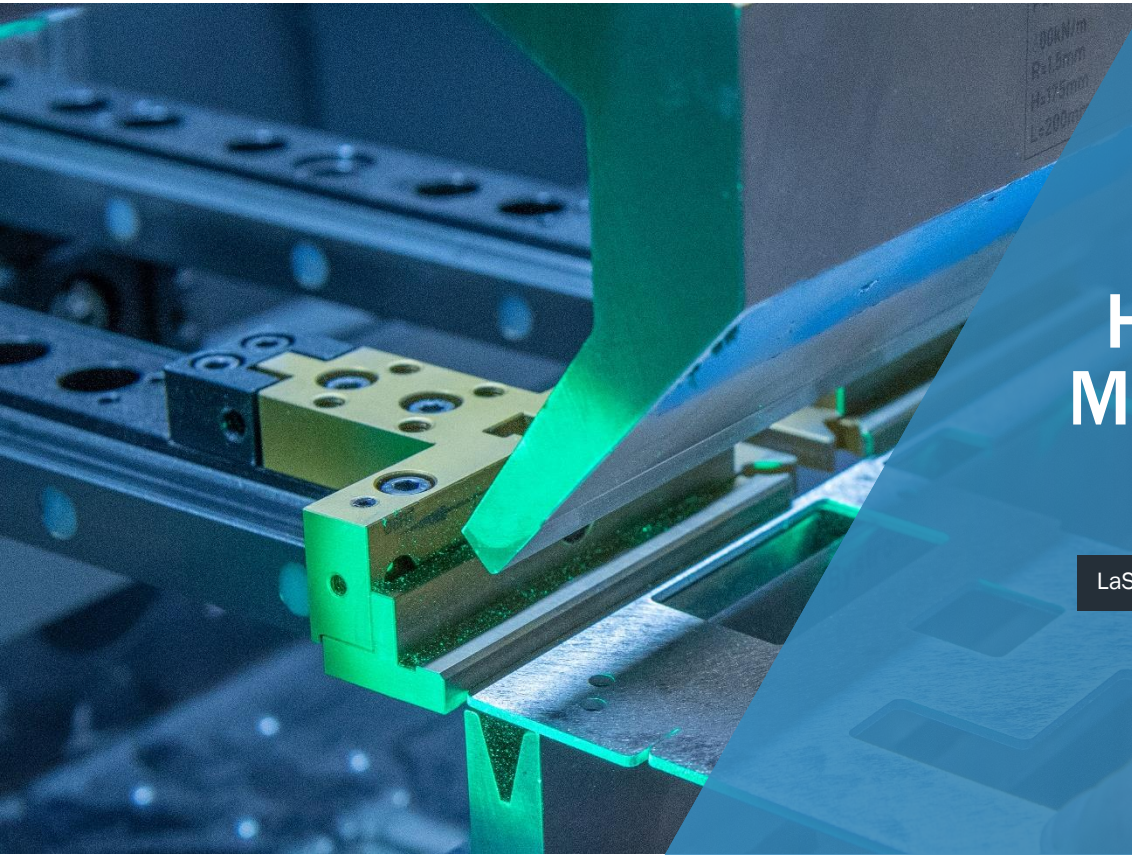




PROTOLABS
Manufacturing. Accelerated.



