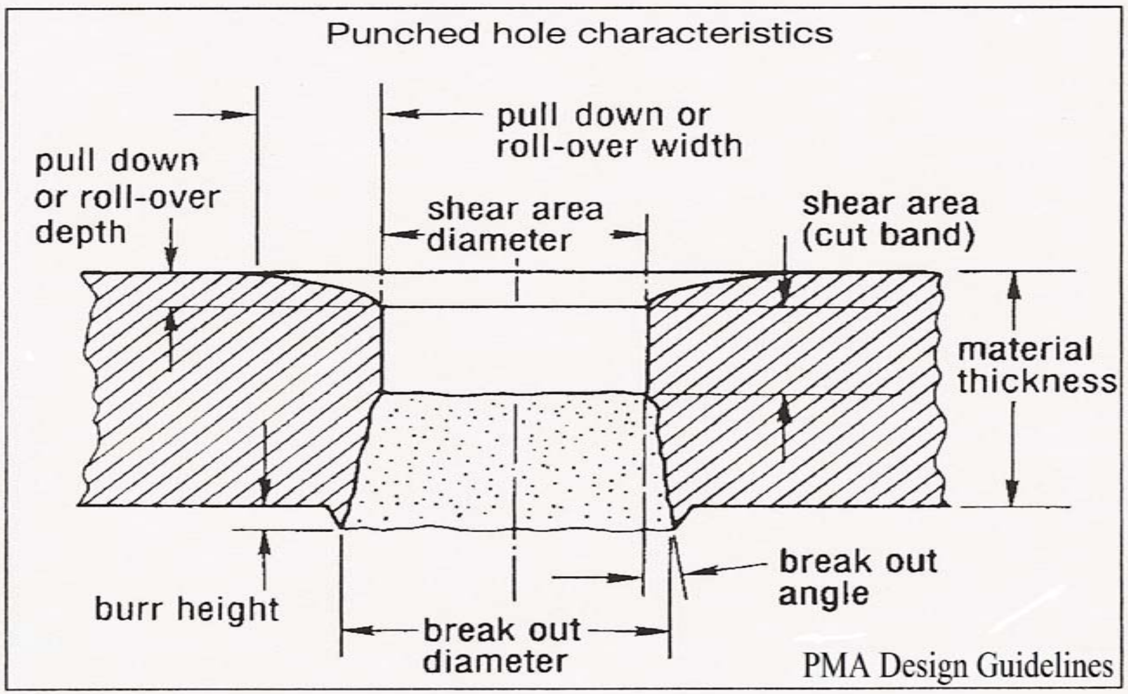
1 = Low to 6 = High

Design for Manufacturability and Lowest Cost: Stamping



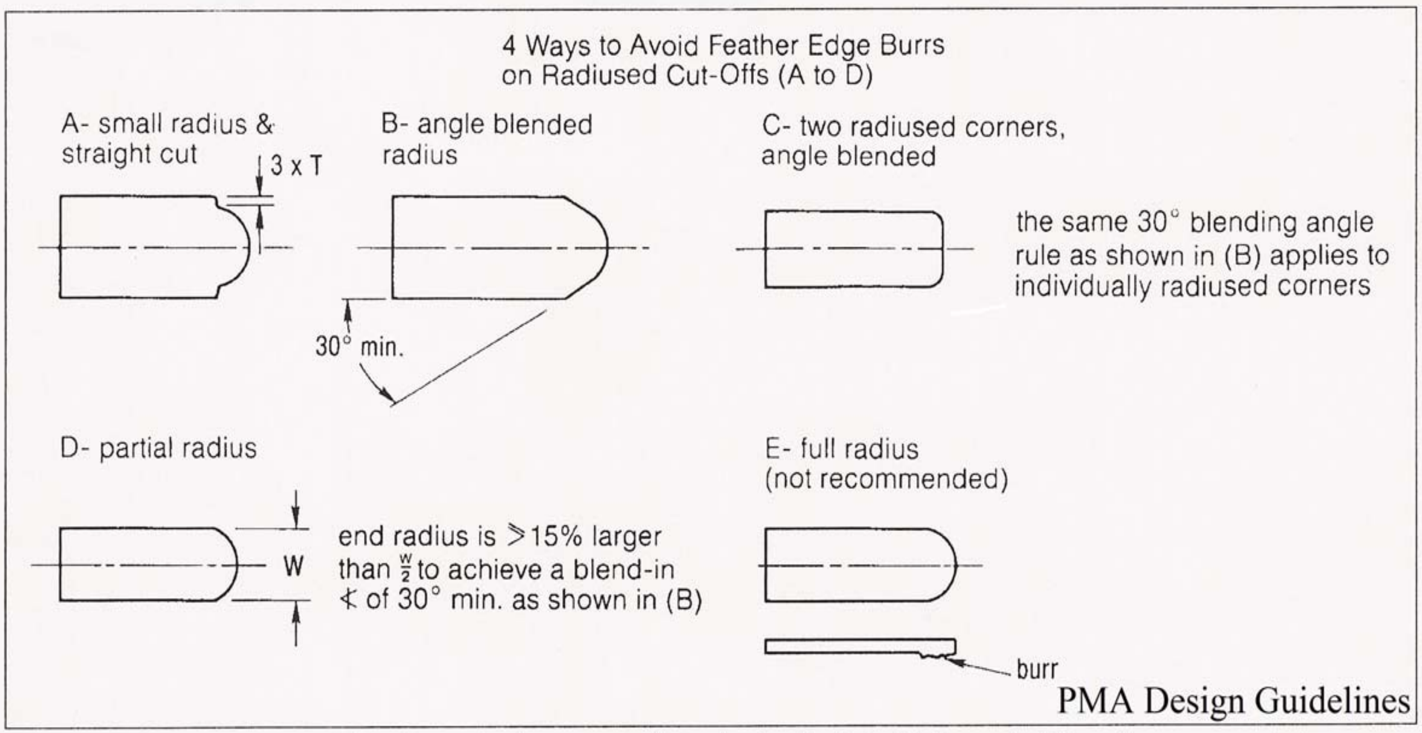
Strip development via progressive dies for a ring-shaped part.

Design for Manufacturability and Lowest Cost: Stamping



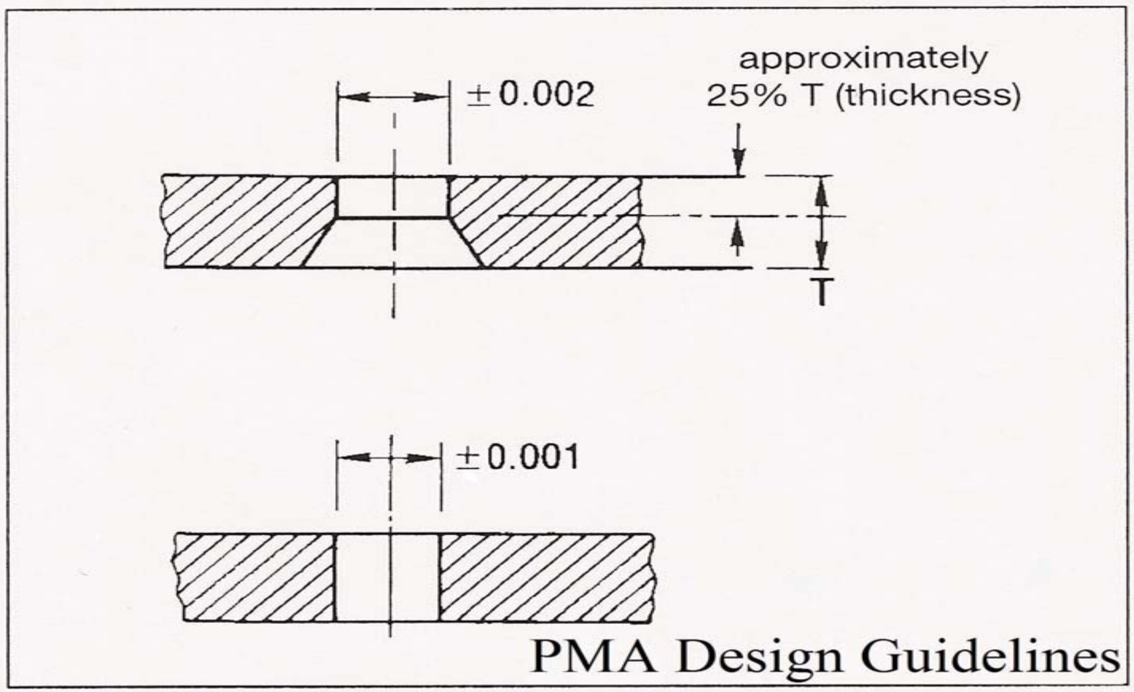
Standard terminology that refers to cutting or shearing metal with a punch and die. In practice, dimensional measurements are made at the shear area.

