

## DESIGN GUIDE INTRODUCTION

P773.463.6211

Fotofab uses the photochemical machining process to produce a wide variety of precision industrial parts in thin metal economically and quickly.

This special "Design Guide to Photochemical Machining" was created specifically for those who are involved with the designing and/or purchasing of metal parts.

### The Design Guide provides you with:

- Engineering advantages of photochemical machining.
- Overview of our photochemical machining process.
- Considerations for the design of your thin metal parts.
- Considerations for your engineering drawings/sketches.

The information in the Design Guide provides you with considerations and general guidelines for designing metal parts to be made with Fotofab's photochemical machining process.

Fotofab offers free consultation and quotation for your specific designs. Our Technical Sales Staff is available to assist you with your specific metal parts requirements. By designing with an awareness of our process capabilities, you will minimize the cost and delivery time of your metal parts, whether for prototyping or production.

### Design Advantages

- Many intricate part geometries, like those found in fine resolution screens, can be photochemically machined easily and economically.
- Extremely thin metal can be machined without distortion; dimensional accuracy actually increases as metal thickness decreases.
- Physical properties of the metal, such as hardness, strength and formability, are not changed by the process.
- Brittle metals, which often fracture during conventional stamping, are machined without difficulty.
- Magnetically soft materials can be fabricated while retaining their optimum permeability.
- Parts are inherently free of burrs.

### Tooling and Delivery Advantages

- Tooling and set-up costs are extremely low compared to hard tooling.
- Initial quantities of newly designed parts can be produced on short notice - sometimes within days after the design is conceived.
- Revisions to part designs are similarly implemented quickly and economically.

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### Overview of the Fotofab Process

The Fotofab Process of photochemical machining (often abbreviated as PCM, and sometimes referred to as chemical milling or chemical etching) is a technique for manufacturing high-precision flat metal parts by chemically etching away the unwanted materials, using a photographically prepared mask (a Phototool) to protect the metal that is to remain after the etching process.

This process begins when we receive your engineering drawing or sketch that defines the precise characteristics of your part. We then utilize our CAD system and laser plot technology to generate an exact image of your part on a set of photographic films, called a Phototool. Depending upon the size of your part, the Phototool may contain from one to several thousand exacting images of your part.

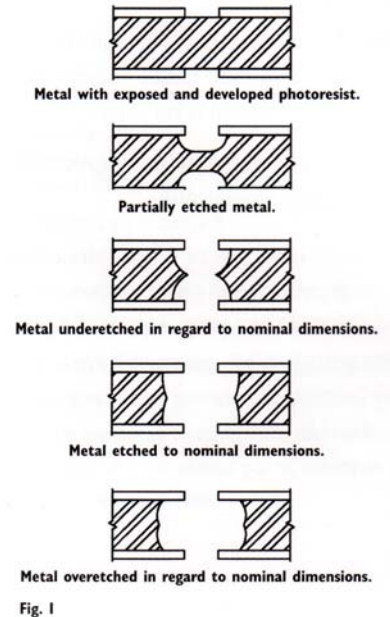
The Phototool is used to transfer the images of your part photographically to a sheet of clean flat metal which has been coated on both sides with a photosensitive, etchant-resistant polymer called photoresist. The result of these processes is a sheet of metal that is covered with photoresist over only that metal that will eventually become your parts.

The sheet is then sprayed with a heated etching solution. The metal not covered by the photoresist is dissolved, leaving precisely the parts that you specified. (Refer to Figure 1 below, which illustrates a progression of etching levels.)

### Design Considerations

As you proceed with the design of your metal part, the following considerations will help you take full advantage of the Fotofab Process.

- Material Selection
- Part Geometry Considerations
- Process Capabilities
- Tolerances
- Selective Etching
- Tabs
- Data Creation and Transfer



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# MATERIAL

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### Metal Alloy Type

Fotofab's process is capable of producing your part from over 50 different metal alloys, including:

Alloy 42	Molybdenum
Alloy 48	Monel
Aluminum	MuMetal
Beryllium Copper	Nickel
Brass	Nickel Silver
Copper	Permalloy 80
Hastalloy	Phosphor bronze
Hy-mu 80	Silicon steel
Inconel	Spring steel
Invar	Steel
Kovar	Stainless Steel
Metglas	Titanium

Call or Email us to discuss metals not listed.

### Metal Alloy Temper

Most metal alloys that Fotofab can etch are available with different tempers. These tempers determine some physical properties of the metal. The physical requirements of your part will dictate the temper of the metal you decide to use.