How to Reduce Sheet Metal Design Risks and Production Costs

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Agenda

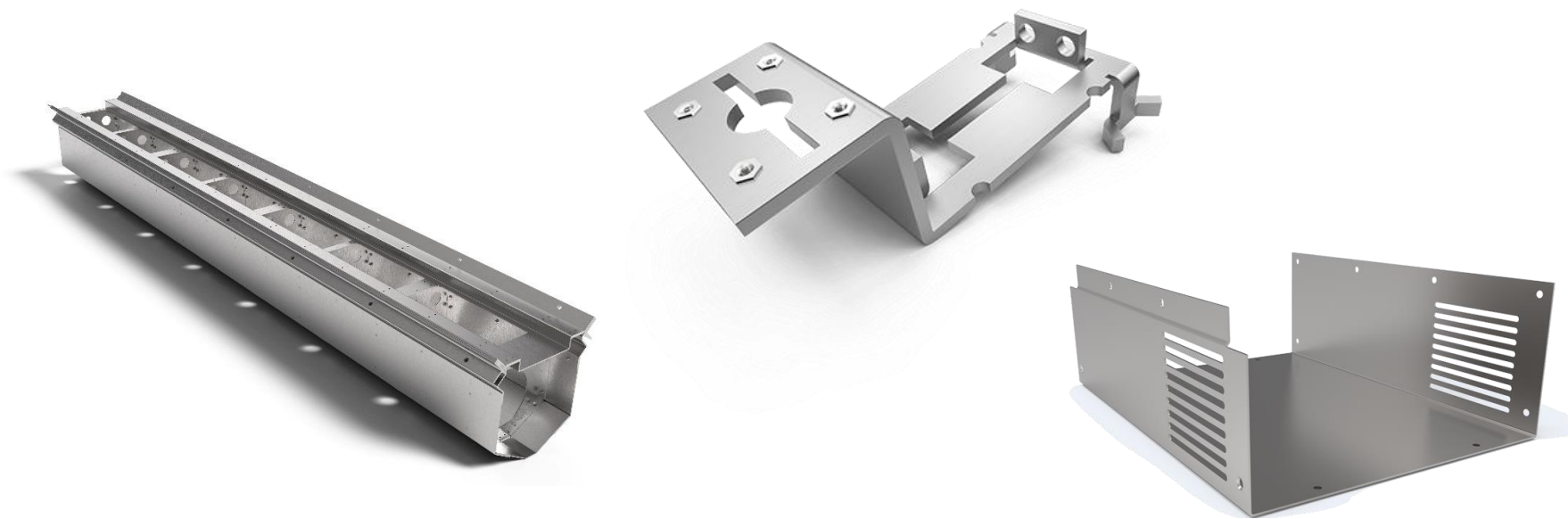
1. Materials
2. Laser Cutting and Punching
3. Forming
4. Hardware
5. Finishes
6. Tolerances





Sheet Metal Fabrication

Protolabs now offers sheet metal fabrication through Rapid, following the 2017 acquisition.





Sheet Metal Fabrication Process

- A manufacturing method using forming
- Starts with flat material and bend could be added if needed.
- Review process steps to reduce risks in part design:
 - Materials
 - Laser cutting
 - Forming
 - Hardware
 - Finishes





Technical Information

CUSTOM PROTOTYPING:

- 1-10+ parts
- Shipped in as fast as 3 days

LOW-VOLUME PRODUCTION:

- 10-1,000+ parts
- Shipped is as fast as 7 work days

MAX. PART SIZE:

- 39" x 47"

COMMON APPLICATIONS:

- Large geometries
- Prototype box builds and end-use components
- Assemblies and custom finishes

FINISHING OPTIONS:

- Powder coating (stock colors)
- Chromate
- Anodizing
- Silk screening
- MIG/TIG
- Hardware insertion
- Riveting ***Up to 4 components***



Procedural Overview



Material Options

- Material options include steel, aluminum, copper, and brass
- Standard material thicknesses between 0.024” and 0.134”