Design for Manufacturability and Lowest Cost: Stamping



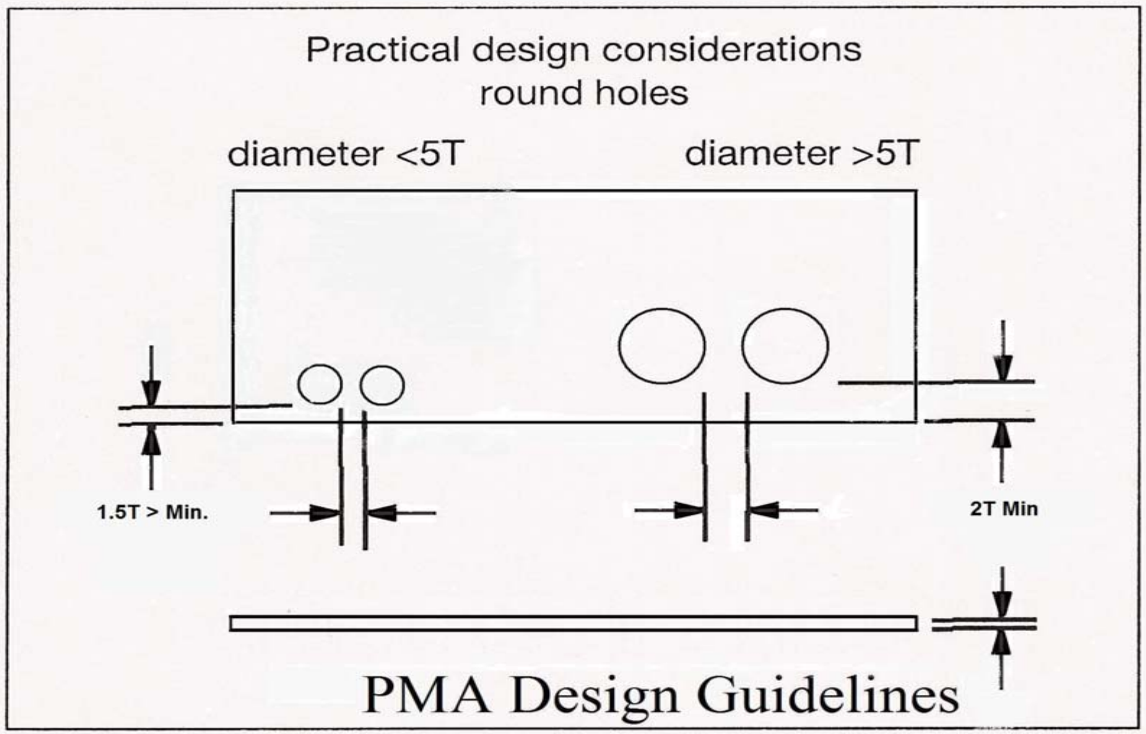
Four ways to avoid feather edge burrs on radiused cut-offs (A to D). Example E is not recommended.

Design for Manufacturability and Lowest Cost: Stamping



Reaming or shaving is required at extra cost where straight holes are necessary.

Design for Manufacturability and Lowest Cost: Stamping



Recommended minimum hole spacing (edge-to-edge) is 2 times T.

Recommended hole diameter >/= 1 times T

Design for Manufacturability and Lowest Cost: Stamping

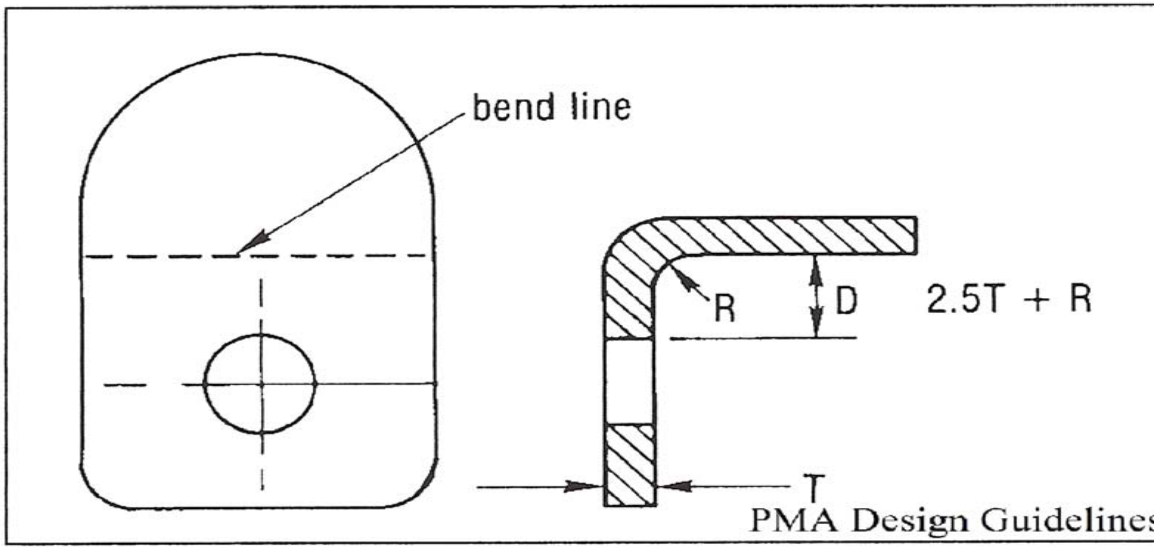
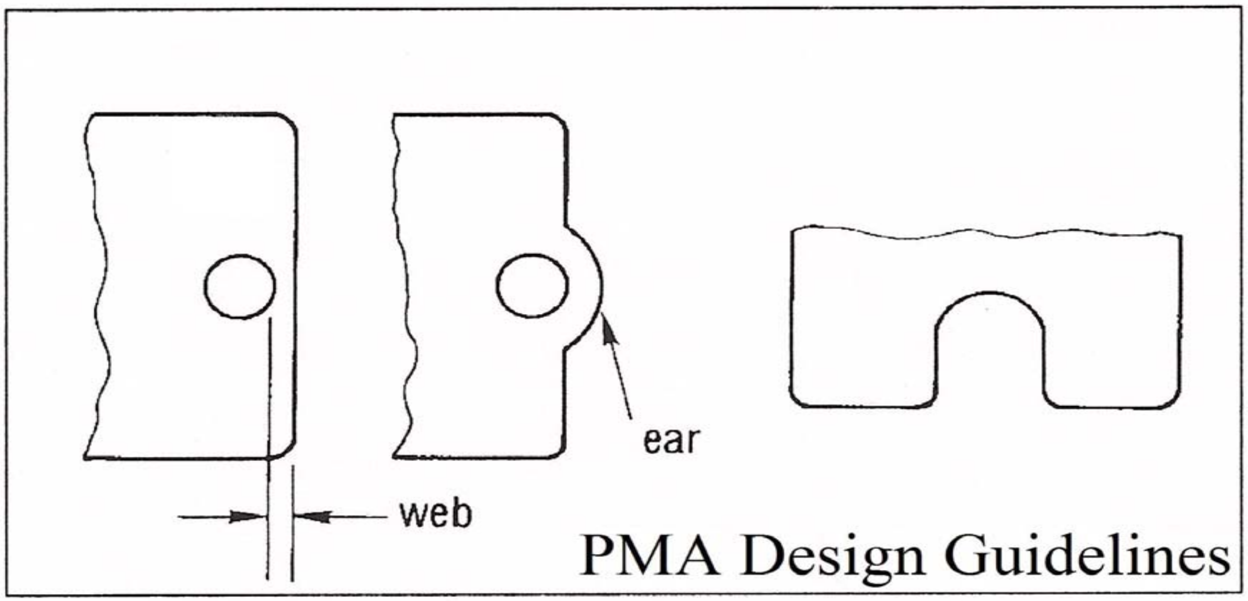