### Metal Thickness

Fotofab can produce your part from sheets of metal ranging in thickness from .0005 inch (0.013 mm) up to .062 inch (1.575 mm). Metal thickness tolerance often varies with the metal thickness; generally, the thicker the metal, the larger the thickness tolerance associated with it.

Fotofab stocks a wide selection of metals with various tempers and thicknesses. It is likely that we can meet your metal requirements from our stock. Our formal Lot Control Program allows us to trace each of your parts back to its certified metal source.

Fotofab metallurgists are available to help you select the most appropriate metal for your application.

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# GEOMETRY

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### Overall Part Size

Fotofab typically produces parts from metal sheets that measure 12 inch (305 mm) by 18 inch (457 mm). The overall size of the parts we make can vary from a single part occupying an entire sheet to those yielding several thousand pieces per sheet. Depending on the metal required, the largest part we can manufacture is 19 inches (482 mm) by 38 inches (965 mm). The smallest part that we can make is dependent on the parts geometry and thickness.

### Part Configuration

The Fotofab Process places no limit on the complexity of your parts configuration as long as the dimensions and tolerances along the plane of the part are within our capability, as explained in the next section.

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## DESIGN GUIDE CAPABILITIES

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There are limits to the dimensions and tolerances that can be machined along the plane of the metal sheet, since etchants used in the photochemical machining process concurrently etch metals laterally and vertically through the thickness (T) of the sheet.

Because the metal at the surface of a sheet is exposed to etchant longer than the metal at the center of the sheet, the surface of a part etches laterally more than metal at the center. The following planar dimensions are related directly to the thickness of that sheet.

### Hole Size/ Slot Width

The smallest hole diameter (D) or slot width that can be produced by the Fotofab process, as a general rule, is 1.2 times the metal thickness. The minimum practical diameter or slot width that can be machined is .005 inch ( 0.13 mm).

### Bar Widths

Spacing of metal between the holes and/or slots in a design is not an issue using photochemical machining. However, when a part contains holes and/or slots that are spaced closely together, such as with a fine resolution screen or encoder disc, the width of the metal that remains between them is referred to as the bar width (W).

With metals over .005 inch (0.13 mm) thick, minimum bar widths must generally be at least 0.9 times the metal thickness. With metals at or under .005 inch (0.13 mm) thick, the minimum practical bar width that can be machined is .003 inch (0.076mm).

### Radii

In the photochemical machining process, all corners in a part, whether within or along an outside edge, will have an associated radius. The examples of various part corners and angles illustrate how we can compensate for some radii, and will help you determine whether these compensations are appropriate for your design.

*(Continued)*

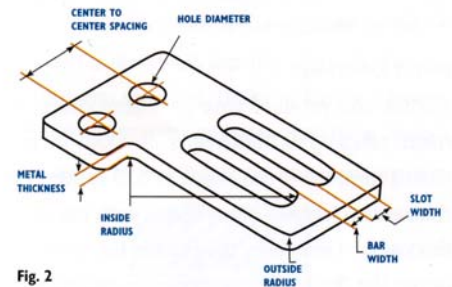


Fig. 2

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## DESIGN GUIDE CAPABILITIES

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### Example 1: Basic Inside and Outside Corner Radii

The diagram below illustrates various corners that are basic to many part designs. Using the photochemical machining process, the smallest inside radius (R) we recommend for a part design is approximately equivalent to the metal thickness. The smallest outside radius (r) we recommend is approximately equivalent to 0.9 times the metal thickness.

### Example 2: Sharp Cornered Objects

For most applications, basic inside and outside corner radii are suitable. If your design requires a sharp-cornered object to fit into a photochemically machined square hole, for example, we can compensate for radii by incorporating corner reliefs as shown here.

### Example 3: Corner Radii of a Narrow Lead

The Fotofab Process is well suited for making parts with narrow leads. The following figure illustrates the radii that will result at the base and end of the lead. If the base area of this lead needs to fit flush against another flat surface, we can compensate for the basic radii by providing the base of the lead with "relief radii" on either side.

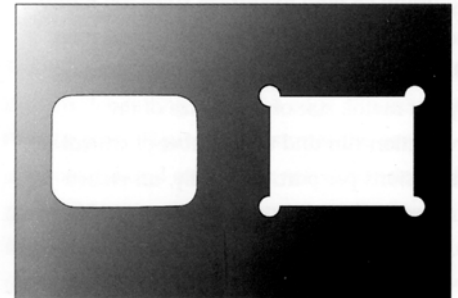


Fig. 3a.  
Rectangular hole as etched.