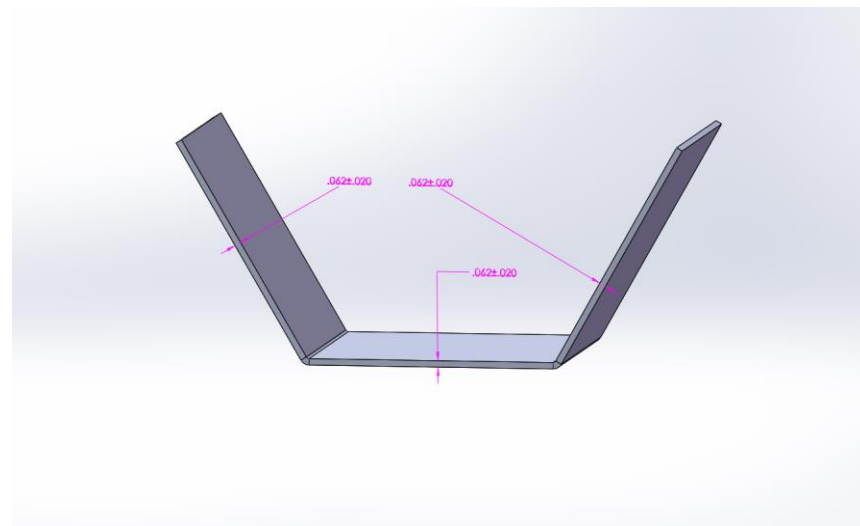
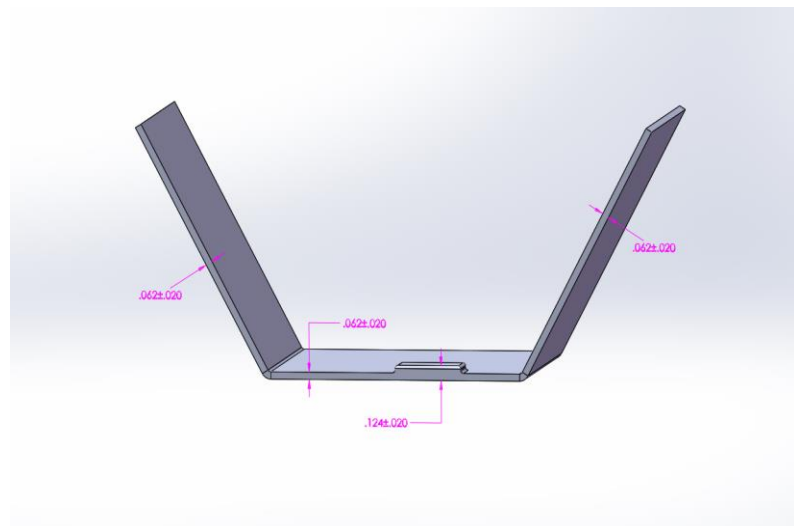
Gauge	Steel non-RoHS coated steel			Stainless steel		Aluminum		Copper		Brass
	CRS	Galvanneal	Galvanized	304	316	5052	6061-T6	C101	C110	CDA260
24	0.024	0.024	0.024	0.024	0.024	0.020		0.020	0.020	0.020
22		0.029	0.029			0.025	0.025	0.025	0.025	0.025
20	0.036	0.036	0.036	0.036	0.036	0.030	0.030		0.032	0.032
19	0.042							0.040	0.040	0.040
18	0.047	0.048	0.048	0.047	0.047	0.040	0.040	0.050	0.050	0.050
16	0.059	0.060	0.060	0.059	0.059	0.050	0.050	0.062	0.062	0.062
14	0.074	0.075	0.075	0.074	0.074	0.062	0.062	0.080	0.080	0.080
13	0.089	0.089	0.089	0.089	0.089			0.090	0.090	0.090
12	0.104	0.104	0.104	0.104	0.104	0.080	0.080			
11	0.119	0.119	0.119	0.119	0.119	0.090	0.090	0.125	0.125	0.125
10						0.100	0.100			
8						0.125	0.125			

