



# ENCLOSURE DESIGN BASICS

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Toll free: 1-866-849-3911 (US & Canada only)  
Tel: 1-902-567-3335  
Fax: 1-902-567-3336  
Email: [info@protocase.com](mailto:info@protocase.com)

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## Introduction

Whether you design your enclosure from scratch or make use of one of our simple template based design, knowing the basics of enclosure design will make your work easier.

Below you will find information on some of the basic concepts of enclosure and sheet metal design. Looking for further information? Don't hesitate to ask [tech@protocase.com](mailto:tech@protocase.com). One of our technicians will be happy to answer your questions.

Please see the below menu for more information:

- Metal selection
- Bending metal and bend radius
  - Consequences
- Self-clinching fasteners (PEM ®)
  - Standard stocked PEM ®
- Welding
- Finishing
  - Powder coating
  - Silk-Screening

## Metal selection

Major considerations for the metal selection are the types of metal and their thickness. Protocase Inc. offers carbon steel and stainless steel as standard offerings. The table below shows the standard sheet metal thickness:

Gage #	Plain Steel	Stainless Steel
11	0.120 in	-
12	-	-
14	0.075 in	0.078 in
16	0.060 in	0.063 in
18	0.048 in	0.050 in
20	0.036 in	0.038 in
22	0.030 in	0.031 in
24	0.024 in	0.025 in

Carbon steel is suitable for the majority of electronic applications, and shows long-term durability in indoor applications when finished with powder coat.

Stainless steel should be used when corrosion resistance is an issue, or when that 'special look' of brushed stainless steel is desired. Stainless can be powder coated just like carbon steel. It exhibits exceptional corrosion resistance whether bare or powder coated. However, users should be aware that stainless steel could show surface corrosion when contaminated with traces of carbon steel or other corrosion susceptible metals. If stainless comes into contact with such metals (for example, if it is finished with a carbon steel wire brush) then it must be 'passivated' to remove that contamination.

Protocase Inc. has an in-house environmentally friendly citric-acid based passivation process.

If a particularly corrosive environment is anticipated, please contact [tech@protocase.com](mailto:tech@protocase.com).

### Bending metal and bend radius

Sheet metal enclosures are fabricated by 'cold forming', where the metal is clamped and bent in machines called 'press brakes'. As a result, metal typically cannot be formed into a true 90 deg. corner, but rather, the corners are curved as per the figure below (FIG 1). Different degrees of curvature can be achieved, and it is described by a parameter called 'bend radius' (see figure showing series of different bend radius FIG 1). Note that bend radius is specified as the radius of the INSIDE surface of the bend.

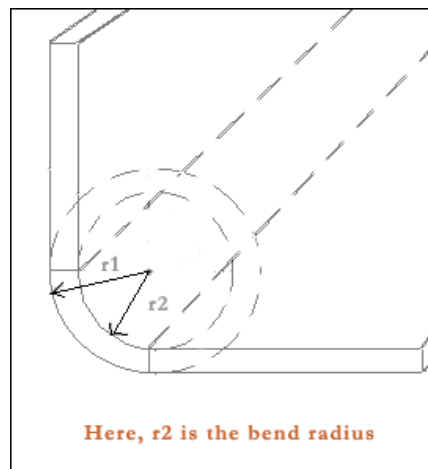
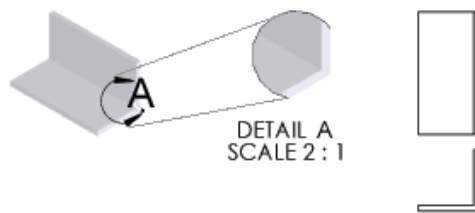
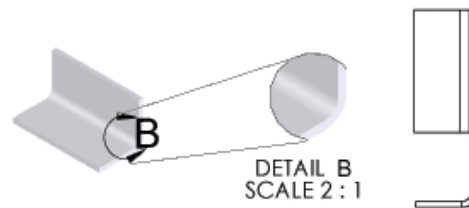


FIG 1 (A)



A: Ideal 90° bend with no bend radius - not achievable in the real world.



B: Typical achievable bend radius

### Bending metal and bend radius

FIG 1 (B)

**Consequences:**

Sheet metal stretches during forming to some degree and the manufacturer must consider this when fabricating the enclosure. It is a function of tooling, metal thickness, bend radius, and metal composition. Metal composition varies somewhat with even the best quality metal from the best suppliers and as a result, there is always a certain tolerance on dimensions when bends are involved. Manufacturers will supply standard tolerances on request.

Generally, cutouts should stay a minimum distance from bend radii in order to avoid deformation and wrinkling of the enclosure during forming. See Fig 2 below. Strictly speaking the cutout need only avoid being on the bend, but in practice, an exclusion zone of 1/16" is suggested to allow for mfg tolerances.