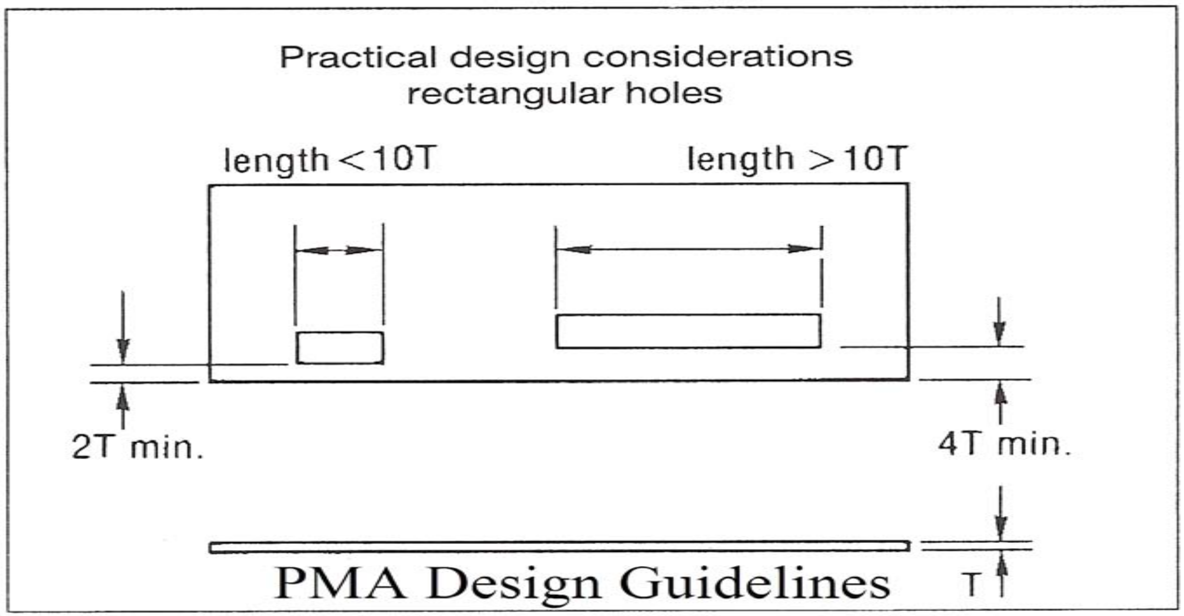
Figure 19. To avoid distortion, holes should be located a minimum distance (D) from forms. D = 2.5T + R, where T = material thickness and R = bend radius.

Design for Manufacturability and Lowest Cost: Stamping



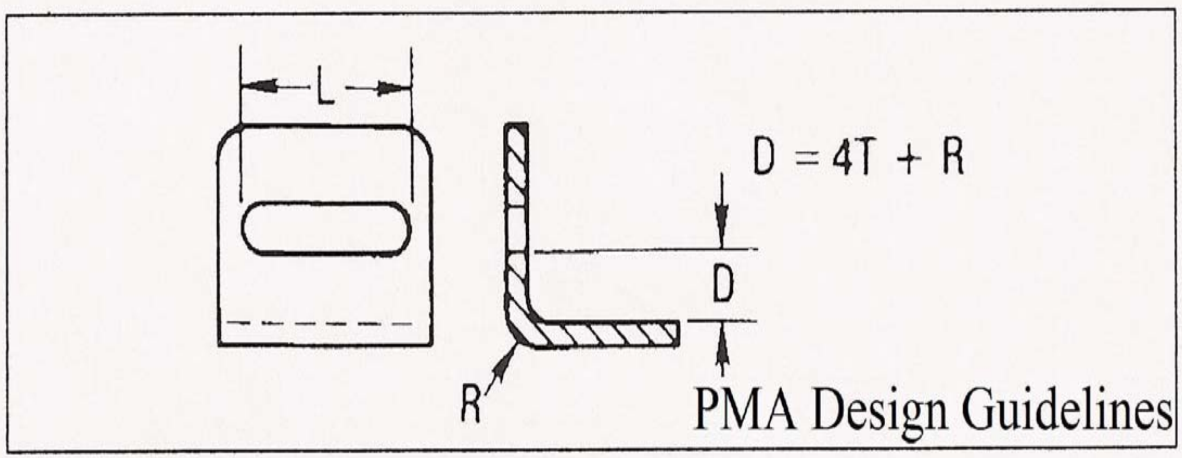
Webs should be at least 2 times the stock thickness (T) to avoid distortion or bulging. Alternate designs include a notch or, a pierced hole within an ear.

Design for Manufacturability and Lowest Cost: Stamping



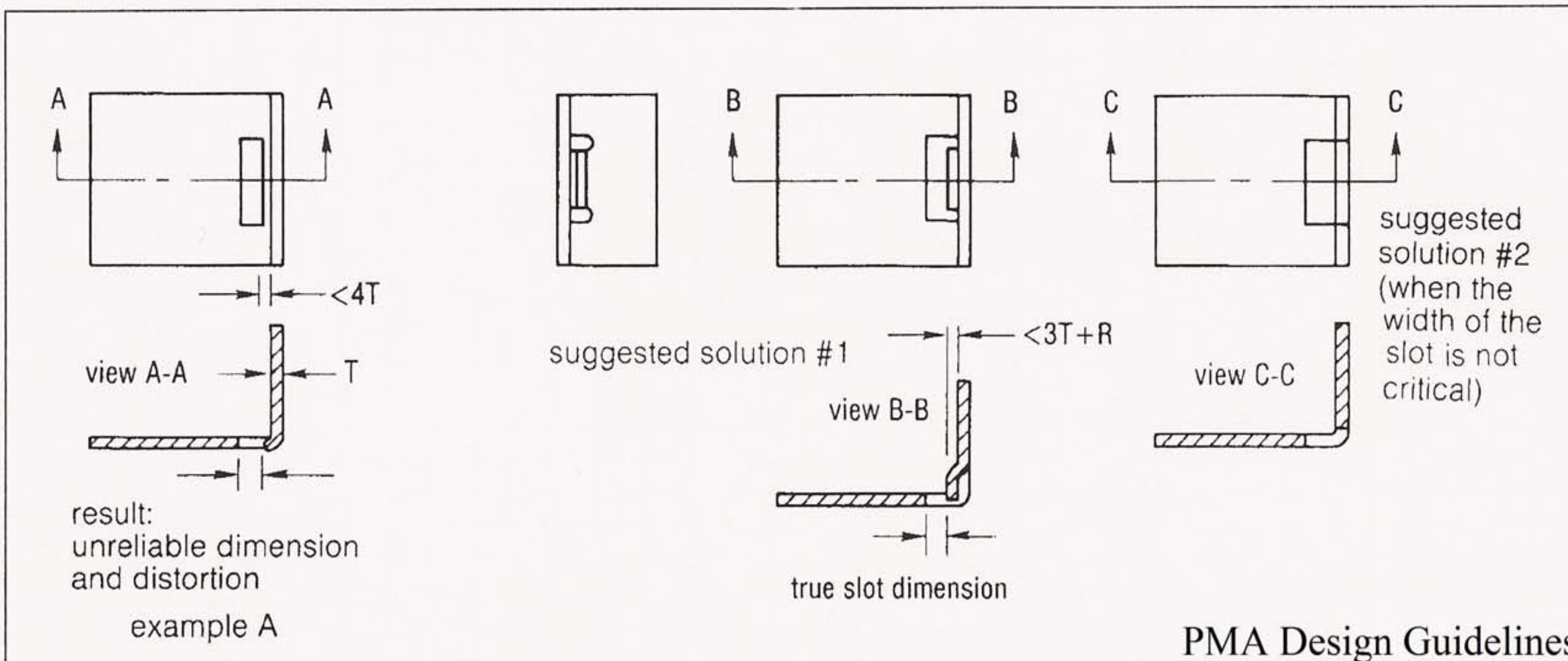
Minimum distance of a slot edge from another feature like a hole should be at least 2 times the material thickness (T).

