RF Enclosure Design Concepts

for Electrical Engineers

Jamie Howton
Chief Technical Officer

http://www.fotofab.com
https://www.linkedin.com/company/fotofab
https://www.facebook.com/fotofabllc

Email: jhowton@fotofab.com
Business cellphone: 630-715-3801
Tel: 773.463.6211

https://www.linkedin.com/in/jamiehowton

What is an RF Shield?

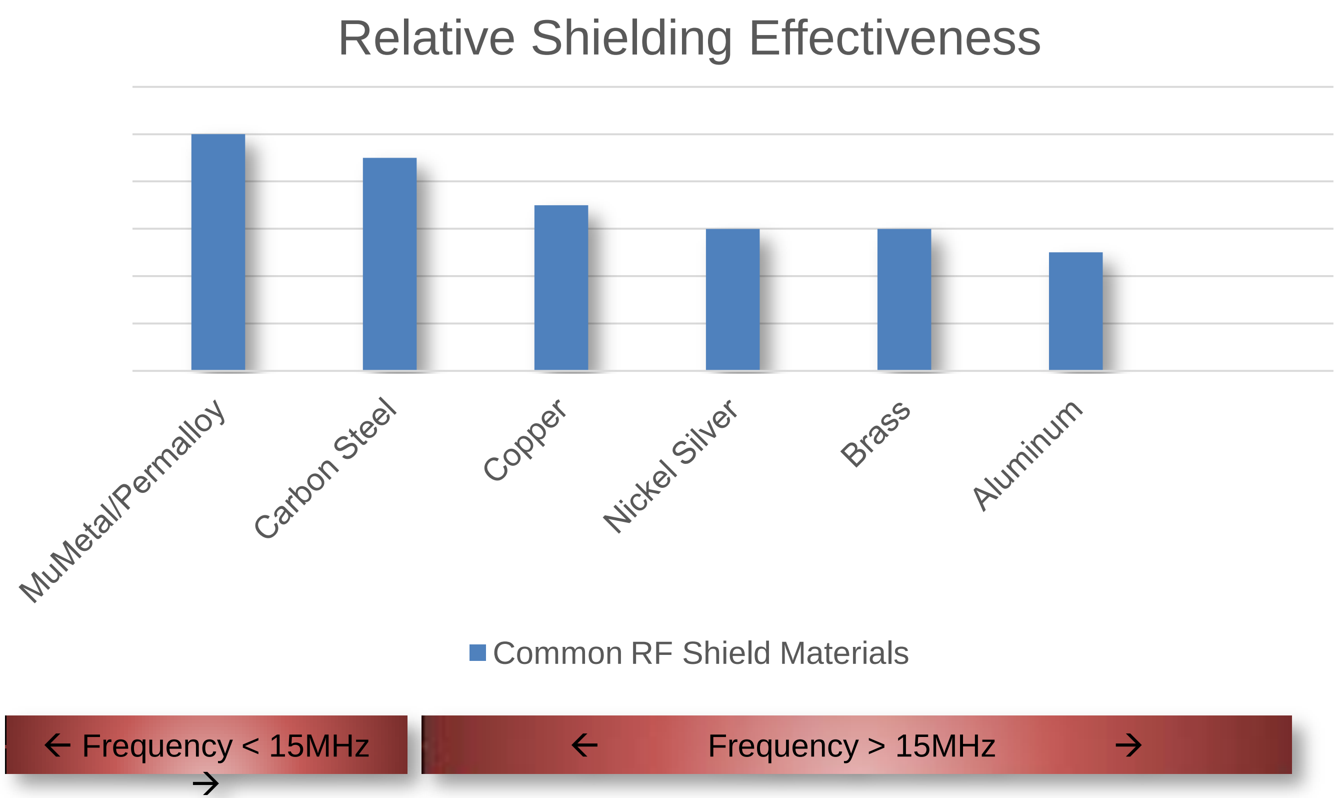
- Faraday Cage – Invented by Michael Faraday in 1836 “Ice Pail” experiment.
  - Based upon earlier work by Benjamin Franklin in 1755.
  - Usually a metal box or mesh.

- External electric field causes a distribution of the electric field within the conducting material of the cage such that they cancel the field’s effect inside the cage.
- Also works in reverse, preventing electric fields from leaking out of the shield

- Electrically conductive material shields better than less conductive material
- Holes in the shield must be smaller than the wavelengths to be shielded against
- Board Level Shield must be electrically grounded
  - Not true if the external enclosure of a product is the shield.

External Reference: https://en.wikipedia.org/wiki/Faraday_cage

Board level shielding material selection guide



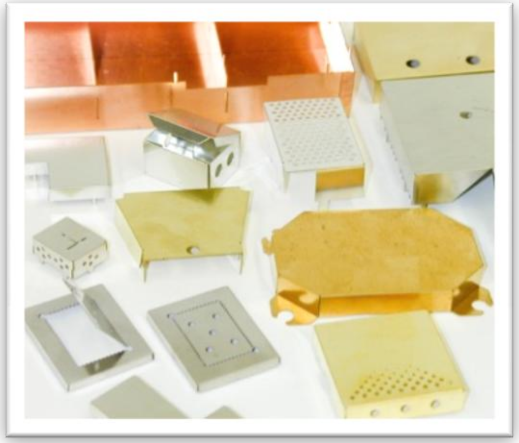
Online Resource:

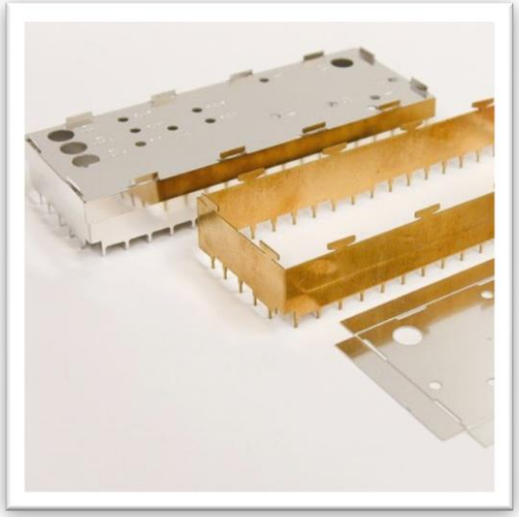
Board level shield Material Selection Guide
http://www.fotofab.com/dg_shielding.php

Board Level Shield Types

- Single piece
  - A shield made from a single piece of metal
  - Sides “fold down” from top
  - Can have almost any number of sides
  - Etched, stamped or drawn
  - Soldered to board, not easily removable

- Two or more pieces
  - Base(fence)/cover(lid)
  - Internal dividers – soldered, spot-weld or interlocking tabs
  - Fence soldered to board, cover is removable





Bend construction methods

Full thickness bends

- More closely replicates stamping
  - Stiffness, tolerances
- Requires tooling
- Lead time impact
- Cost impact in prototype quantities
- Inside radius > 2 x thickness

