



## How to Optimize your Photoplot Design using AutoCAD®

### DFM = Design for Manufacturability

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Here at Fineline Imaging we receive AutoCAD files that are created by hundreds of different designers from both commercial and university customers. Each designer has a special way to create the mask design, and some techniques work better than others. From our perspective, the least amount of work we have to do to prepare the data for the laser photoplotter (i.e. convert it to plotter-ready Gerber format) the better. With this in mind, we've compiled the following list of recommended design rules that will help ensure that the design will flow through the process with as few problems as possible. We recommend that these also be used as a check-off list to evaluate the drawing before sending it off to us for plotting.

Please feel free to share this post with your colleagues!

So, here you go:

Please construct your designs in Model Space, not Paper Space or Layout Space.

Please make sure that only 2-dimensional data is present. All data must be on the X-Y plane, with Z=0. Ideally, the X-axis will point to the right and the Y-axis will point up. (If 3-D entities are present, we have a procedure to change the elevation to zero. However, 3DPOLYLINE's can be a bit of a challenge to work with.)

Use layer 0 only for the insertion of BLOCKS.

Do not draw any entities on layer DEFPOINTS. This layer is reserved for dimensions. Dimensions are typically ignored unless you specifically require them to be part of your photoplot.

Draw all entities on any layer but layers 0 and DEFPOINTS. Do not turn off layer 0.

Remove all POINT entities.

Remove all LINE, ARC, and POLYLINE entities that both begin and end at the same point and have no vertices in between - i.e. have zero length.

Remove all LINE, ARC, and zero-width POLYLINE entities that do not form, or cannot be readily joined to form, a completely closed boundary or polygon, or which are not otherwise part of the design.

Remove all fully or partially redundant, duplicate, and/or coincident entities. (AutoCAD's OVERKILL command is useful for this.)



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Remove all HATCH entities. These are typically ignored by our data format translators. If you find them necessary to include for illustration purposes, then be sure that the original boundaries that were used to create the HATCH patterns remain in your drawing.

Purge all unused BLOCKs, LAYERs, and other items from your drawing before sending it to us.

Remove all data that you do not want to appear on your photoplot or photomask; or if it is useful reference data, please move it to a layer that is either labeled as "reference", frozen or turned off.

Close all gaps between the endpoints of all the LINE, ARC, or POLYLINE entities that are intended to form a continuous outline - making sure that the endpoint of each entity exactly matches the start point of the next entity. Using the FILLET command set to a zero radius can help here. Note: these entities must also be on the same layer in order to be joined properly.

Join all LINE and ARC entities that make up a single continuous boundary into a single closed zero-width POLYLINE outline. (The PEDIT and BOUNDARY commands are useful for doing this.)

If more than two lines or arcs meet at the same exact point, then this totally confuses our program when it tries to join the entities to form a closed boundary. I.e., "Which way should we go, Joe?"

CIRCLE, SOLID/PLANE, and TRACE entities are OK, and usually process as is. CIRCLE entities are converted to round pads, defined with a center point and a radius or diameter, and will be automatically filled in by the plotter.

It's almost always best to digitize the circles, rather than the areas around the circles.

We process 2DPOLYLINE and LWPOLYLINE entities in exactly the same way as we work with regular POLYLINE entities.

Tapered POLYLINES, POLYLINES of varying width, and POLYLINES that double back on themselves or cross themselves can be processed, so long as you make us aware of their presence. They may require special settings to be used during conversion. In addition, they often require extra labor during the data conversion process, and may incur additional charges.

SPLINE entities are now accepted. SPLINE entities can be converted to POLYLINE entities using the ExplodeX command in Draftsight. In AutoCAD, SPLINE entities may be converted to POLYLINE entities by using MODIFY/EDIT SPLINE command sequence.

SPLINES are converted by our LinkCAD conversion program into segmented curves represented by straight line segments. The accuracy of the conversion depends upon the radius



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tolerance that we use to govern the conversion, which we typically set at 50 nm. ARC's and curved PLINES are also converted to segmented curves in the same way.

Dashed LINE or POLYLINE entities will typically be drawn without the dashes, unless specifically instructed otherwise.

We can process HELIX entities by using the ExplodeX command in Draftsight to form polylines with segmented chords that approximate arcs on the X-Y plane.