Note: Material thickness is listed in inches



Design Tip: Uniform Wall Thickness

- Manufactured from a single sheet
- Must maintain uniform material thickness





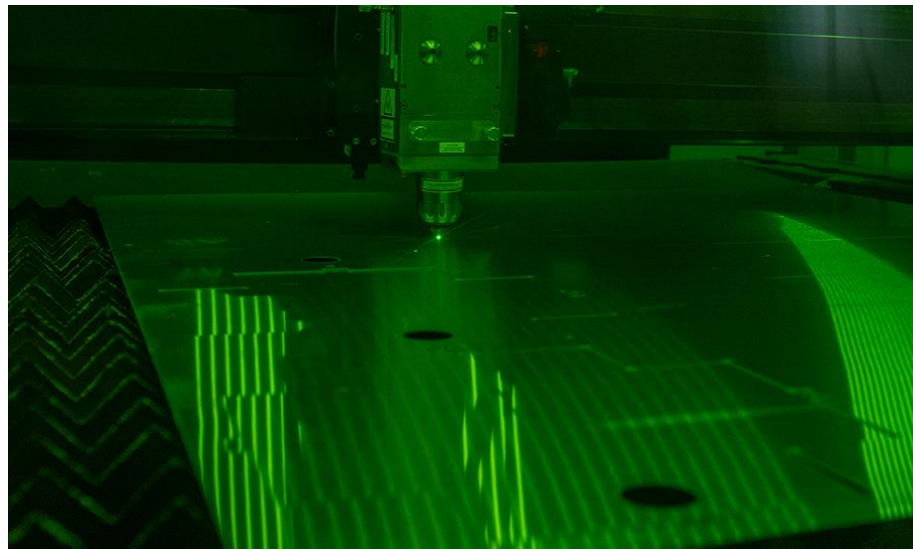
Cutting Operations

Laser

- Focused light shielded by a gas is directed through the sheet

Punching

- Punch features are achieved by using a die tool and removing/stretching the material to achieve the specified feature.
- We can use multiple punch tools on the same part if the direction is the same or the tools specify opposite directions.





Cutting Equipment

- Laser: IPG Laser Cube
- Punching: Murata





Cutting: Best Fits and Implications

Laser

- Standard sheet metal flat patterns
- Thru holes/cut features
- Longer/larger parts
- Curved features



Punch

- Formed geometries (louvers, bridge lances)
- Countersinks
- Standard tooling sizes
- Square corners





Design Tip: Dealing with Sharp Edges

- Standard process is to deburr customer parts post laser operations
- We deburr to a standard edge break.
- Save time and cost by following standard procedure





Forming

- We use press break machined to form our parts
- A press brake uses hydraulic pressure to force material between two dies.





Press Brake Forming

Bump Forming

- Forms multiple smaller radius bends that accumulate to a non-standard radius
- Can be time consuming
- This will leave die marks roughly every .010" of the bend.

Air Bending

- The part will hit the press brake tooling in three places.
- Inside bend radius is largely controlled by the size of the V opening of the bottom die



Press Brake Forming Equipment

Two primary pieces of equipment:

- Cincinnati
- Toyokoki
- Bystronic





Press Brake: Best Fit and Implications

Best fit geometries:

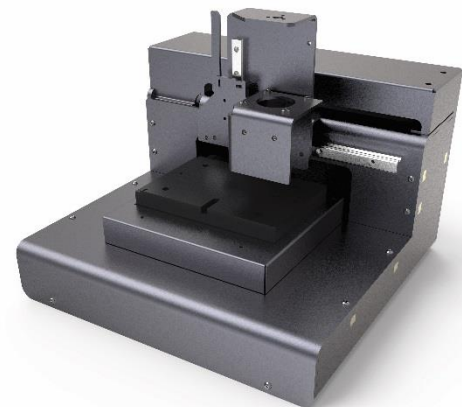
- Enclosures, chassis, brackets

Challenging geometries:

- Wrap-arounds, non-standard or large bend radii.
- Tear drop hems and barrel hinges.

Implications:

- Clearance for tooling.
- Dissecting components into assemblies.
- Tolerances can add layer of complexity