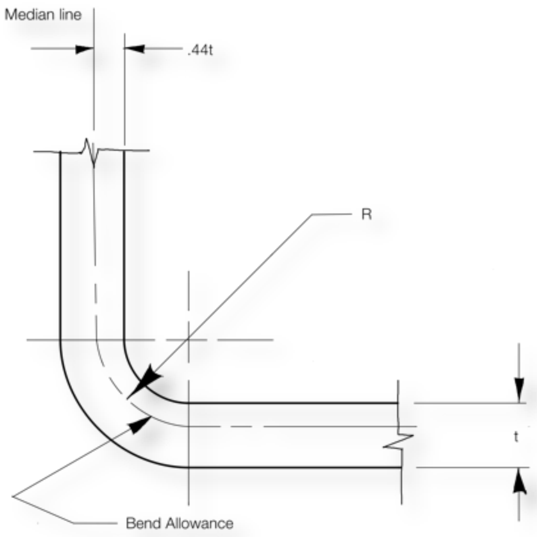
- Stamping – Much lower part cost with tooling investment

"1/2-etched" bends

- Zero inside radius
- No bend tooling
- Very short lead time
- Bending labor only when needed
- Shipped and stored flat
- Complex geometries inexpensive
- Not as rigid, thinner bend area

Full-Thickness Bends

$$Kfactor\ is\ between\ .3\ and\ .5$$



$$Min\ Inside\ Bend\ Radius > 2t$$

$$R = Inside\ radius + .44t$$

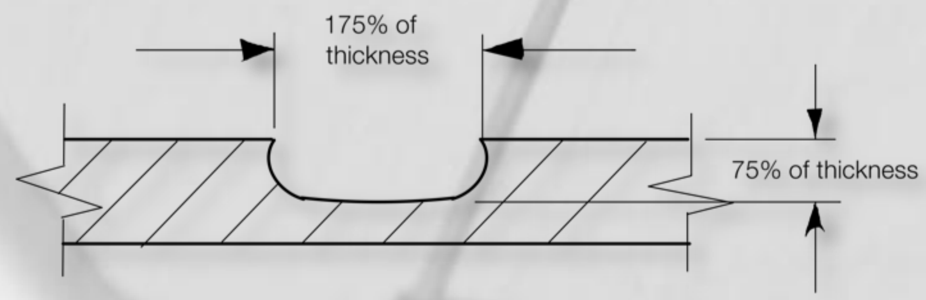
$$Circumference = 2 * \pi * R$$

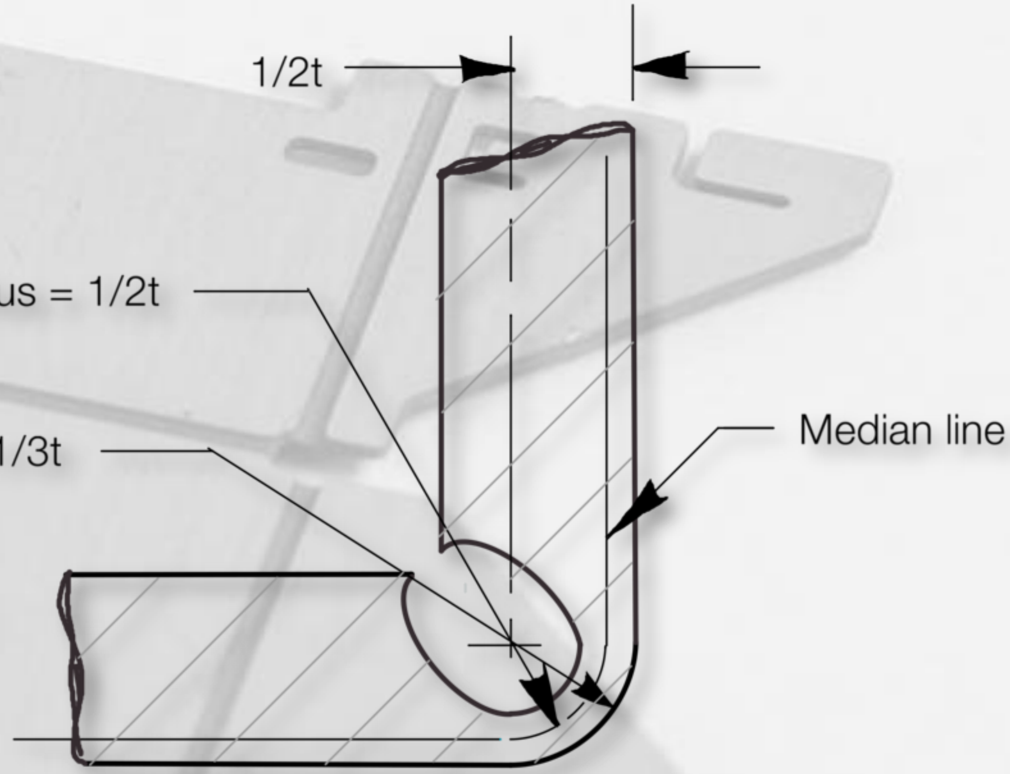
$$Bend\ Allowance = \frac{Circumference * Bend\ Angle}{360}$$

- Online resources:
  - Wikipedia: https://en.wikipedia.org/wiki/Bending_(metalworking)
  - Engineers Edge Sheet Metal Calculations: http://www.engineersedge.com/sheet_metal_calc.htm
  - Bend Allowance Calculator: http://www.custompartnet.com/calculator/bend-allowance

Pro-tip: *Find an M.E. with Solidworks or Pro/Engineer*
Buy them a case of beer…

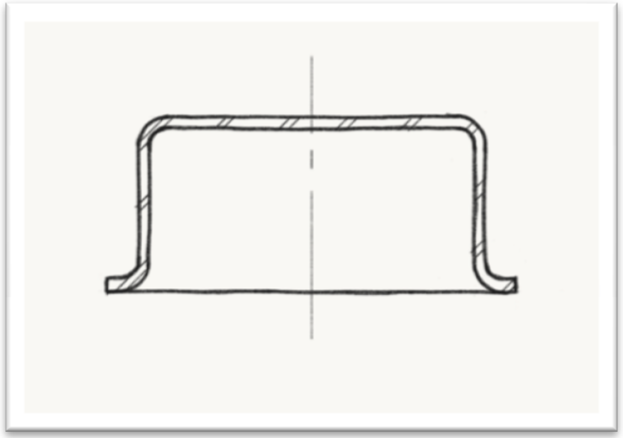
“1/2-Etched” bends



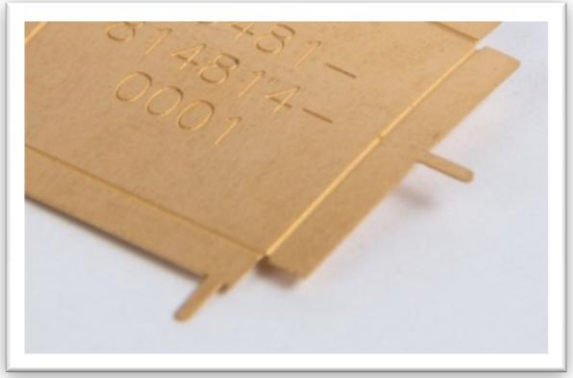


t = Overall Metal Thickness

Single Piece – stamped/drawn can

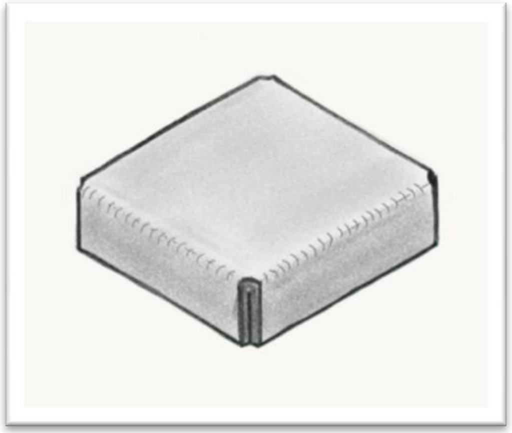


- Thinning of walls and top
- Flat within: .005” with bottom flange
  +/-.005” without flange