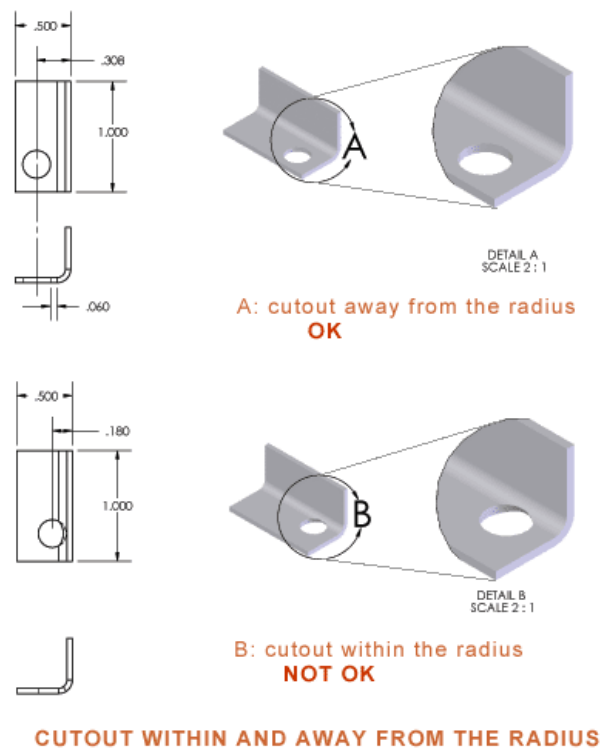
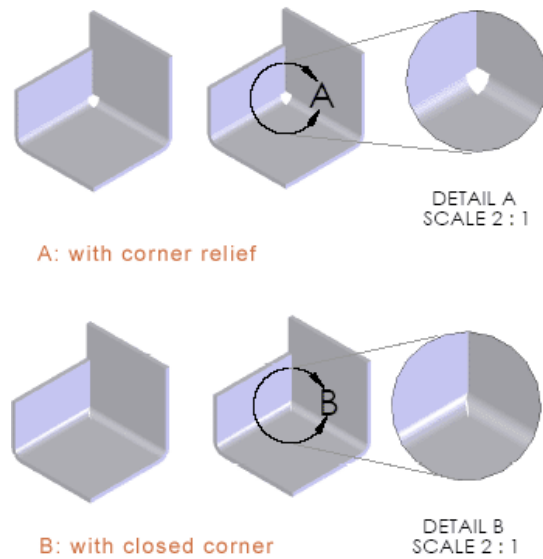


FIG 2

Special consideration must be given to the intersection of two bend lines, i.e. a corner of an enclosure. Specifically, extra material must be removed in order to prevent bends from interfering with each other and is called a corner relief. See FIG 3 below. This is done automatically in ProtoCase templates, but must be considered when designing enclosures from scratch.



**CORNER RELIEF**

FIG 3

**Self-Clinching Fasteners**

Self-Clinching fasteners are threaded nuts, studs, or standoffs that are mechanically pressed into sheet metal to provide solid fastening points. Nuts can be used to accept bolts, standoffs can be inserted for mounting circuit boards and studs can be used for mounting connectors. See FIG 4 below. They are sometimes referred to by the most common brand, called 'PEMS®', which is a trademark of Penn Engineering & Manufacturing Corp (<http://www.pemnet.com>). They are a very useful item and solve a lot of component mounting problems.

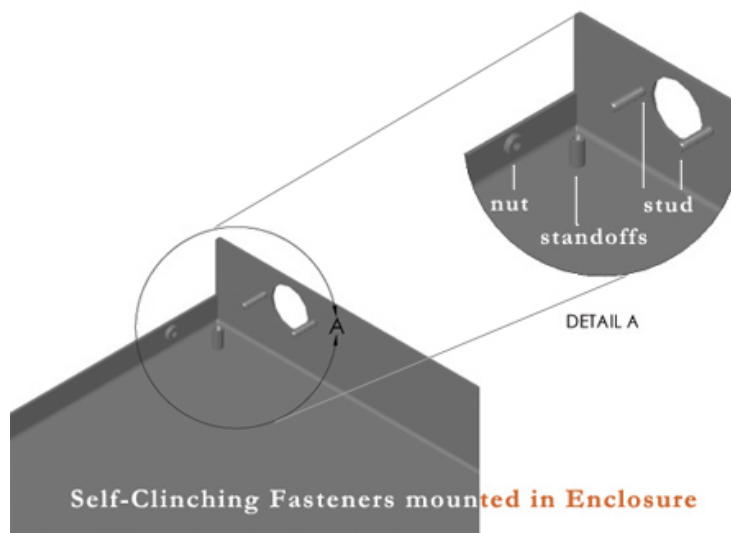


FIG 4 (A)

Protocase stocks a large assortment of self-clinching fasteners and will install for a very reasonable cost.