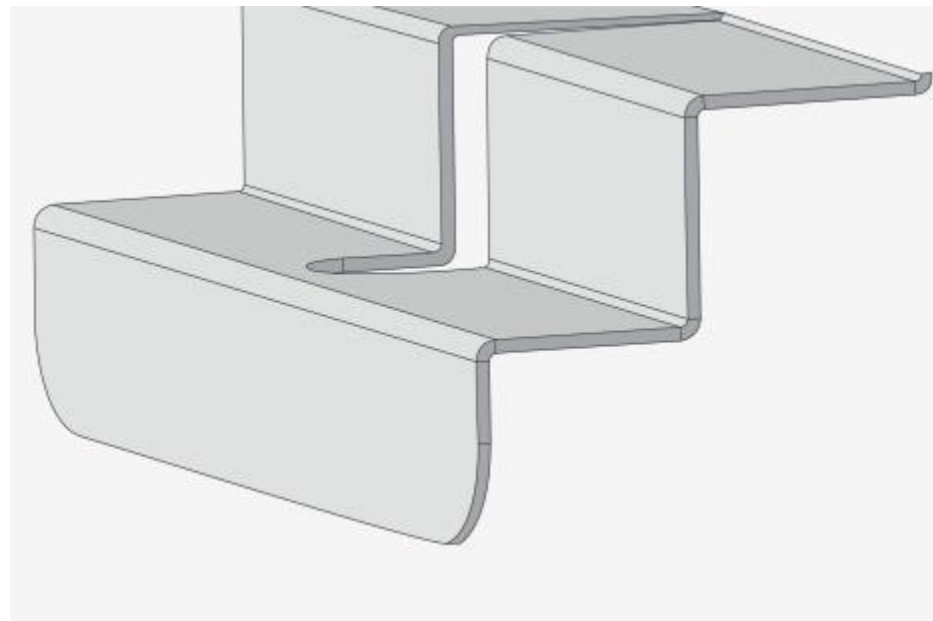


Design Tips: Formed Geometries



Bends

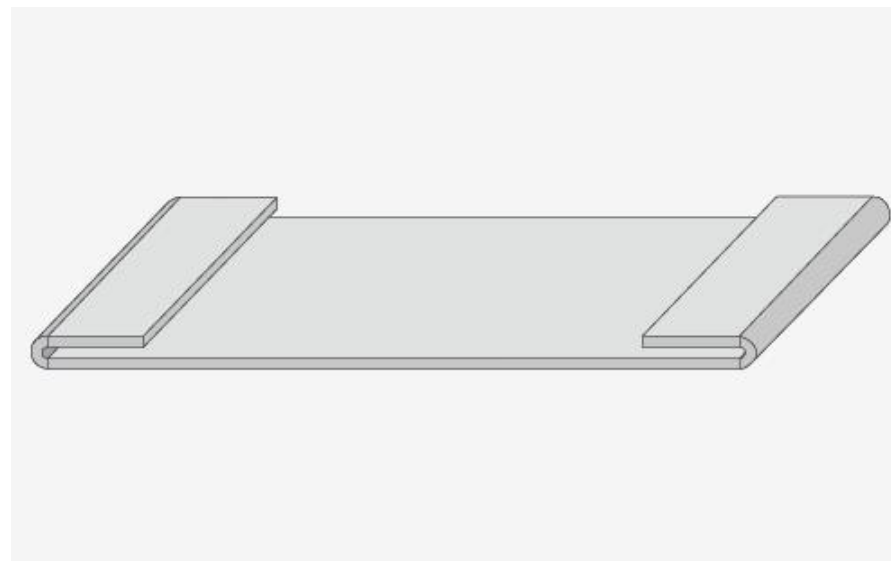
- Manufactured using sheet metal press breaks.
- Preferred bend radius is 0.030”.
- Other inside bend radii available—some will drive economic tradeoffs to part
- Please keep the same bend radii across all bends when possible.





Hems

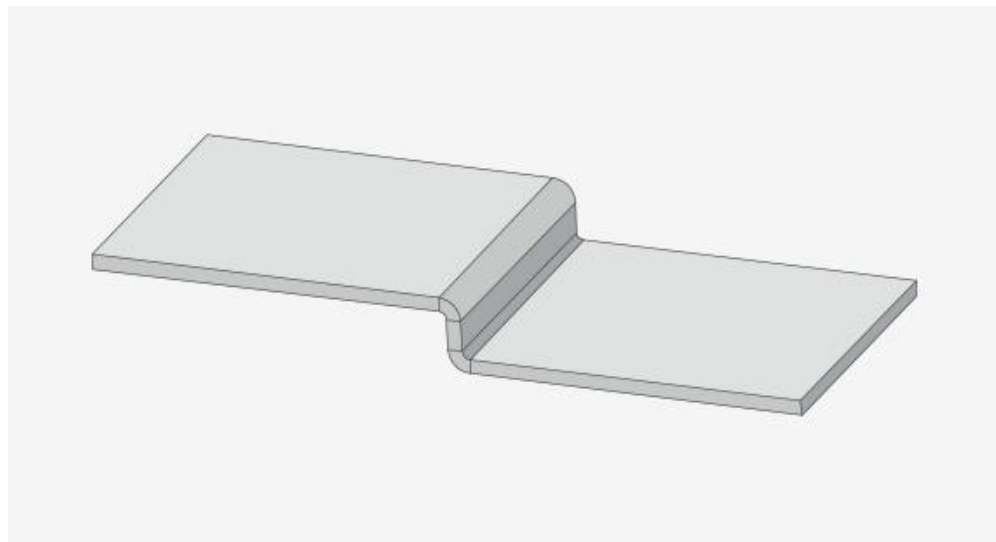
- Fold outs at the end of a part that create a round edge
- Can be used for stiffening
- Can form both open and closed hems
- Tolerance depends on radius, material thickness, and features in proximity to the hem
- Recommended minimum inside diameter equals material thickness and return length is 4x the thickness