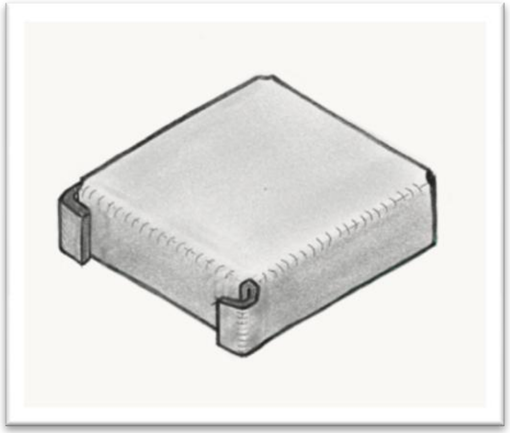
Single Piece Shields - Corners

- Pick a corner design – Vacant, inside or fold-over flap.
- Remember – Metal has thickness!!!
- Add bend Reliefs
- Clearances .003”/005”
- Leads? Where? Add reliefs?



Vacant

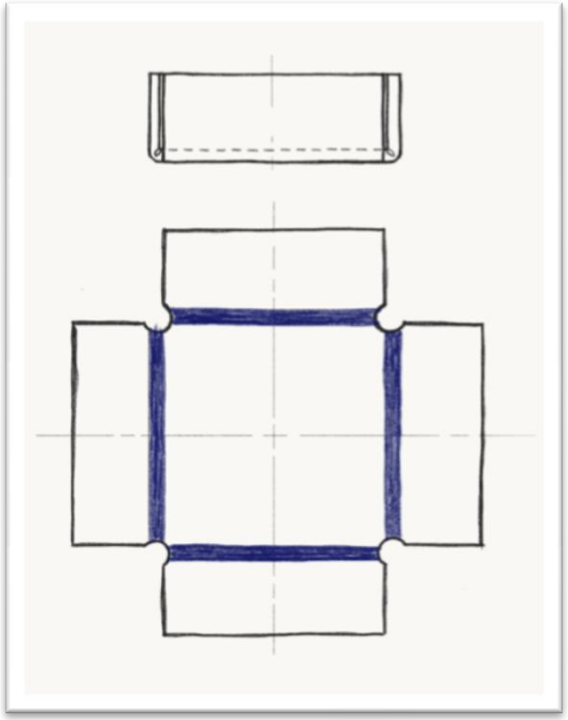
Inside



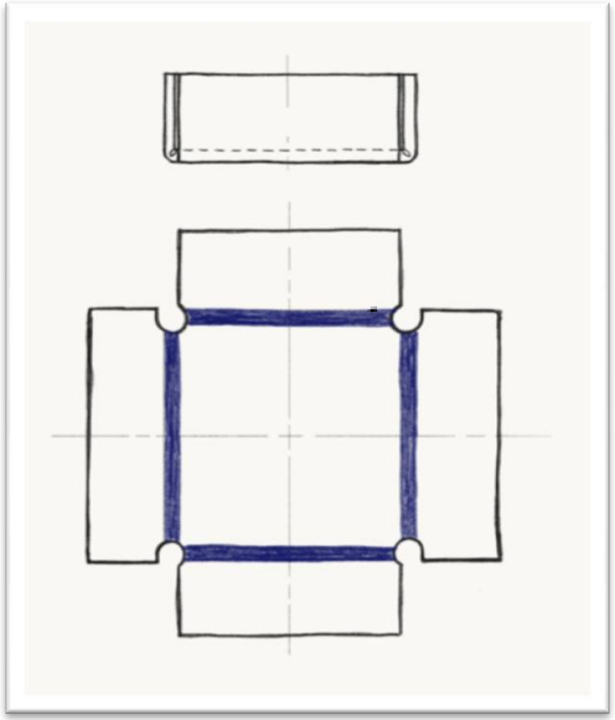
Fold-over

- Poor heat transfer during solder without holes
- Cleaning not possible after solder
- Repair/rework requires de-soldering shield