Design for Manufacturability and Lowest Cost: Stamping



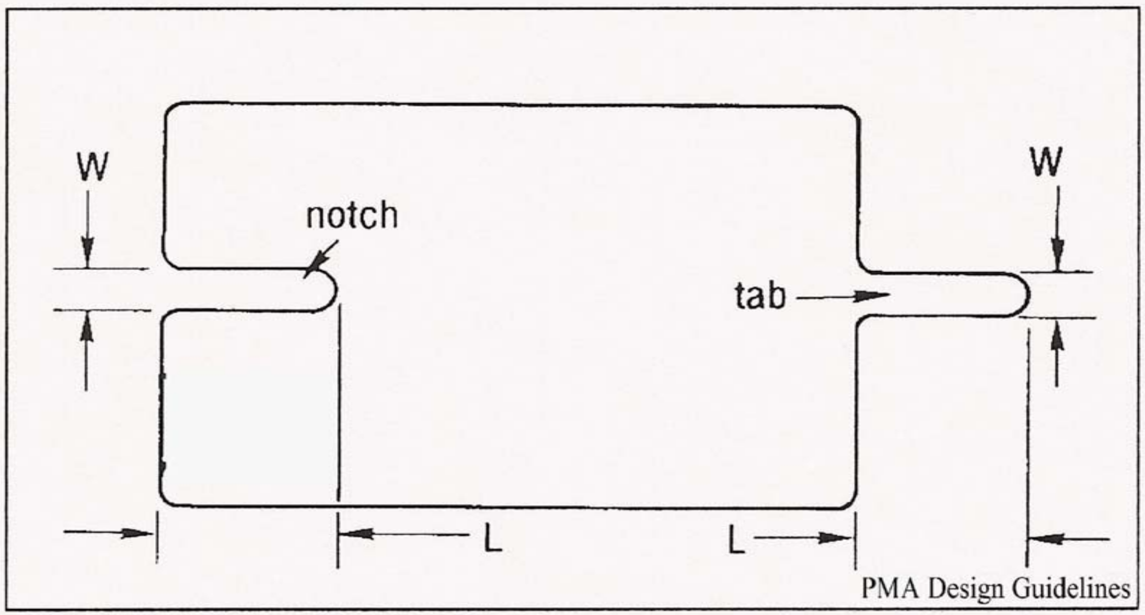
Long slots should be positioned at a minimum distance (D) from forms. D = 4T + R. T = material thickness and R = bend radius.

Design for Manufacturability and Lowest Cost: Stamping



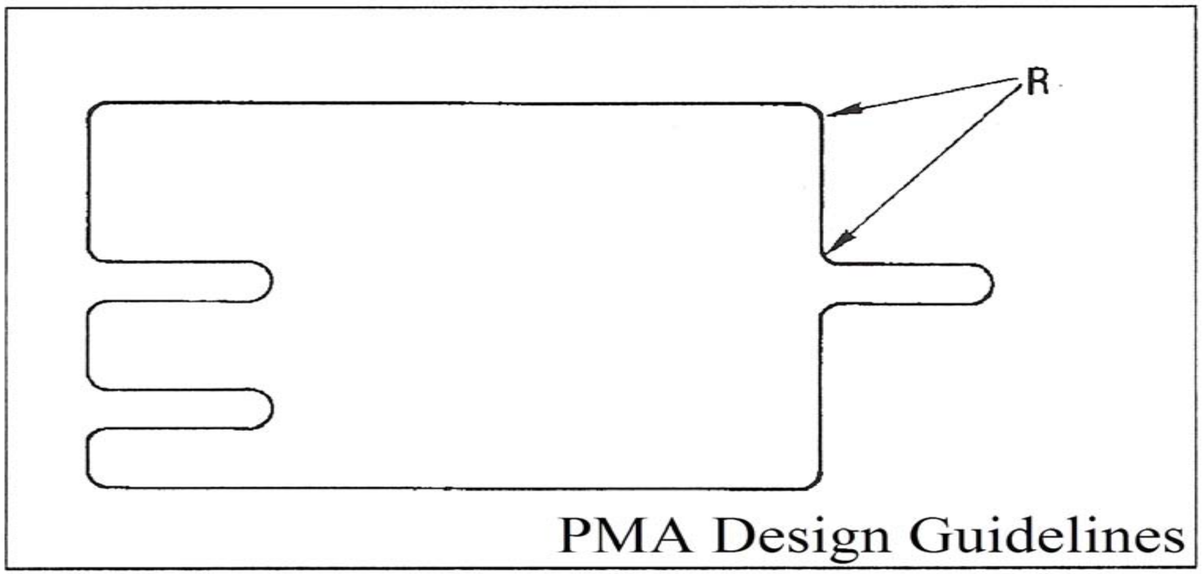
Design alternative to following recommended slot-to-form spacing is punching out the entire area.

Design for Manufacturability and Lowest Cost: Stamping



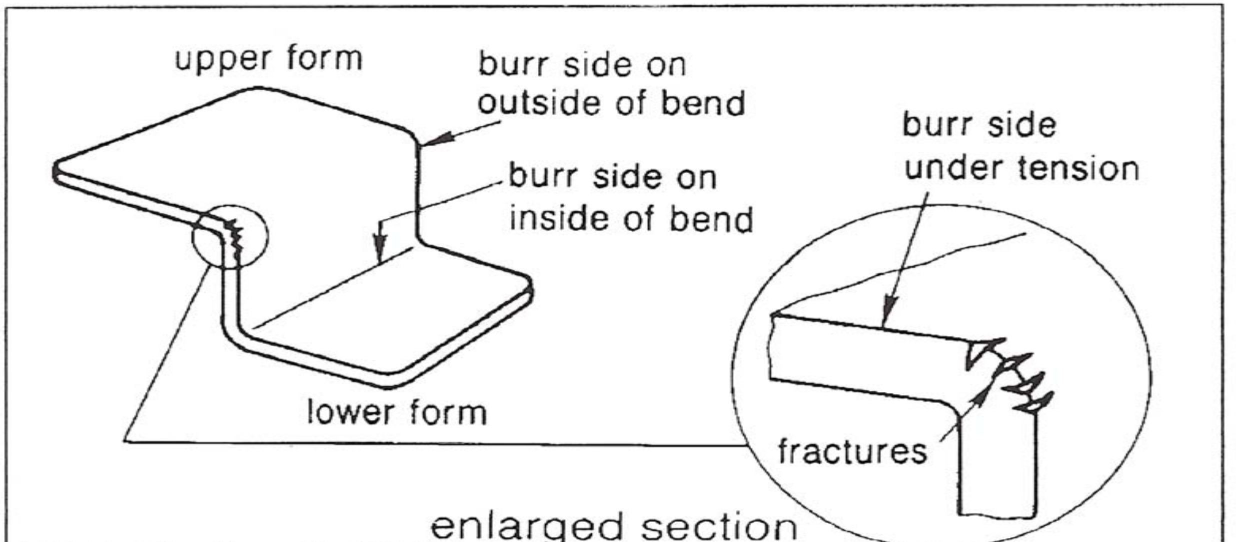
Notches in blanks should not be narrower than 1.5 times the material thickness. Notches can be extended and narrowed slightly if they are tapered.