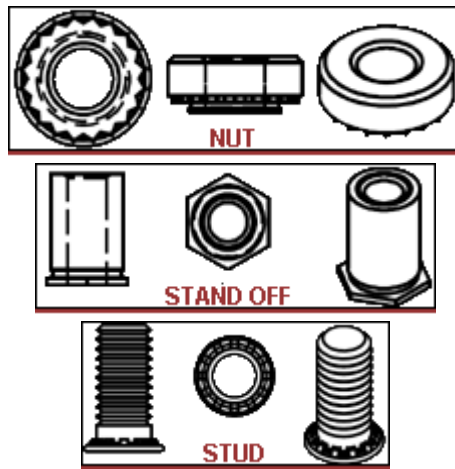


FIG 4 (B)

### Standard Stocked PEMs ®

Stand Offs - Sizes Stocked
<i>Thru Hole</i>
4-40 x 1/4", 5/16", 3/8", 7/16", 1/2", 9/16"
6-32 x 1/4", 5/16", 3/8", 7/16", 1/2", 9/16"
8-32 x 1/4", 3/8", 1/2",
10-32 x 1/2"
M3 x 3mm, 4mm, 6mm, 8mm, 14mm
M4 x 6mm, 12mm
M5 x 12mm
<i>Blind</i>
4-40 x 5/16", 3/8", 7/16", 1/2", 9/16", 5/8", 11/16", 3/4"
6-32 x 5/16", 3/8", 7/16", 1/2", 9/16", 1"
8-32 x 5/16", 1/2"
10-32 x 3/8", 5/8"
<b>Nuts - Size Stocked</b>
2-56, 4-40, 6-32, 8-32, 10-32, 10-24, 1/4-20
M3, M4, M5, M6
<b>Studs - Size Stocked</b>
2-56 x 1/4", 1/2"

4-40 x 1/4", 3/8", 1/2", 5/8", 3/4"
6-32 x 1/4", 3/8", 1/2", 5/8", 3/4"
8-32 x 1/4", 3/8", 1/2", 5/8", 3/4"
10-32 x 3/8", 1/2"
10-24 x 3/8", 1/2"
1/4-20 x 1/2", 1"
M3 x 8mm, 10mm, 12mm, 15mm, 18mm
M4 x 8mm, 10mm, 12mm, 15mm, 18mm
M5 x 12mm
M6 x 12mm

## Welding

Depending on the user's particular application, spot-welded enclosures or fully seam-welded enclosures may be desirable. With many enclosure designs, such as our standard U-shape (clam shell), no welding is required. One section of the enclosure contains small flanges with self-clinching nuts and the other section of the enclosure is fastened using mechanical fasteners such as machine screws or sheet metal screws.

However, in some cases welded flanges are desired. Spot welding would be used in cases where disassembly is not required. Fully seam welded edges may also be a requirement, especially if the application requires a more tightly sealed enclosure. Protocase offers both spot-welded and fully seam-welded enclosures.