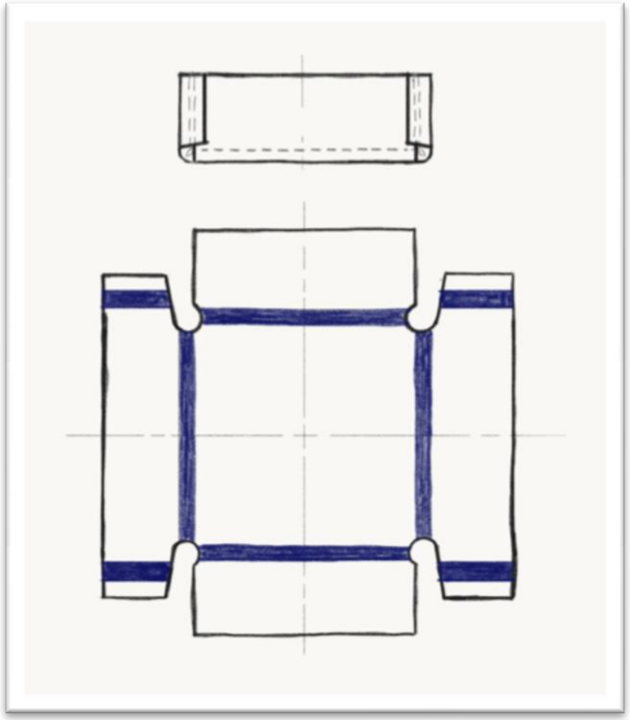
Single piece Shields - Blanks



Vacant Corners

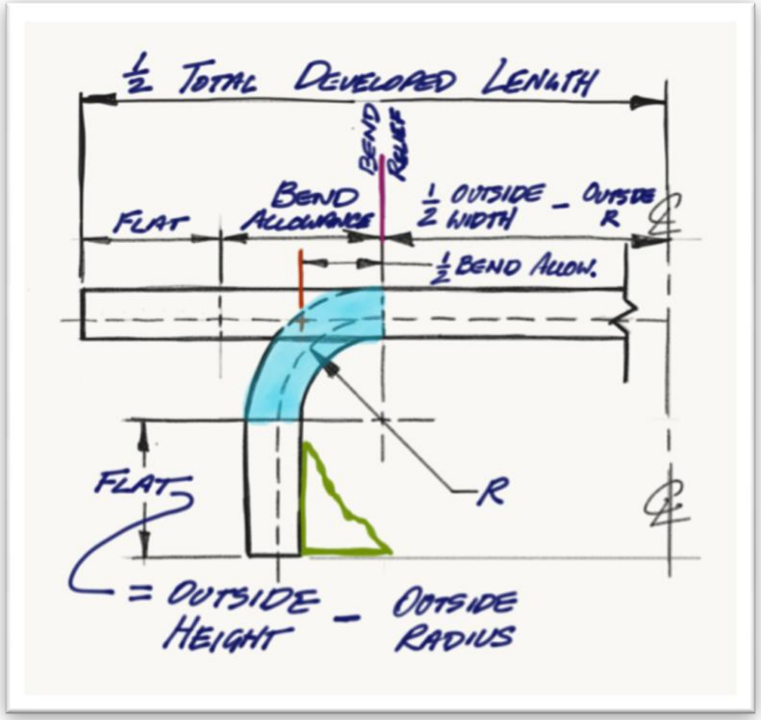


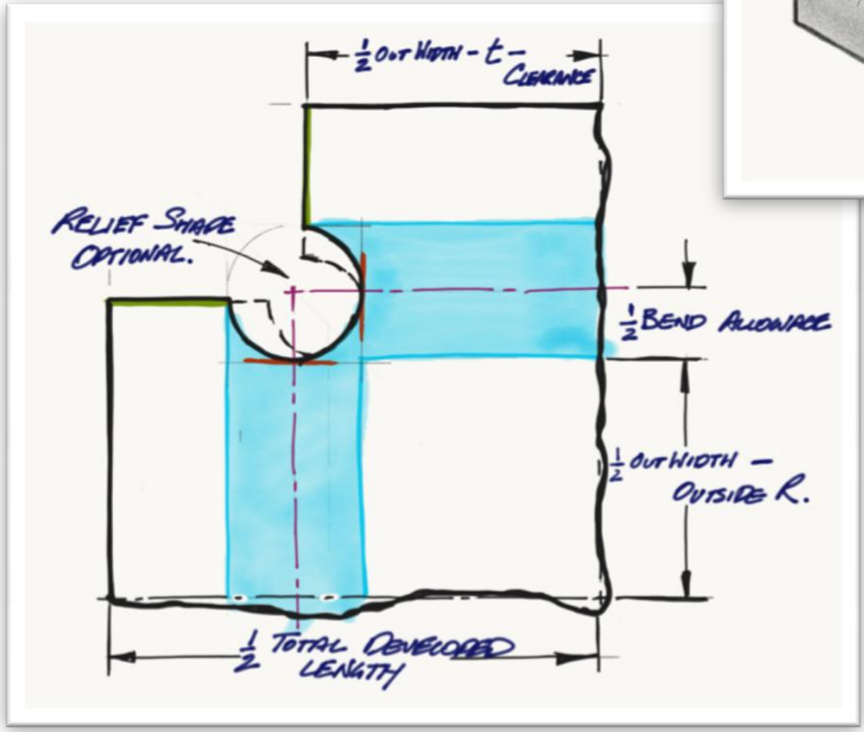
Inside Corners

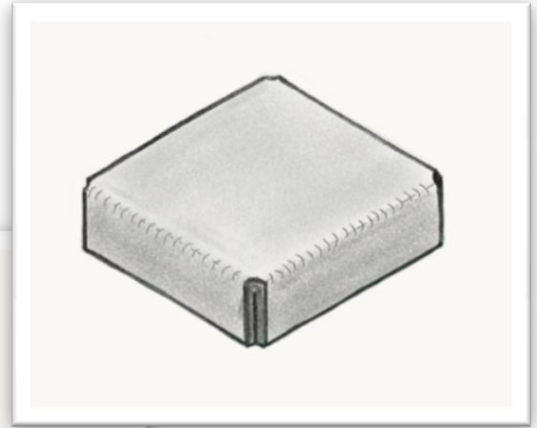


Fold-over Corners

Bend reliefs and total developed length

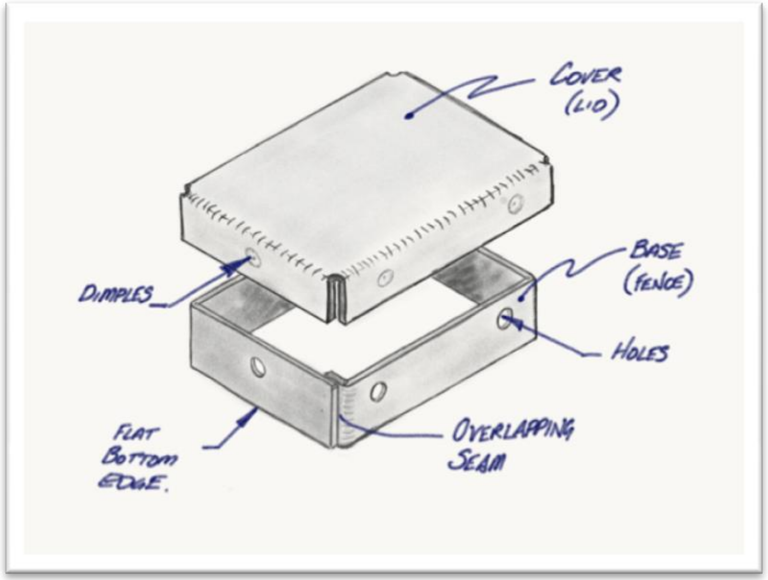


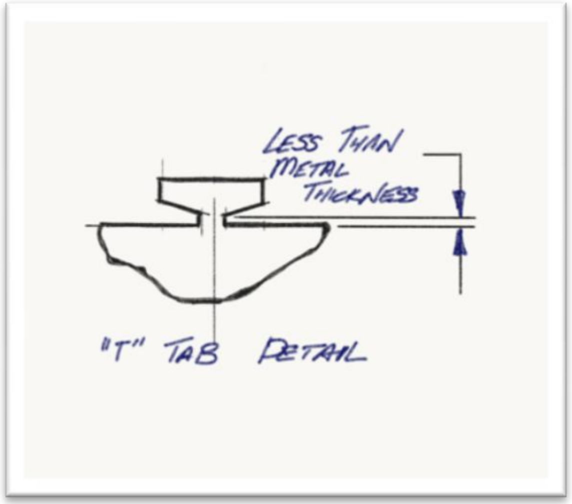


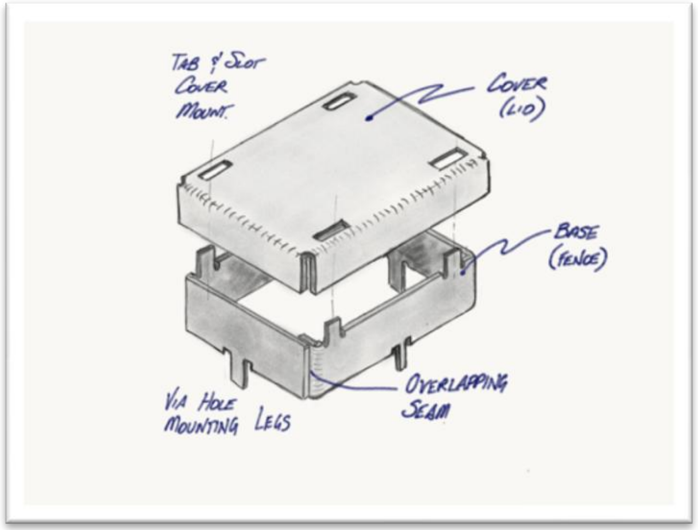


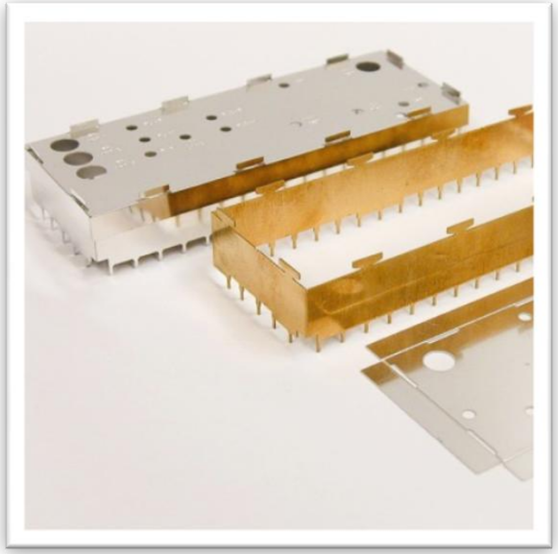
- Metal has thickness
- Features add cost
- Bends add length

Two-Piece Shield - Base(Fence) & Cover(Lid)