Fig. 3b.  
Rectangular hole with  
optional corner reliefs.

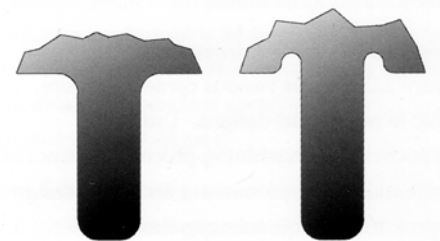


Fig. 4a  
lead as etched.

Fig. 4b.  
Narrow lead with optional reliefs

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# TOLERANCES

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### Center to Center Tolerances

Center to center accuracy is determined photographically, rather than by the etching process. This tolerance is typically considered to be within +/- .0005 inches (.013 mm) over 6 inches (153 mm).

### Etched Dimensional Tolerances

It is not possible to establish hard and fast rules regarding etching tolerances since so many factors are involved. Some of the variables that affect accuracy are: type of metal; size of sheet; size of the production run; and the number of critical dimensions per part. Typically, an etched dimensional tolerance of +/- 10% of the metal thickness is considered acceptable by the industry.

Parts that are designed with score lines for hand forming, such as RFI and EMI shields, are an exception to this guideline. The dimensional tolerance for hand-formed parts is approximately +/- .010 inch (.254 mm).

Dimensional tolerances for parts that are formed with hard tooling after photochemical machining have to be determined on a part specific basis by the fabricator.

Finally, dimensional tolerances for dropout parts are different than for parts that remain in the sheet. Refer to the section under "Tabs" for more information.

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# SELECTIVE ETCHING

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Fotofab can selectively etch your part so that any portion of it can end up approximately half the thickness of the original metal sheet. This technique gives you the option to have us chemically engrave the identification number or a company logo, for example, into your part.

Another selective etching option allows you to integrate bend (score) lines into your design. Applications that benefit from bend lines for easy manual folding include such diverse parts as complex screen enclosures and RF shields for surface mount boards.

You can also design larger portions of your part to be etched to approximately half the thickness of the metal. We refer to these selectively etched areas as step etched areas. You can take advantage of this option, for example, to provide a recessed area in a metal part to place and protect a self-adhesive label.

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## DESIGN GUIDE

### TABS

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To provide the tightest tolerances, we recommend that parts be tooled to remain within the metal sheet from which they are etched. The small amount of metal that is designed to bridge the part to its metal sheet is called a tab. Parts that are tabbed to remain in the sheet also allow for safer handling and easier inventorying.

Fotofab gives you the option of two different tab designs, depending on the edge requirements of your part. The upper figure to the right illustrates the general appearance and maximum tab dimensions of a part held to the sheet by an external tab after it has been removed from the sheet. The lower figure illustrates the general appearance and maximum tab dimensions of a part held to the sheet by a recessed tab after it has been removed from the sheet.

For thicker metal parts, Fotofab can design a small score line etched into one side of either an external or a recessed tab to facilitate the part's removal from the metal sheet.

If your part's outside edge requirements are critical, we can produce the part without tabs. We refer to an untabbed part as a dropout part. The benefit of a dropout part is that it will not have a tab because the part does not remain in the metal sheet during etching. However, a dropout part can be etched less consistently than a tabbed part, and therefore has a guaranteed dimensional tolerance of approximately +/-15% of the metal thickness with an absolute minimum of +/-0.003".

Depending on the strength of the metal chosen, typically only a part that is thicker than .010 inches (.254 mm) is a candidate for a dropout part. Note that a dropout part is more expensive to handle, inspect and package than a tabbed part, so consult with us prior to selecting this option

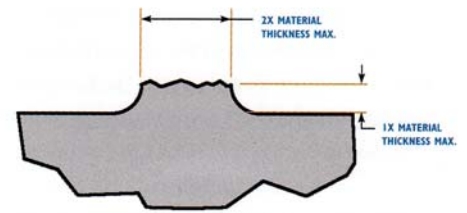


Fig. 5a External tab.