Design for Manufacturability and Lowest Cost: Stamping



Generally, radii for corners should be 1/2 of the material thickness or greater, with a 0.015 in (0.4 mm) minimum radius preferred.

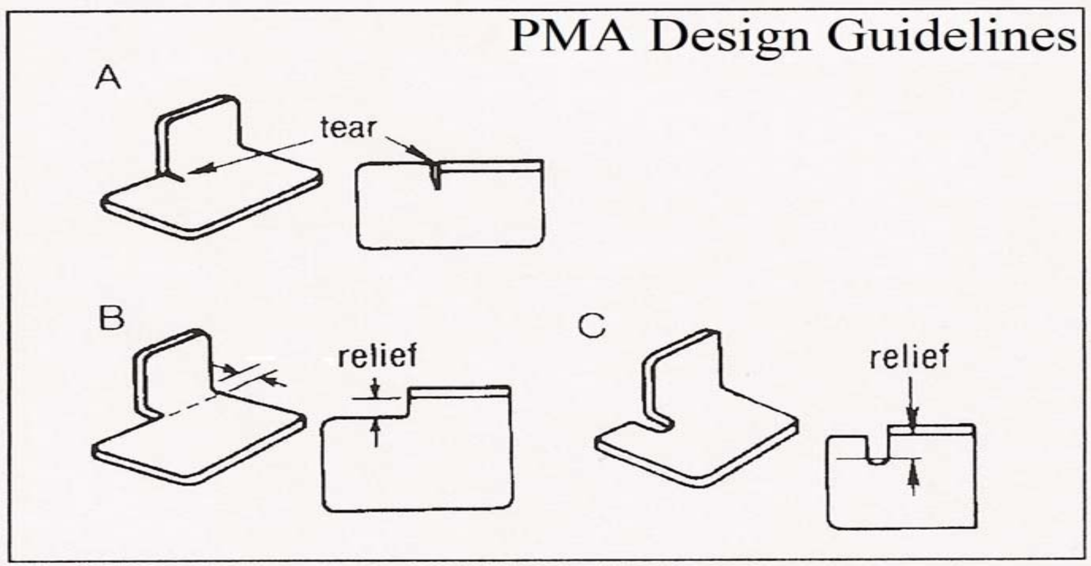
Design for Manufacturability and Lowest Cost: Stamping/Fabrication



PMA Design Guidelines

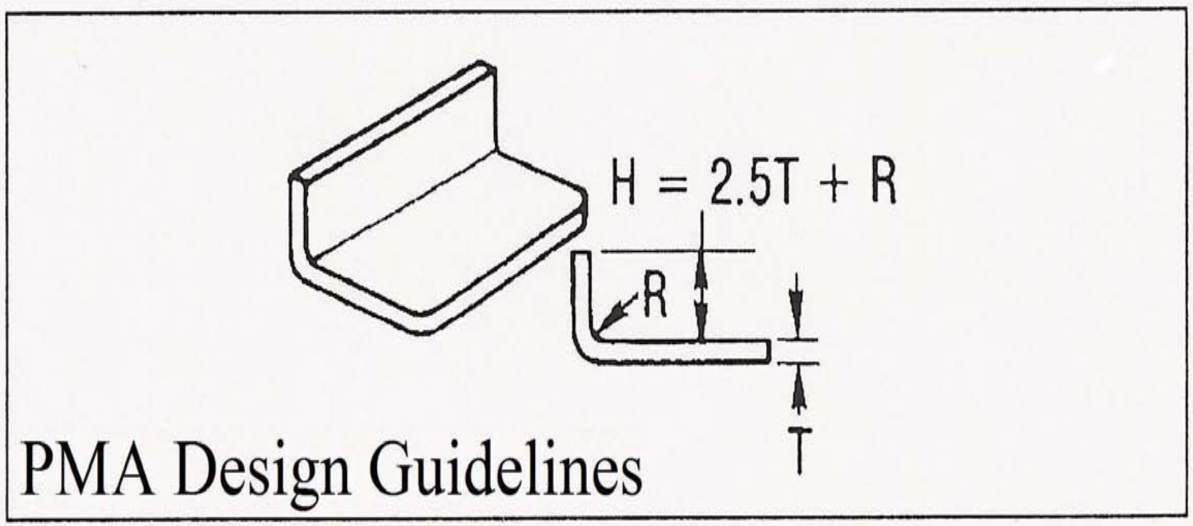
Under tension from forming, the burr side of a blank may develop fractures, which may affect cosmetic appearance.

Design for Manufacturability and Lowest Cost: Stamping/Fabrication



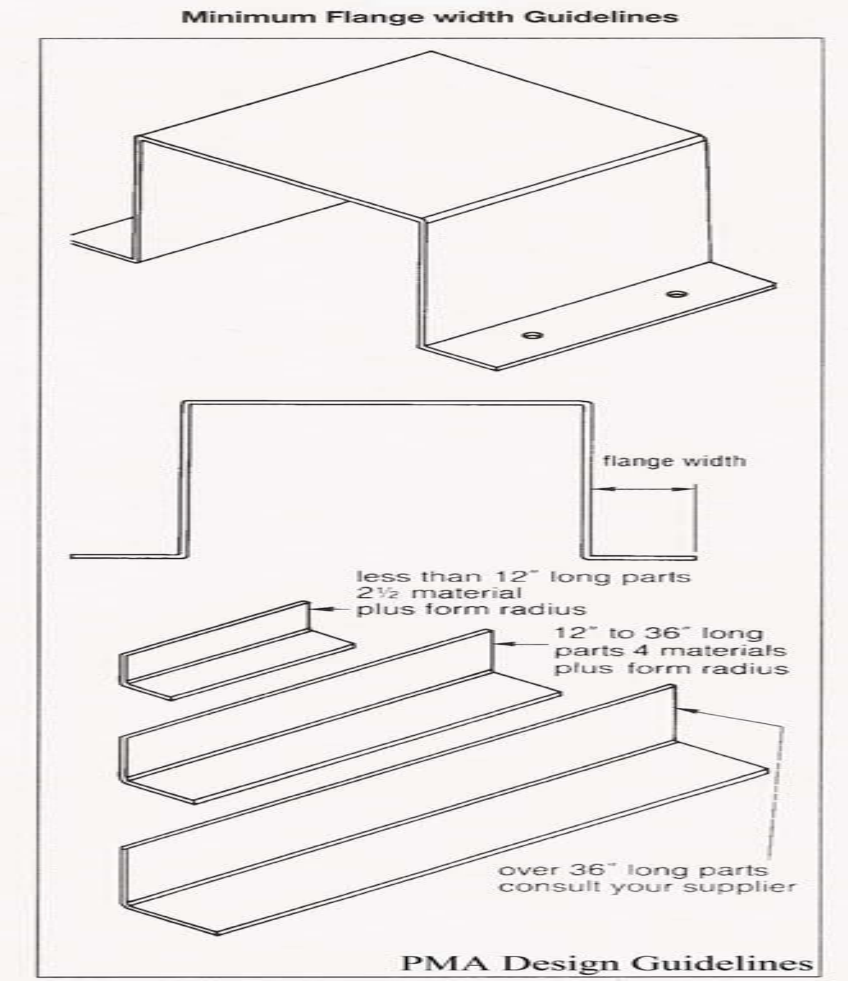
Notches on formed L-shaped parts. Example A is not reccommended. Examples B and C are recommended designs. Notch width = 2 times material thickness, min. 0.060 in. (1.5 mm). Notch depth = radius plus one material thickness.