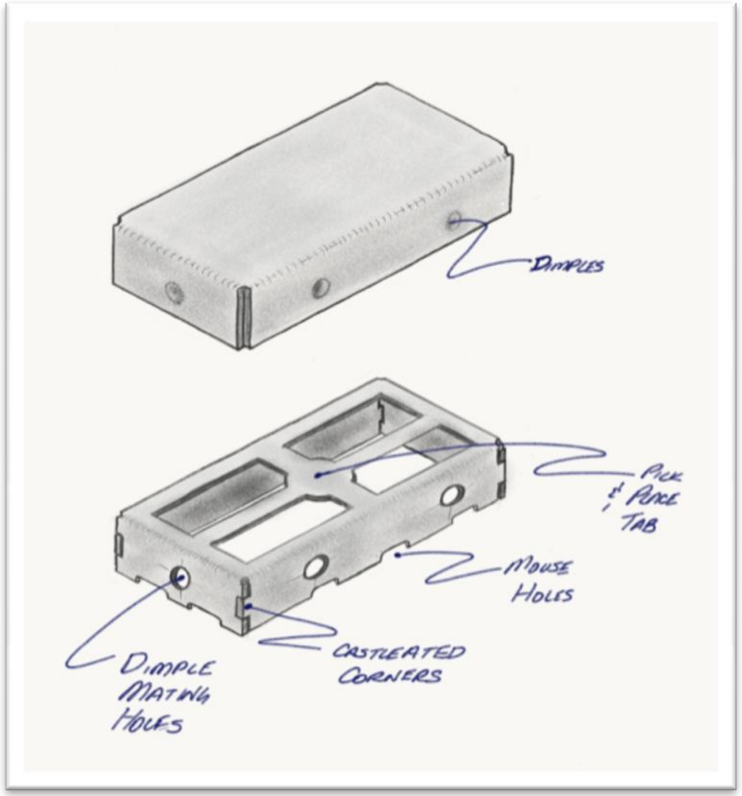


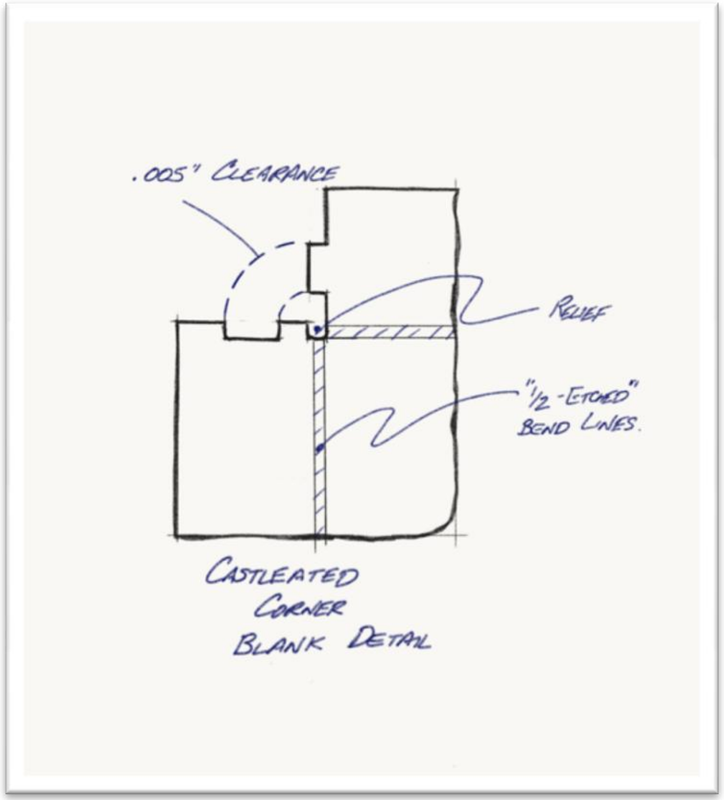


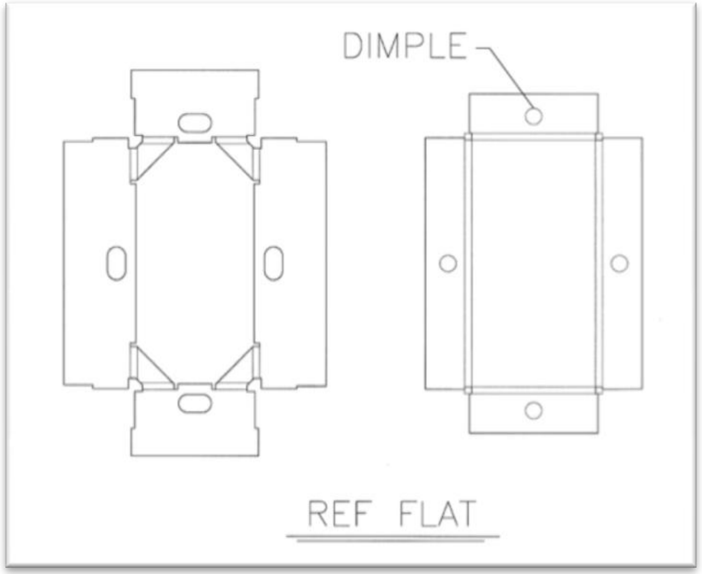


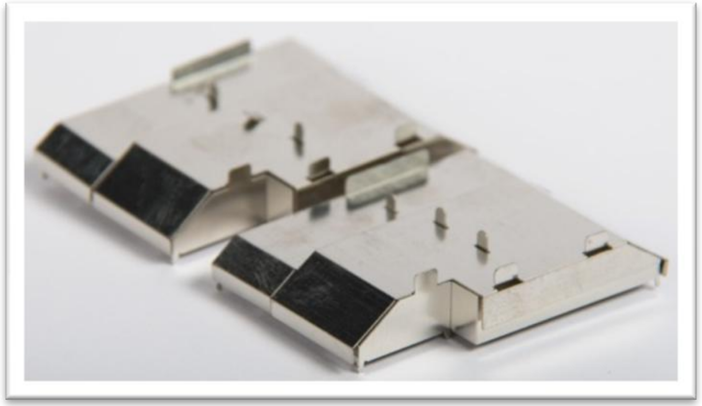


- Better heat transfer during solder
- Better cleaning after solder
- Repair/rework is possible