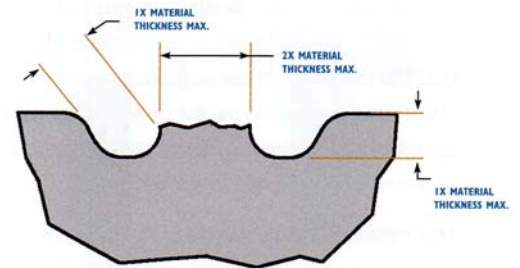


Fig. 5b Recessed tab.

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**DATA**

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Fotofab drafting engineers have experience working with customer drawings ranging from E-size prints to hand drawn sketches to CAD files. You can use the following methods to communicate your drawing to us.

Send your dimensioned prints or sketches by fax: 773-463-3387

E-mail your CAD file in .dxf, .dwg or .pdf format:  
[engineering@fotofab.com](mailto:engineering@fotofab.com)

Large-format prints, diskettes or CD's can be mailed to:

3758 W Belmont Ave  
Chicago, IL 60618  
Attn: Technical Services Staff

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# SHIELDING DESIGN GUIDE

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Fotofab has helped our customers manufacture custom RFI/EMI shielding enclosures for over fifteen years. If you are considering a shielding enclosure for your project, the following considerations should ensure that your design is as comprehensive and robust as possible. Don't hesitate to reach our Technical Sales staff for advice beyond the scope of this list.

Fotofab will meet your shielding needs from the first prototype quantity to the largest production quantities. If your shielding enclosure may eventually be used in quantities of several thousand or more, please consult our Technical Sales staff as soon as possible, since our progressive die stamping may be the most economical way to produce it. In this case, our Technical Sales staff will want to explain the few differences in design that you will want to take into consideration during the prototyping phase.

### Metal

Fotofab manufactures RFI/EMI shielding enclosures for attenuating components ranging in operating (and harmonic) frequencies ranging from a few hertz to over 50 GHz.

The type of metal that you specify may have an impact on a shield's performance. In general, shielding against frequencies of 15 MHz or lower is a bulk material effect, and can best be served by employing a ferromagnetic metal such as steel. For greater attenuation at these lower frequencies, metals with high permeabilities and low core losses such as Permalloy 80® or MuMetal® are good candidates.

If the frequencies you are shielding against are greater than 15 MHz, shielding becomes less of a bulk material effect and more of a skin (conductivity) effect. At frequencies (and harmonics) of 900 MHz and above, almost any metal, including brass, nickel silver, copper and steel, shields similarly assuming a thickness of .002" (.05mm) or greater.

Consider specifying a metal alloy called nickel silver (55% copper; 27% zinc; 18% nickel; and not a speck of silver) for shields that will be hand soldered or re-flow soldered with flux. In these two soldering environments, nickel silver is inherently solderable without any tin or tin/lead post plating. Going less the post solder plating will shave a few days and a few dollars from your shielding order. Note that you should consider post-solder plating like bright tin or tin/lead with any soldering processes which do not utilize an active solder fluxing agent.

While Fotofab is capable of making your shield in metal thickness from .001" (.025mm) to .060" (1.5mm), the most common metal thickness that we stock and which offer good shielding and adequate mechanical strength are: .006" (.15mm); .008" (.2mm); .010" (.25mm); .012" (.3mm); .015" (.38mm) and .020" (.5mm).

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### Bend channels

Hand-foldable, etched bend channels are one of the unique features that Fotofab can incorporate into your RFI/EMI shielding enclosure. In the common metal thickness listed above, our etched bend channels allow anyone to bend the sidewalls of a shield from a 2D blank to a 3D finished shield easily, quickly and precisely. Many of our customers refer to this feature as "metal origami". Click to see a graphic of a folding shield with etched bend channels in action.

Incorporating our etched bend channel feature can offer you several benefits. First, since your shielding enclosure can be formed without the need for any traditional forming tooling, you can typically save hundreds of dollars in NRE tooling and several days of delivery lead time for your prototype and production needs. Second, because the etched bend channels exhibit a zero inside radii when formed, you can save space on your board by reducing the clearance necessary between the shield and the components within it. Third, although the etched bend channels are typically intended to create 90° right angle bends, they can also be used to create acute angle bends between 0° and 90°.

Fotofab does not recommend the use of etched bend channels for applications that are load bearing or encounter extended periods of vibration, since the etched bend channels are created by removing anywhere from 50% to 75% of the original metal thickness, and thus affect the strength of the metal along these bend channels proportionally. For shields which are subjected to loads or extreme vibration, we recommend forming the shield blanks with our traditional forming tools, which will create inside bend radii equal to the metal thickness, at minimum.