## Finishing

### ***Powder Coating***

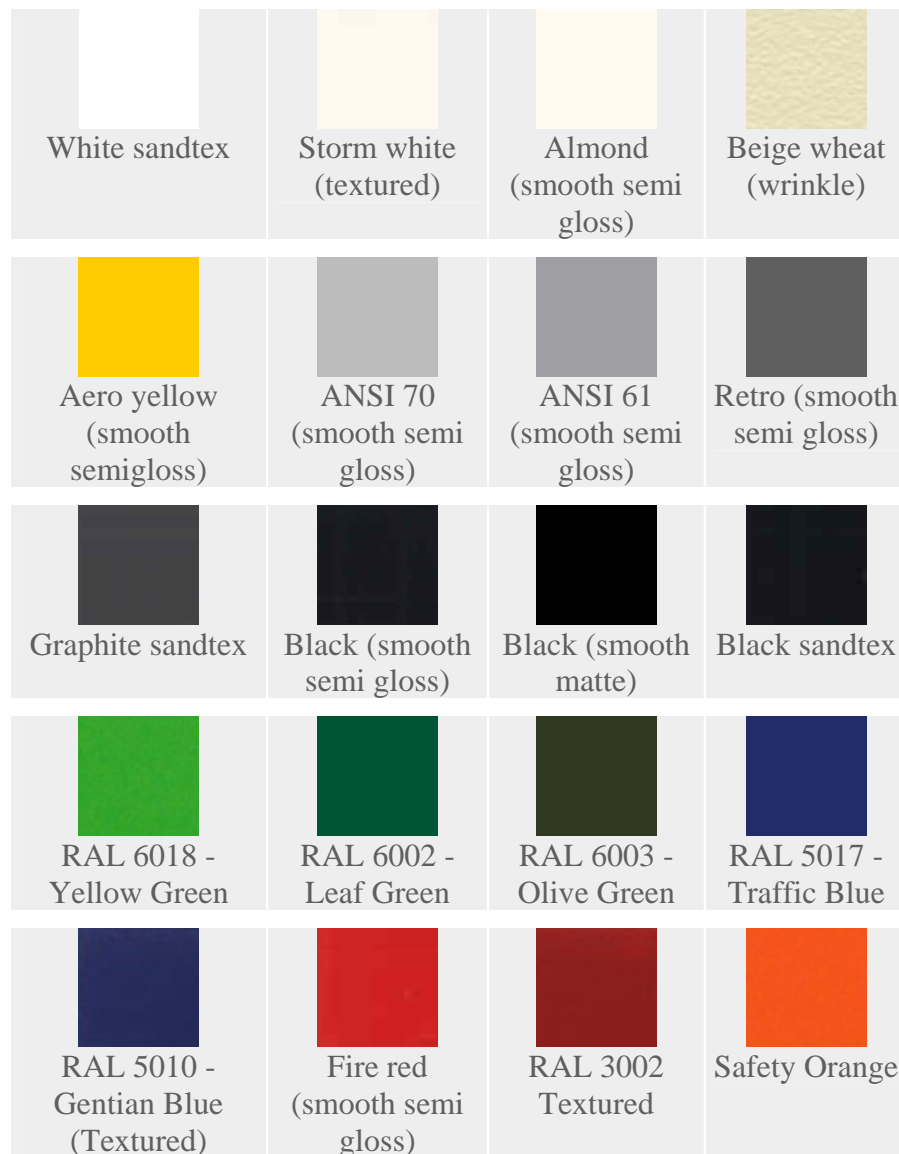
The standard finishing offered by Protocase is powder coating. This is now widely recognized as the industry standard for painting metal, providing a high quality, highly durable finish. Protocase offers a variety of standard stocked colors and textures. There is no additional charge for using one of our standard stocked colors.

We can also provide fully custom colors for an additional fee (depends on the size and the quantity of the parts). Lead times for fully custom colors vary and may affect delivery. For more information please contact us.

Powder coat colors are identified by an RAL number. When specifying a fully custom powder coat colors please provide us with the RAL number. Click here for [RAL color chart](#).

### ***Stocked powder coat colors***

Note: The color representations below may deviate from the actual color due to variations in browser software, video cards, and monitors.



Stainless steel may be used bare without any finish. However, cut edges may have imperfect aesthetics, such as slight roughness or slight discoloration, and consideration should be given to 'molding' such edges by overlapping front panel components or adjacent surfaces.

Carbon steel can be finished in other ways for special purposes. For example, white or yellow zinc can be electroplated onto carbon steel to enhance corrosion resistance (this is very durable when used in combination with certain powder coats.)

### **Silk Screening**

Protocase completes the task of manufacturing fully finished, quality enclosures by offering silk-screening, a process that provides required labeling for connectors, switches, ports, etc., along with adding special graphics such as a company logo, product identifier graphics, etc.

Our silk-screening process utilizes the latest in screen preparation technology, as well as using durable epoxy based inks, ensuring a high resolution, quality finish. Protocase stocks a variety of standard colors, but can provide custom colors upon request.

The clarity of silkscreen can be greatly affected by the texture of powder coat used. Generally for best results it is recommended you use a smooth finish. Silkscreen will work on various textures and colors but each situation is unique. This may require modifications to your silkscreen such as changing of fonts and thickening of fine lines. For more information, please contact tech support at [tech@protocase.com](mailto:tech@protocase.com).

Images such as company logos must be provided electronically. Faxed images will not provide sharp enough resolution for our process to replicate. If text-only screening is required, simply provide information's such as font type, font size, font color etc by fax or e-mail. Our tech support team will be happy to produce the required text-only screens.

### ***Silk Screen samples***



Traxi Technologies



X-Ray Imaging Solutions



Stanford University

### Adding company logo's, ventilation, and text as cutouts

Protocase provides custom cutouts to mount connectors, displays, switches, etc. There are very few limitations to the cutouts we can provide. For the most part, if you can draw it, we can provide it.

Protocase offers clients the ability to be very creative with cutouts. In some cases we can provide your company logo or name cut out in your enclosure.

We are also creative with ventilation cutouts. You no longer have to settle for conventional straight-line ventilation cutouts.

### Cutout Samples

Circular Ventilation Cutout



Celtic Ventilation Cutout



Scion Logo Cutout



Honda Logo Cutout



Traxi Technologies Logo Cutout

EPIACENTER.com Name Cutout



www.advancedglazings.com Cutout

www.protocase.com Name Cutout



### Questions / comments

If you still have questions or comments please do not hesitate to contact us at [tech@protocase.com](mailto:tech@protocase.com) or 1-866-849-3911 (toll free US & Canada).