Two-Piece Shield – fold-down base and cover

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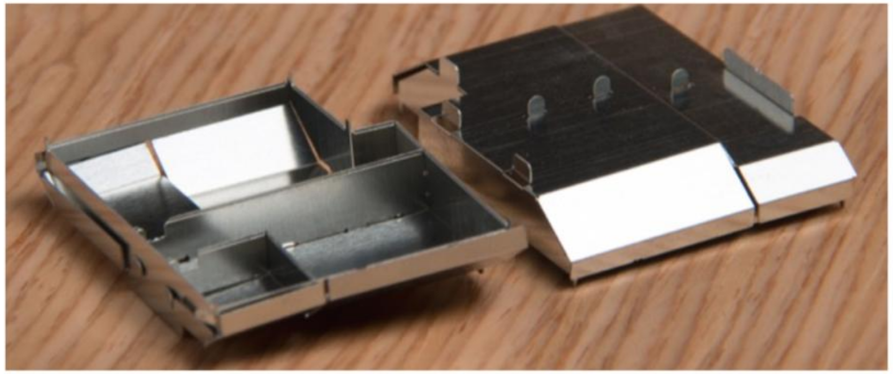
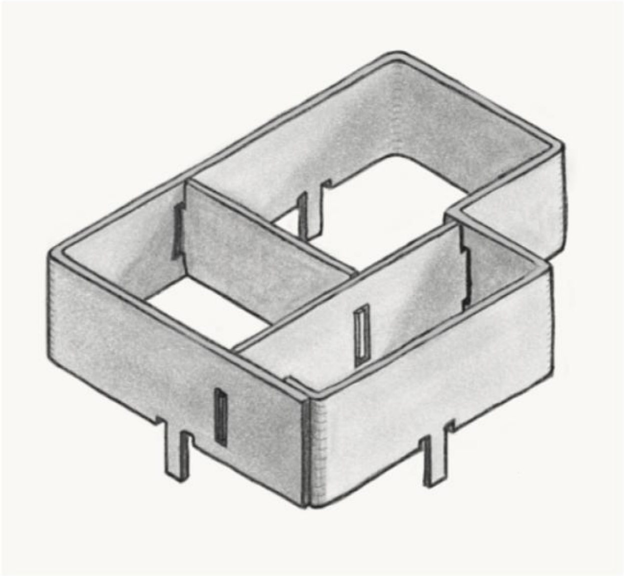
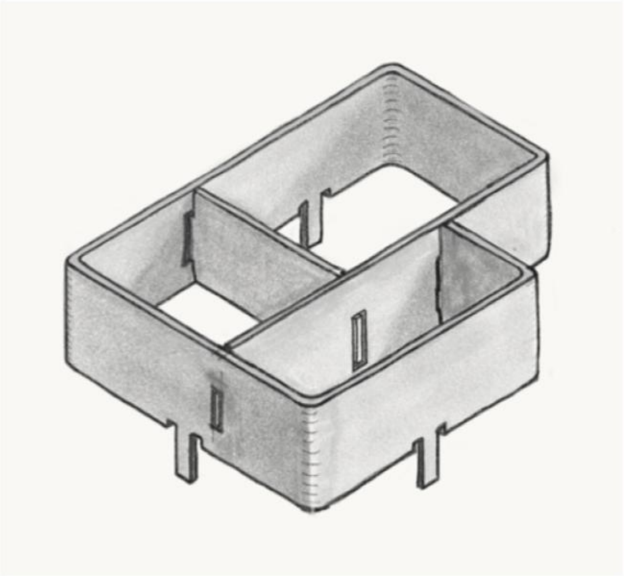
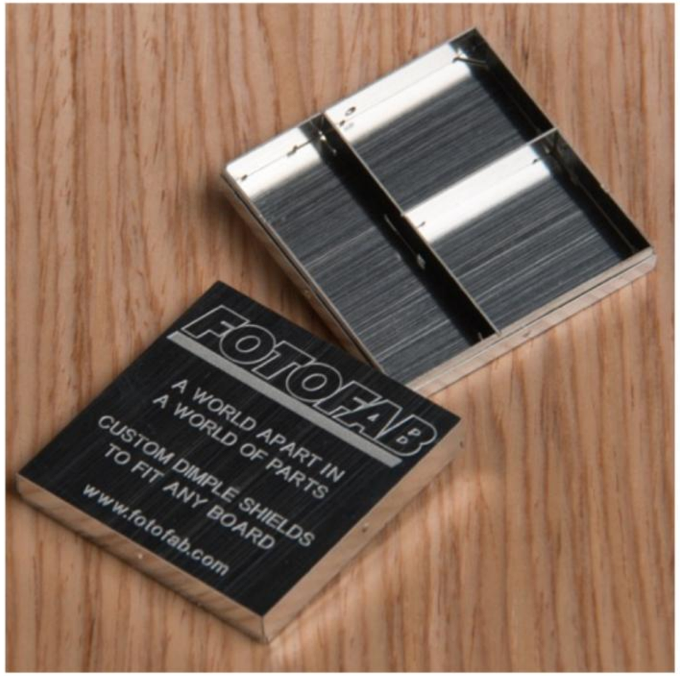