Design for Manufacturability and Lowest Cost: Stamping/Fabrication



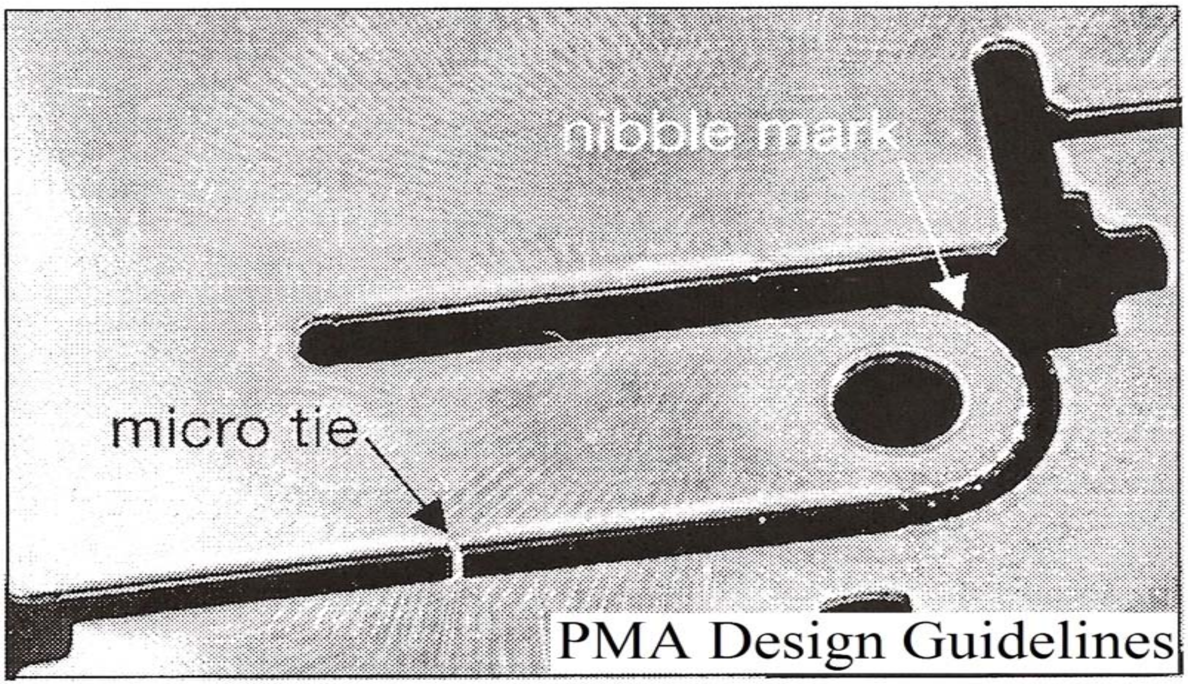
Form height (H) should be at least equal to 2.5T + R. T = material thickness and R = bend radius.

Design for Manufacturability and Lowest Cost: Fabrication



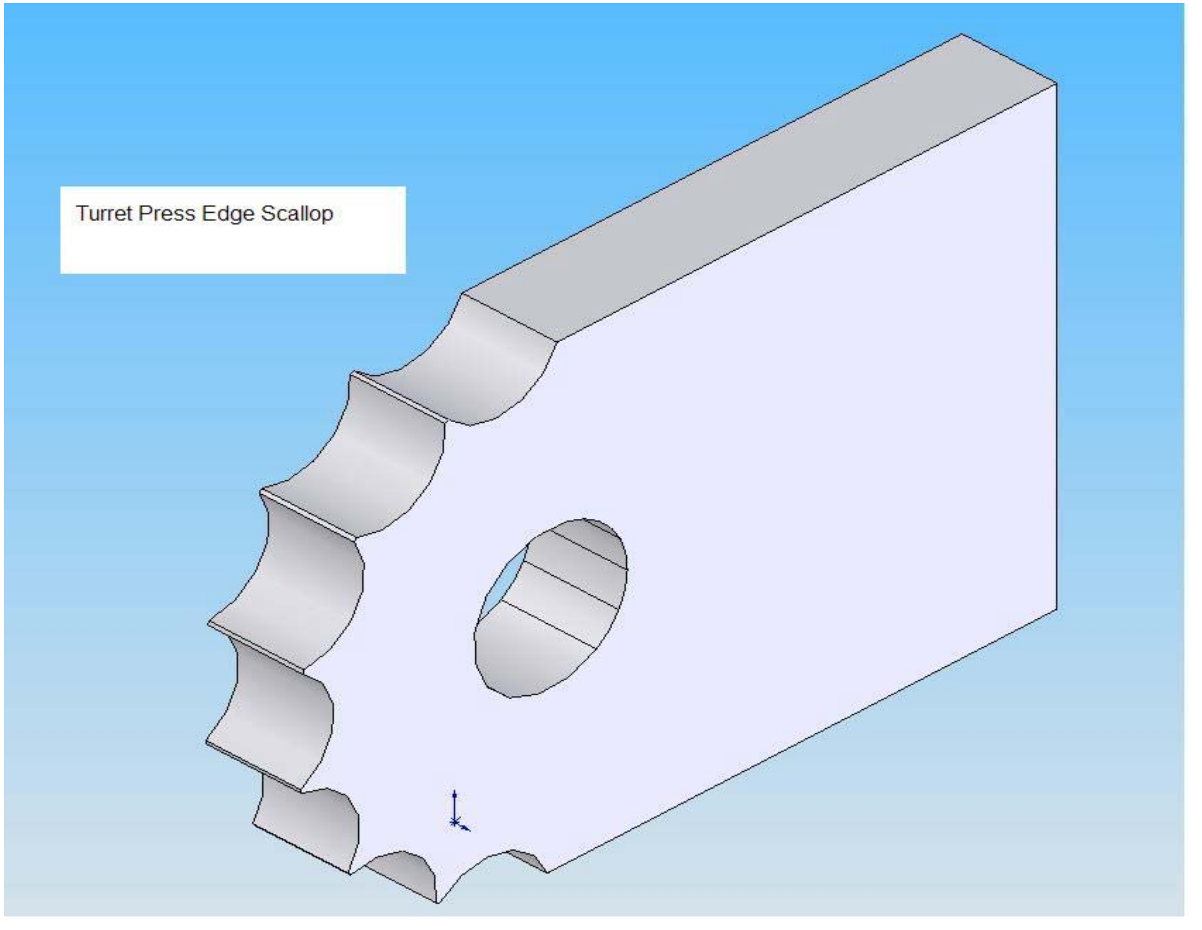
Minimum flange width guidelines.

Design for Manufacturability and Lowest Cost: Fabrication

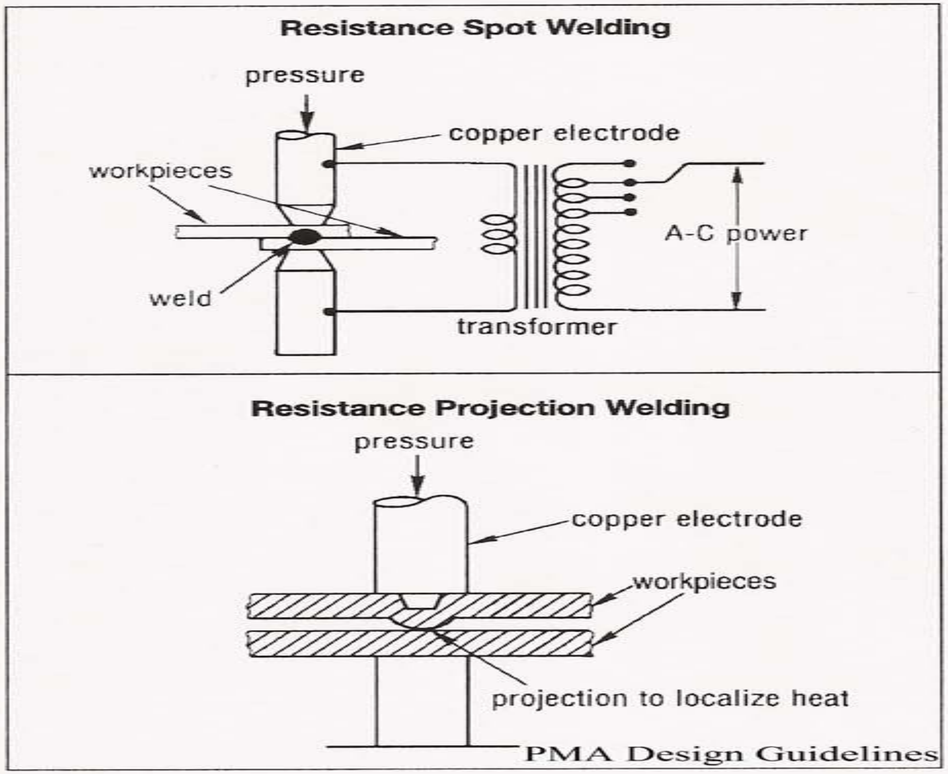


Close up of nibble marks and micro ties.