Offsets

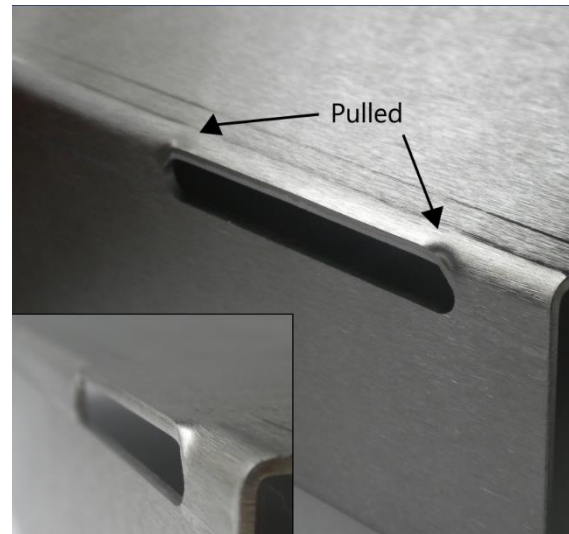
- Used to create a Z shape profile
- Height tolerance is ± 0.012 " top of sheet/form
- Preferred offset is 0.030"
- Other options are available, but add economic tradeoff in part.





The 4x Rule

- 4x material thickness needed between most sheet metal features and the bend.
- This rule will change as material thickness and bend radii increase.
- Flanges must be 4x material thickness to achieve a full 90 degree bend.
- Hem length must be 4x thickness in length
- Hole features must be 4x thickness away from bend line to prevent deformation