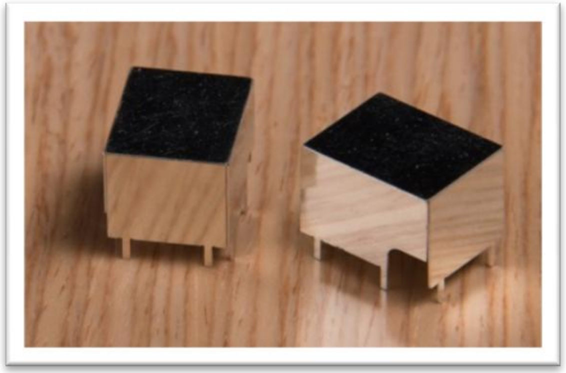


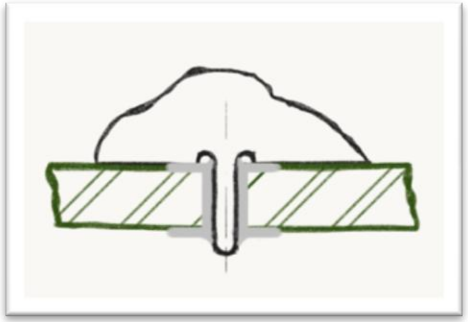
Internal walls/Dividers

- Creative bending
- Insert - Thru tabs
- Insert - Soldered
- Insert - Welded

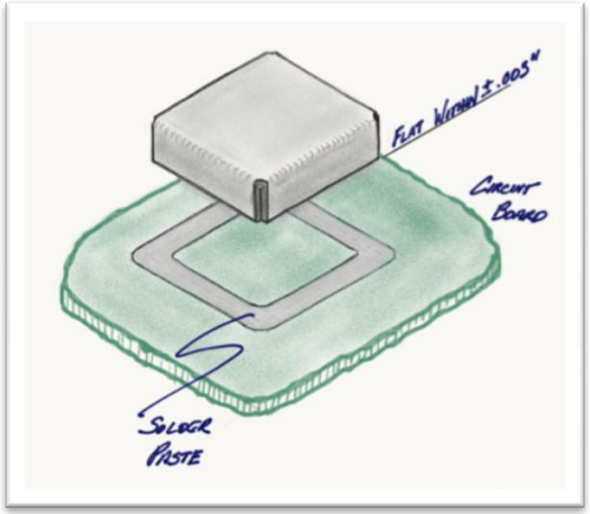
Board Mounting Solutions

Via hole leads

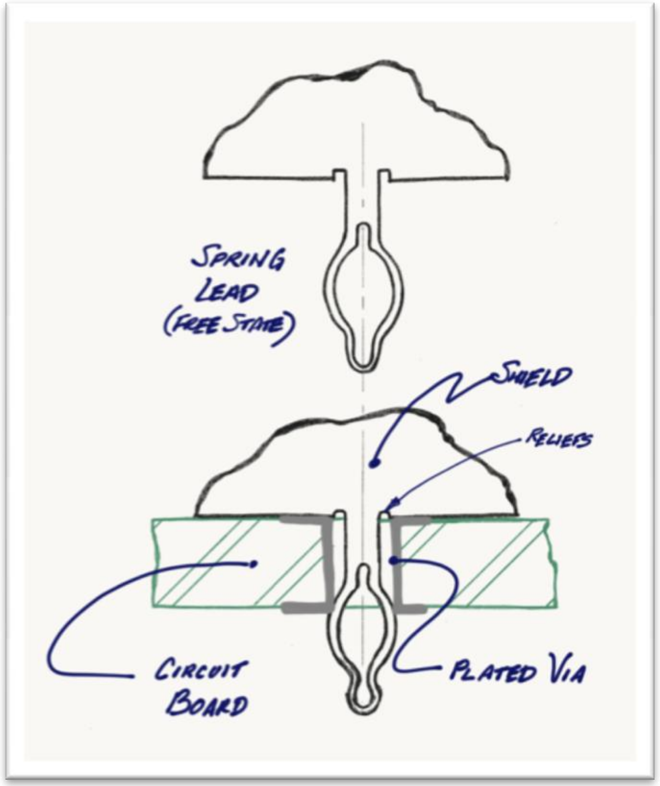




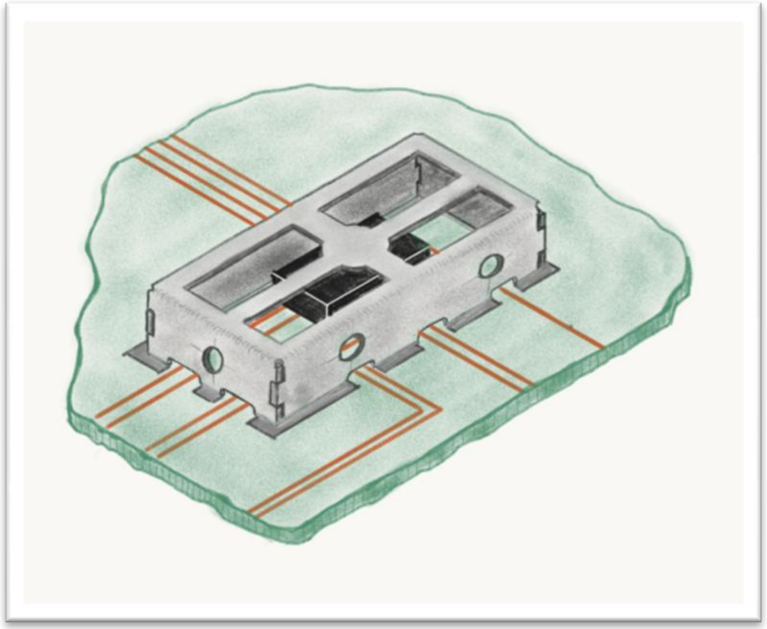
Surface Mount (SMT)