Design for Manufacturability and Lowest Cost: Fabrication

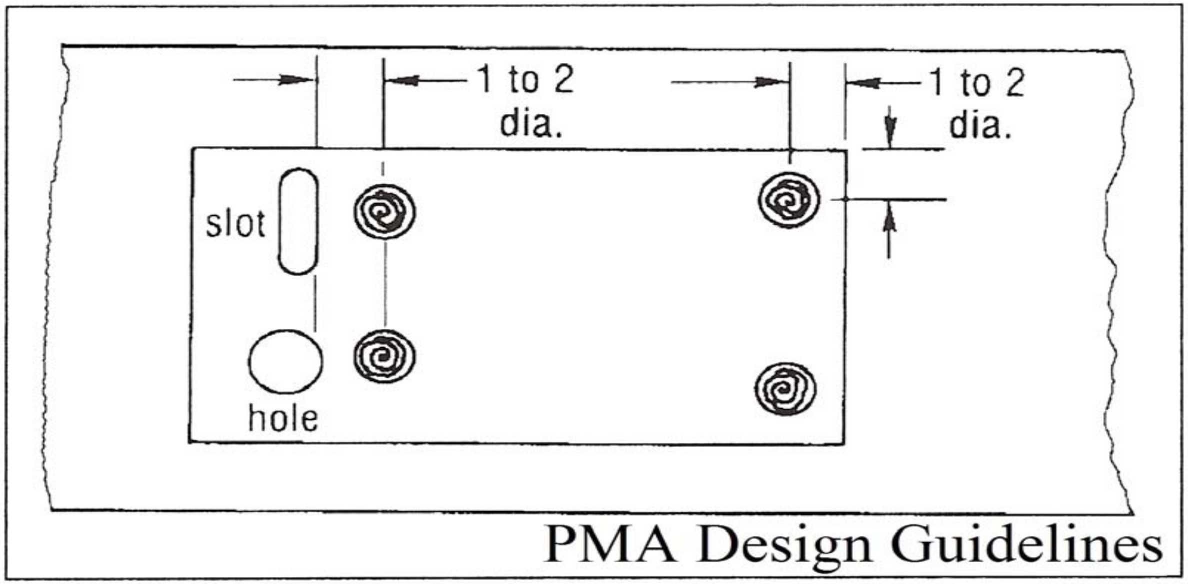


Design for Manufacturability and Lowest Cost: Welding



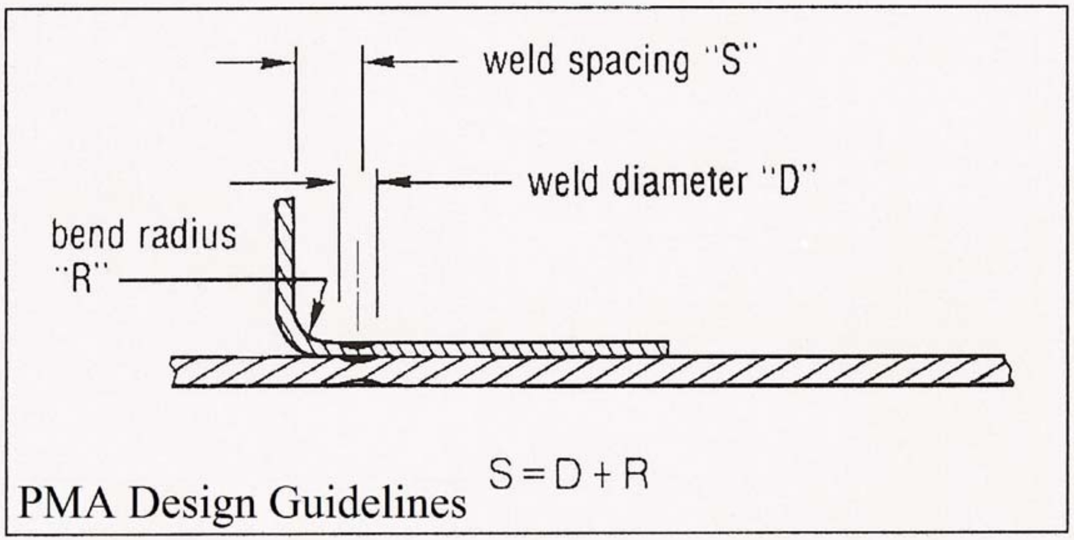
In resistance spot and projection welding, two sheet metal parts under pressure are heated by electrical resistance, melting the metal and forming a weld "nugget." Circular in shape in a plan view, the nugget has an oblong cross-section that, ideally, penetrates both thicknesses equally.

Design for Manufacturability and Lowest Cost: Welding



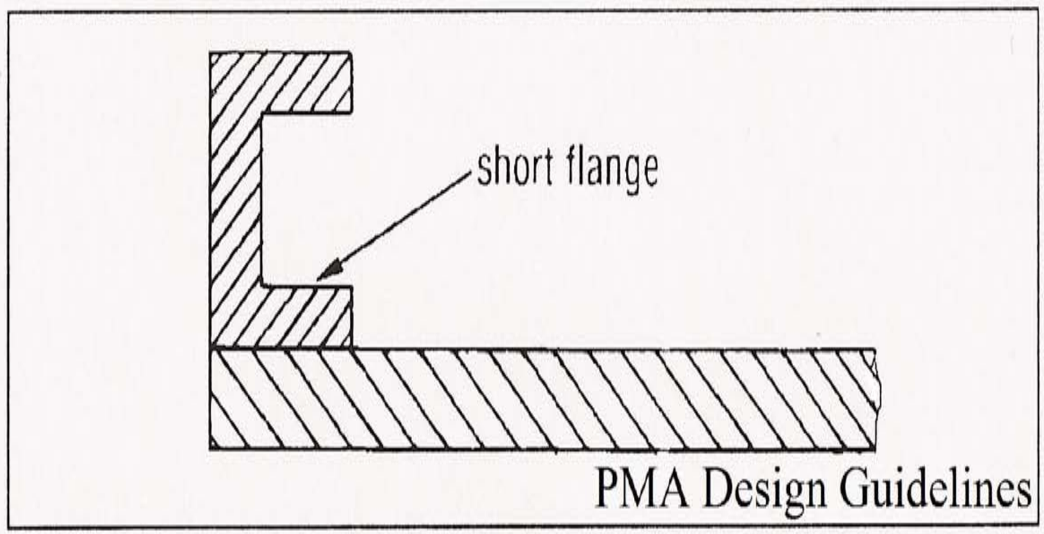
Recommended minimum spacing between spot welds and edges of parts to be joined also applies to slots and holes in the workpieces.