### Part Geometry

The economics of Fotofab's parts are similar to purchasing PCB's, in that you are purchasing the real estate of the part rather than the feature internal to the part. Therefore, features internal to the part, such as mouse-holes for traces, holes for tuning or heat dissipation, identification for your shield or shielded components and even your company's logo, are effectively "free". And similar to any other custom part from Fotofab, there is no limit to the complexity of your shield's configuration as long as the dimensions and tolerances are within our capability, as under *Dimensional Capabilities*.

Since higher RF frequencies radiate through smaller openings than do lower frequency waves, take advantage of our fabrication process to minimize the size of hole features and slots in your shield design. Because there isn't any difference in tooling or part cost for features interior to your part, consider making any mouse-holes for traces and any holes for tuning, cleaning or heat dissipation as small as possible. We can make slots as narrow and hole diameters as small as

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If your design would benefit from being identified with its part number or the component's part number, or you want your customer to see your logo "engraved" into your product, specify in your print where you would like us to incorporate these features for no additional tooling or part cost, and provide us with a CAD file (.dwg or .dxf format) of your company's logo.

### Removable/Replaceable Covers

Your shielding design may require that the cover or lid (i.e. the top portion of the enclosure) can be removed, so that the components underneath can be tweaked or replaced, and the cover or lid can be resealed. We refer to this design as "removable lid" shield or a "two piece" shield. We are familiar with and capable of making removable lid shields with several different mechanical locking or mating methods. The methods that we are most familiar with include: 1) mating dimples, 2) mating tabs and slots, 3) friction fits and 4) locking spring fingers. Each of these methods is best suited to different shield designs. Please contact our Technical Sales staff to discuss which method(s) best pertains to what you are trying to achieve.

### Internal walls

We are very accustomed to making RFI shielding enclosures whose components need to be isolated from one another under a common cover or lid. Similar to the removable/replaceable cover shields, there are several methods for fabricating and assembling internal walls or fences that prevent cross talk among different regions or components under a larger, universal shield. We would be glad to discuss the trade-offs of using one universal cover with one or more internal walls versus designing several individual, stand-alone shielding enclosures.

### Raised or rounded features

While it's not as common to see, your shielding design may require a part to have a unique feature such as a stepped or domed region, or a shield with rounded, rather than squared, edges or corners. With 15 years of shield fabricating experience, Fotofab has the confidence and know-how to help you with all of your metal shielding needs.

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# SHIELDING DESIGN GUIDE

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### Forming options

Finally, you will want to let us know how you want to receive your custom shielding enclosures, since we offer you a few options. We can ship your parts:

- with etched bend channels, tabbed into the metal sheet for your company or designated contract manufacturer to easily detach and form by hand (refer to Bend Channels above),
- with etched bend channels, detached from the metal sheet and formed by Fotofab, ready for final board assembly, or
- without etched bend channels, detached and formed at full metal thickness to the finished part, ready for board attachment.

This shielding design guide is intended to assist you with the most common design issues that we encounter with our customers' shielding requirements. If you run into issues that are not addressed here, contact one of our Technical Sales staff to discuss and resolve your specific needs.

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**REQUEST FOR QUOTE CHECKLIST**

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Fotofab will be glad to answer your questions and respond to your requests for quotation via email. We can accept your drawings as CAD files (as well as in hard copy or floppy disk), and can work with .dxf, dwg, .pdf (Adobe Acrobat) or almost any other electronic format.

To send in an RFQ online, please fill out the following:

Company: \_\_\_\_\_  
 Name: \_\_\_\_\_  
 Title: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 City: \_\_\_\_\_ State: \_\_\_\_\_ Zip/Postal Code: \_\_\_\_\_  
 Country: \_\_\_\_\_  
 Phone: \_\_\_\_\_ Fax: \_\_\_\_\_  
 E-mail: \_\_\_\_\_  
 Comments: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Here is a checklist of items we need in order to quote your part  
(either on your print or filled in below):

Part Description: \_\_\_\_\_

Quantities: \_\_\_\_\_ Material: \_\_\_\_\_

Additional info or questions: \_\_\_\_\_  
\_\_\_\_\_

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- E-mail your CAD file in .dxf, .dwg or .pdf format: sales@fotofab.com
- Large-format prints, diskettes or CD's can be mailed to:  
 3758 W Belmont Ave  
 Chicago, IL 60618  
 Attn: Technical Services Staff

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