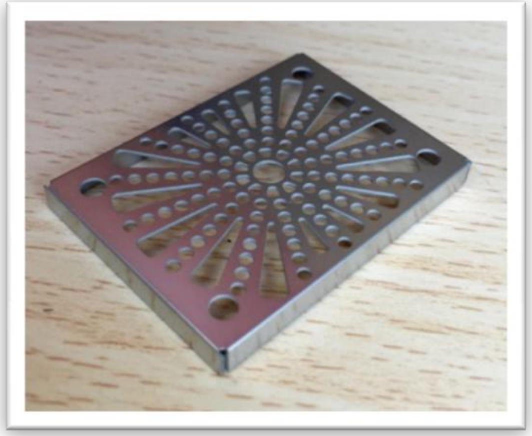


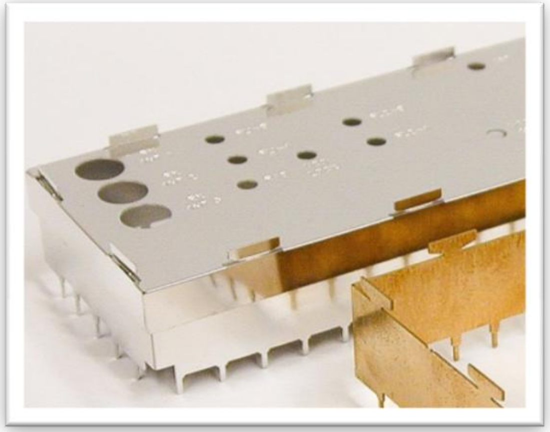
Spring leads

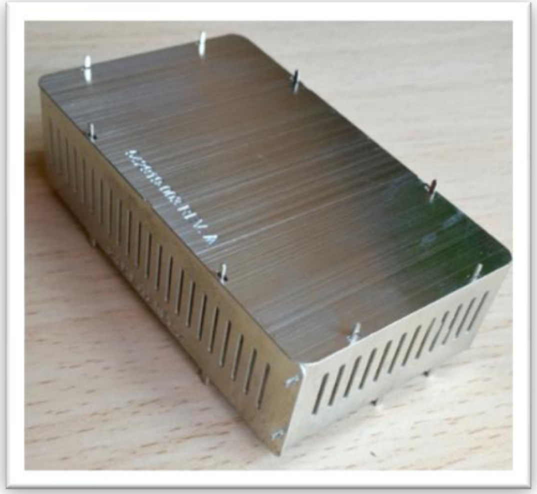


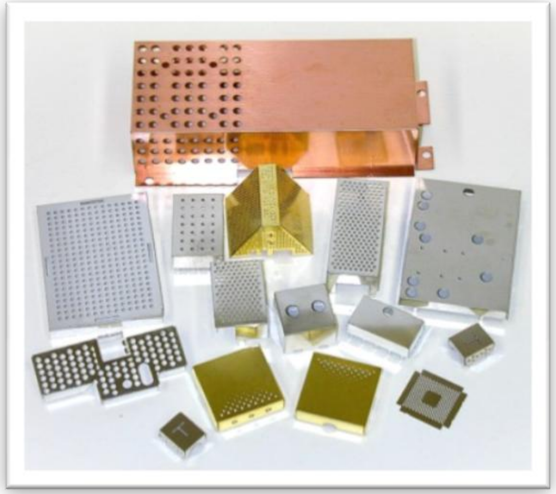
“Mouse” and other holes











Mouse holes:

- Openings for circuit traces through shield
- Better heat exchange during re-flow
- Better cleaning after re-flow

Electroplating

- Electroplating enhances:
  - Solderability
    - Nickel Silver – no EP required with Active Flux
    - Copper and Brass - enhanced
    - Steel, MuMetal – EP Required
  - Corrosion resistance
    - The corrosion resistance of most good shielding materials is poor.
  - Appearance
    - In all cases.

Common electroplated finishes for shielding:

- Tin (*ASTM B545, MIL-T-10727)*
  - *Lead free or Tin/Lead*
  - *Bright or dull finish*
  - *Reflow*
- Nickel Sulfamate – (*AMS-QQ-N-290, ASTM B689, QQ-N-290, MIL-P-81728)*
  - *Dull finish*
  - *Excelent for solderability and ductility*
  - *Base plate for Tin*
- *Electroless Nickel (AMS-2404, ASTM B733, MIL-C-26074)*
  - *Delicate finish, absorbs oil*

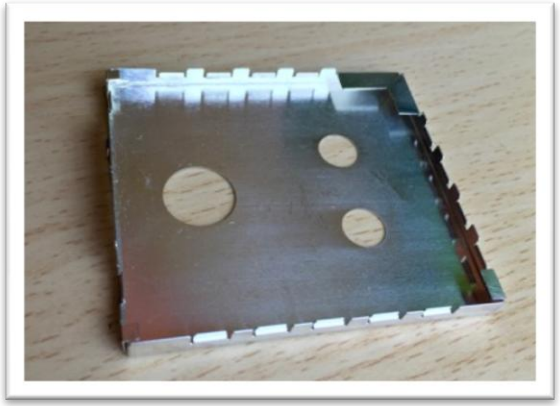
Watch out for:

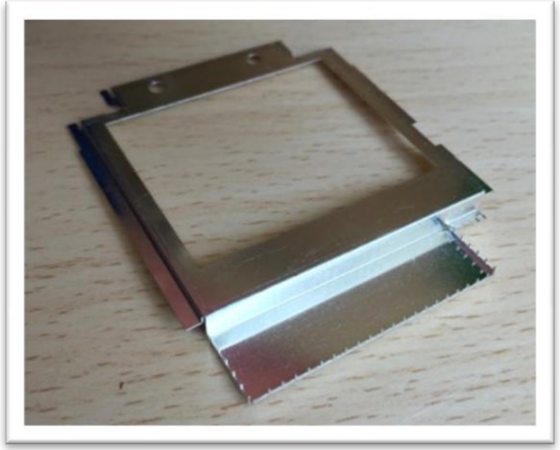
- Nickel Sulfate – “Brite Nickel” (*AMS-QQ-N-290, ASTM B689, QQ-N-290, MIL-P-81728)*
  - *Bright and shiny but not very solderable and very brittle.*

  - *RoHS? Specify a compliant finish.*

Online resources:

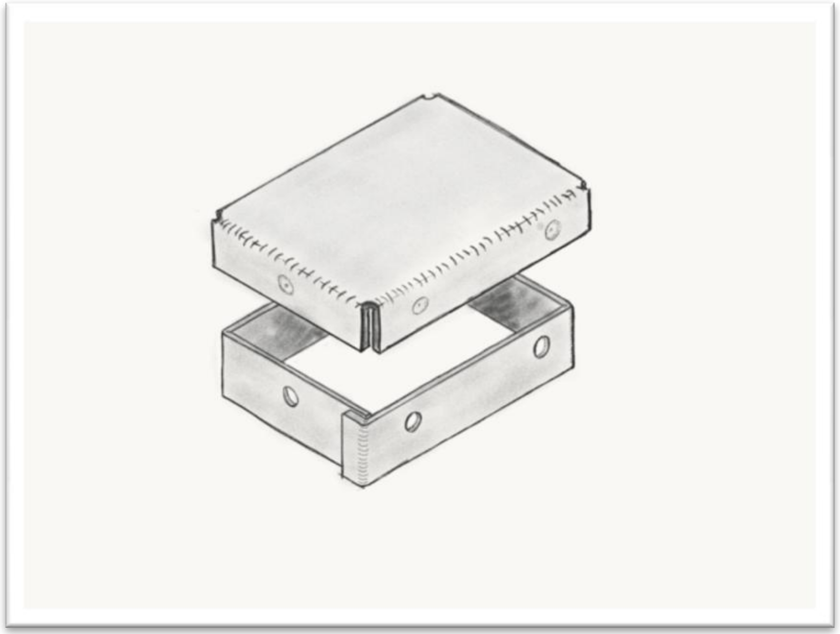
- RF Shield Design Guide
  http://www.fotofab.com/dg_shielding.php
- Wikipedia RF Shielding:
  https://en.wikipedia.org/wiki/Electromagnetic_shielding
- In Compliance Magazine “The Basic Principles of Shielding”
  http://incompliancemag.com/article/the-basic-principles-of-shielding/
- Wikipedia Metal Bending:
  https://en.wikipedia.org/wiki/Bending_(metalworking)
- Engineers Edge Sheet Metal Calculations:
  http://www.engineersedge.com/sheet_metal_calc.htm
- Bend Allowance Calculator:
  http://www.custompartnet.com/calculator/bend-allowance
- Ask Fotofab Engineering a question:
  engineering@fotofab.com
- Ask Jamie Howton a question:
  jhowton@fotofab.com





Question Time

Me first, what's wrong with this drawing?



Thanks for attending!

Don’t miss our Test Bootcamp!
November 16, 2016
www.emclive2016.com