Design for Manufacturability and Lowest Cost: Welding



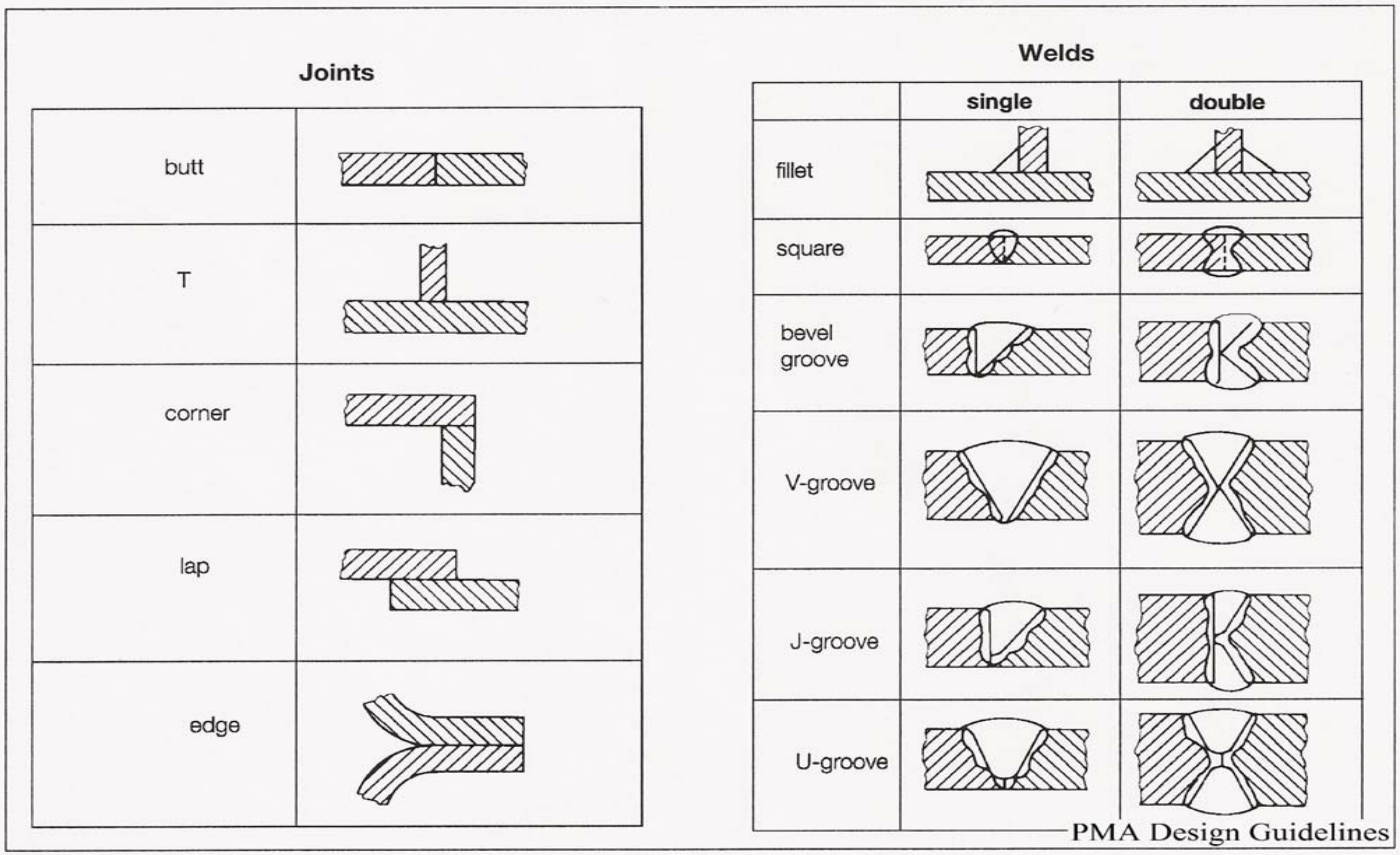
When a part incorporating a formed feature like a bend is joined to another sheet metal part, sufficient clearance must be maintained to form a quality spot weld.

Design for Manufacturability and Lowest Cost: Welding



Specifying spot welds on short flanges could make access nearly impossible.

Design for Manufacturability and Lowest Cost: Welding



types of joints and welds.

Design for Manufacturability and Lowest Cost: Plating

Type	Cost	Hardness	Characteristics
Electrodeposits			
Cadmium	2	2	Prevents rust in humidities to 80%; good coverage; lubricating properties
Chromium	5	5	Chemical resistant; excellent wear characteristics; good corrosion protection, but coverage can in corners can be a problem
Copper	5	2	Limited corrosion protection; good conductivity
Decorative Nickel	2	3	Limited corrosion protection on its own, best as an undercoat for other platings; good coverage
Hard Nickel	3	4	Good corrosion resistance and wear characteristics; cost effective
Tin	1	1	Good corrosion protection if not exposed to heat; will discolor and not cosmetically appealing
Zinc	1	2	Excellent cost effective plating for corrosion protection; sacrificial, but typically married with a chromate top coat for added durability
Immersions			
Electroless Nickel	4	4	Good coverage into corners, holes, and recesses; good corrosion protection and wear resistance
Chemical Conversion			
Anodizing of Aluminum	5	6	With sealing excellent corrosion protection; can be colored; excellent coverage
Hard Anodizing of Aluminum	5	6	Excellent corrosion resistance and resistance to wear
Black Oxide	2	2	With oil good for atmospheric corrosion protection
Chromating	1	1	Limited corrosion protection on some metals
Phosphating	1	1	With oil good corrosion protection and lubricity; without oil improves paint adhesion

1 = Low to 6 = High

Design for Manufacturability and Lowest Cost: Painting

With no universal standard, classifying the appearance of painted parts is difficult. The following guidelines are helpful and should be noted on prints for painted parts:

- Class A designates the primary surface in direct view; these surfaces are most critical
- Class B designates surfaces that are not in direct view but are potentially visible; these surfaces are not critical and the number and size of defects is greater than in Class A
- Class C designates internal or hidden surfaces where protection from the elements is needed, but appearance is not

When properly designated, the cost of painting can be minimized.

Design for Manufacturability and Lowest Cost: Painting

Characteristic	Test Method	ASTM ID
Abrasion Resistance	Air blast abrasion tester Falling sand method	D658 D968
Adhesion	Scrape adhesion Parallel-groove adhesion Tape adhesion	D2197 D2197 D3359
Chemical Resistance	Household chemical resistance Detergent resistance	D1308 D2248
Chip Resistance		D3170
Color Difference	Visual evaluation Instrument evaluation	D1729 D2244
Cracking Resistance		D2246
Elongation	Conical mandrel Cylindrical mandrel	D522 D1737
Gloss		D523
Hardness		D1474
Outdoor Exposure	Blistering Cracking Rusting Checking	D714 D661 D610 D660
Salt Spray Resistance		B117
Water Resistance	High humidity Water immersion	D1735 D870

Design for Manufacturability and Lowest Cost: Painting

Cost and Problem Avoidance:

- Specify paint type and paint manufacturer for supply base consistency
- Adjust tolerances to accommodate paint thickness
- Design in "hanger" holes for racking
- Avoid threaded inserts or features. If not possible, insert threaded components after painting
- Design drain holes into the part
- Use open hems to insure complete coverage and avoid bleed out
- Specify packaging method
- Specify test methods for appearance. Establish chart of allowable defects and viewing time and distance for identifying defects

Part Drawings

- If possible utilize geometric dimensioning and tolerancing
- Standardize tolerance blocks
- Do not "blanket" tolerances; avoid the "everything is 4 places" approach to design
- Send prints electronically
- Verify that the revision level is correct
- Verify that material, finishing, heat treating, etc. are clearly and accurately documented
- Use line weights to differentiate the part from the dimensional lines
- Use notes, in clear language, to aid in interpretation
- Do not over specify
- Clearly identify critical characteristics
- A burr, approximately equal to 10% of material thickness, is inherent in the process. If less or no burr is truly required, additional operations or tool maintenance will be needed, and will generate added cost and time.

File Transfer

- Compress files for faster transfer
- Use native CAD files, if supported, first
- Use .IGS or .STP as a second choice
- Use .DXF or .DWG for drawings
- Use .IGS for design models
- Use .DOC or .TXT files for text
- Your supplier may have an FTP site. If they do, larger files can be transmitted effectively and securely

Federal Tool & Engineering, LLC

Question & Answer

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Thank You!