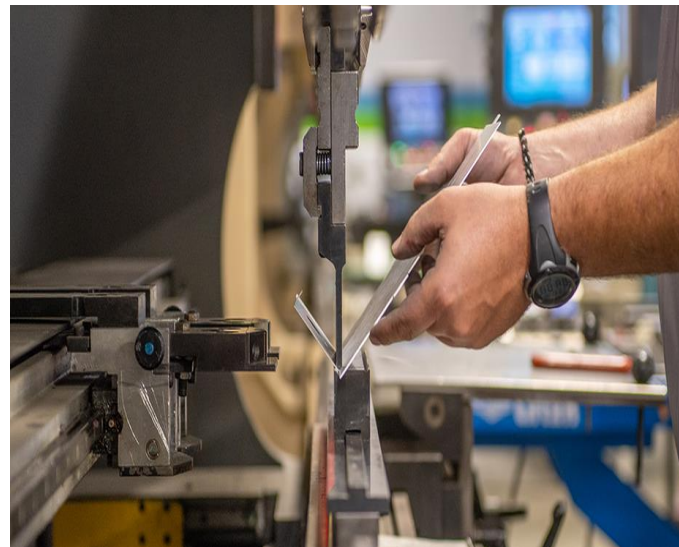


There are exceptions to every rule, but the rule saves money and reduces risk



Bend Reliefs

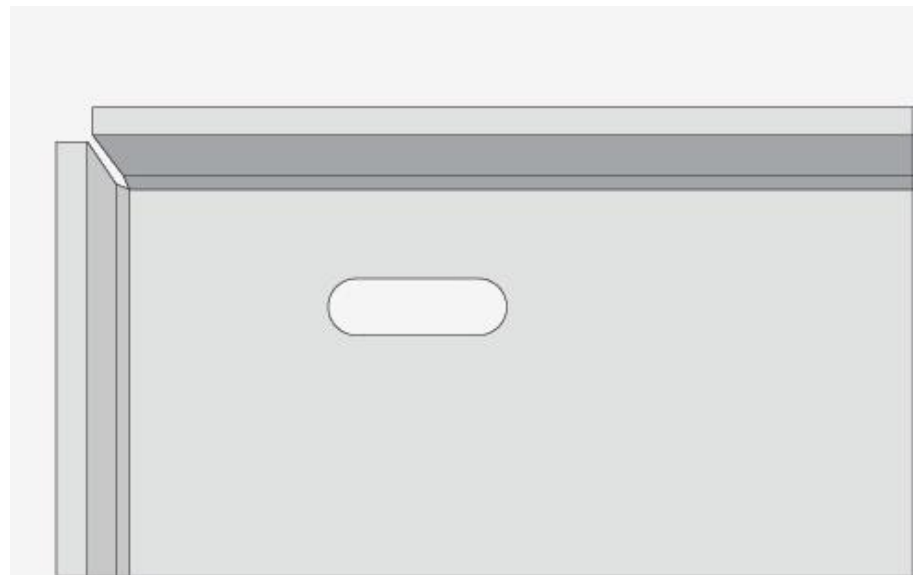
- Implemented where bend extends on an edge
- Bend notch added to prevent tearing
- No deeper than material thickness plus bend radius
- Must be a minimum of .030" wide





Holes and Slots

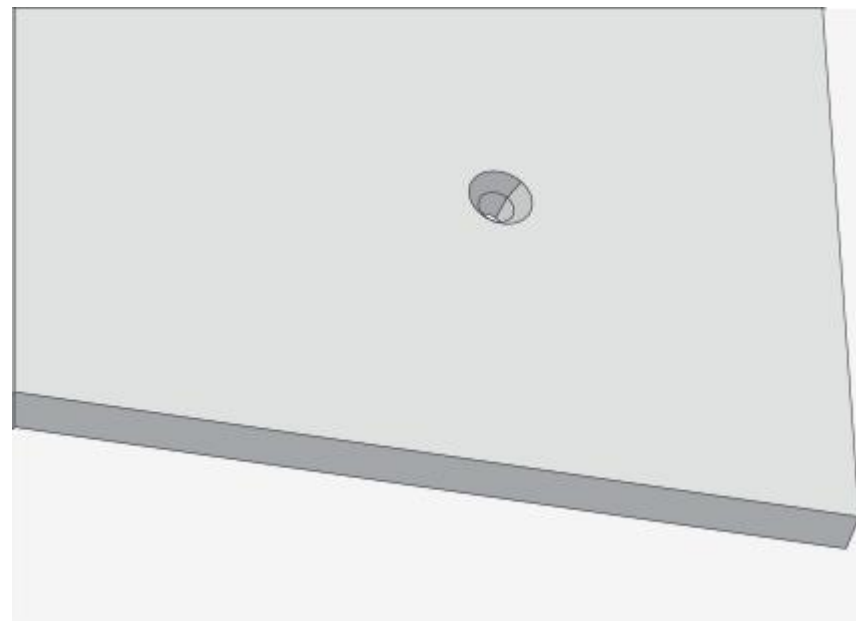
- Minimum of material thickness in diameter
- If material is 0.036 in. or thinner, the hole should be 0.062 in. from the material edge
- Remember the 4x rule for placement near bends.
- Keep spacing to manufacturer's specs if hardware inserts are required





Counter Sinks

- Both machined and formed countersinks available
- We use drill press tooling and could punch the feature if the countersink is standard.





Hardware



Clinch Fasteners

Clinch fasteners are permanently installed using a press. The hardware is pressed into a hole and the material that flows in response to this force creates a permanent mechanical bond between the sheet and fastener.

Types

- Nuts
 - (CLS/S/SP)
- Studs
 - (external threaded)
 - (FHS/FH/FH4)
- Stand-off
 - (internal thread)
 - (BSOS/BSO/BSO4)
- Pins
 - (unthreaded studs)
 - (TPS/TP4)

Clinch hardware must be harder material and not have galvanic reaction with sheet material

	Al	Steel	300 SS	400 SS
Al & Softer	0	X	0	0
Steel	X	0	0	0
Stainless	X	X	X	0



Finishing



Powder Coating and Silk Screening

- Available in compliance with government regulations
- 30 standard powder coat options readily available
- Silk screen can be color-matched to any pantone number

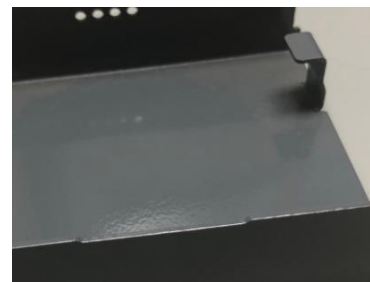
<p>Tiger Drylac 89/71530 Light Gray Textured RAL 7035</p>	<p>Tiger Drylac 49/42310 Dark Blue RAL 5013</p>	<p>Tiger Drylac 49/00530 Sky Blue RAL 5015</p>
<p>Tiger Drylac 49/72020 Telegrey 4 RAL 7047</p>	<p>Tiger Drylac 49/22580 Signal Yellow RAL 1003</p>	<p>Tiger Drylac 089/41050 Azure Blue Textured RAL 5009</p>



Plating

- Effective way to prevent corrosion and improve aesthetics
- Lowest risk plating options are Anodize (Black and Clear), Chromate (Yellow and clear), Zinc (Clear and Yellow), and Passivate (cleaning wash)

Type	Aluminum	Steel	Stainless Steel
Anodize	MIL-A-8625	-	-
Chromate	MIL-DTL-5541	-	-
Zinc	-	ASTM-B-633	
Passivation	-	-	ASTM-A967



Plating is not a cosmetic finish



Tolerances



Tolerances

- Machining tolerances can be summed up quickly, directly relative to the number of significant figures in the dimension
- Sheet metal tolerances, however, can take numerous pages to cover all aspects

Unless otherwise specified, dimensions are in inches			
Angles	.X	.XX	.XXX
+/- 5°	+/- 0.02	+/- 0.01	+/- 0.005

Do not design sheet metal parts to machining tolerances, especially if designing mating components



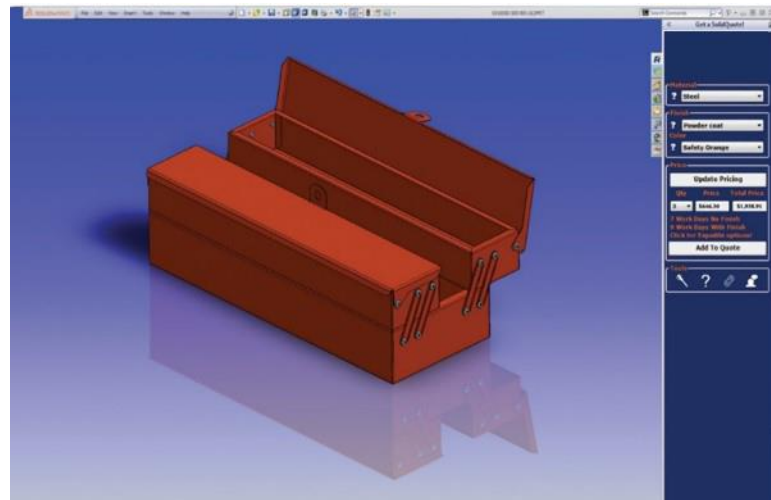
Have a Model Ready to be Quoted?

A **myRAPID** account allows you to get quotes and/or submit parts for manual quoting with most 3D CAD files, have on-going access to your quotes, and more.

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- Instant part cost for sheet metal
- Design feedback
- Budgetary or order now
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THANK YOU

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