Do not use Anonymous BLOCKs (usually having a name beginning with \*U). Always be sure to assign a name to them. Anonymous BLOCKs can be edited, but only by implementing a cumbersome and special process. BLOCK editing is sometimes necessary in order to make the file easier to convert to Gerber data for plotting.

Use BLOCKs (and/or nested BLOCKs) whenever possible in order to conserve file size. All BLOCKs should have a scale factor of 1 in both the X and the Y directions. Mirrored BLOCKs (those which have a scale factor of -1 in one or both directions) cannot be processed through our data converters. Rotated BLOCKs are usually OK. MINSERTED BLOCKs are useful, but we usually explode them down to one level of hierarchy, since that's all that the Gerber 274-X standard allows. One level of hierarchy is preferred over multiple levels of nested blocks.

Do not use REGION's! These are often the result of failed attempts to create closed, zero-width POLYLINE boundaries. They typically do not convert well, and therefore need to be exploded before conversion. Once we explode them, we need to fix the errors that caused the REGION's to be formed instead of a closed BOUNDARY's.

We do not recommend using "convoluted", or self-intersecting POLYLINEs. ("Butterfly" targets are often the culprit here.) Each section of such entities should be separated into its own closed zero-width POLYLINE outline.

All corners will be slightly rounded by the photoplotter when the laser spot illuminates and exposes the emulsion, so if these are critical to your design, please account for this. Corners with acute angles are particularly affected by this rounding. Our plotter typically outputs corner radii in the 3.5 to 5 micron range, depending upon the plotter resolution used.

### Processing TEXT:

- We can now process TEXT, MTEXT, SIMPLENOTE and NOTE entities! We typically explode these into POLYLINE outlines before plotting.
- Windows, OpenType, and TrueType fonts may be used in addition to the standard SHX fonts.
- Numerous regular and outlined SHX fonts are available. Free versions of these may be found by searching online. These are particularly useful for labeling photomasks.



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- We can now process just about any font that can be placed into a design, including proprietary fonts such as Helvetica. If a font cannot be processed, then we will substitute a similar font.

The plotter automatically fills in the areas that are enclosed by entities such as CIRCLES, SOLIDS, and Closed, Zero-width Polyline boundaries. We can flip an electronic switch to tell the plotter to reverse the polarity on the entire plot, if necessary.

If you have features that are completely surrounded by other features on the same layer, the plotter will typically overwrite the inner features - unless something is done to prevent this. This process is called Polygon De-Embedding ([described here](#)). As part of our standard procedures, we will typically run our own de-embedding routines on your data, which also helps to identify duplicate entities.

Please specify the data units with your order. We recommend using at least 5 or 6 decimal places if working in inches, and 4 to 6 decimal places if working in millimeters. Of course, 6 decimal places in mm is 25.4 times more accurate than 6 decimal places in inches. Our photoplotter accepts data having up to 6 decimal places in inches or in mm. We can process data in just about any units, so long as you tell us what those units are. We usually send data to the plotter with 6 decimal places in mm.

Data Extents: Please keep all data within +/- 55 inches (+/- 1400 mm) of the X/Y origin.

Layer names should not exceed 15 characters, and shall have no spaces or special characters other than underscores or dashes.

Whenever possible, please use a 1:1 scale for all inserted blocks. Other scale factors often have an adverse effect on the conversion of curved features to the segmented arcs that we use for plotting.

LINE thickness is ignored. POLYLINE Width is typically maintained.

The following entities are ignored by our converters: SHAPE, POINTS, 3DPOLY, ATTDEF, 3DFACE, HATCH (with limited exceptions), MLINE, RAY, RTEXT, TOLERANCE, WIPEOUT, POLYFACE MESH and XLINE.

DXF files require less processing on our part, and therefore often go faster through the system. Since DXF files can be rather large, please zip them up before sending them to us. This typically reduces their size by about 70% to 90%.

The plotter resolution setting, and resulting price, most often depends upon the minimum feature or space size within the design. The smallest images/gaps that the Barco Silverwriter 860 with Eagle Optics can produce are 7 microns, at 50K dpi resolution. For pricing information, feel free



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to check out the Plotting tab of our website at <http://www.fine-line-imaging.com>. It's posted near the bottom of the page.

If you have an opportunity, please download and test your design using one of the commercial data converters available as fully-functional free-trial versions:

[LinkCAD](#); [ACE3000](#); [ASM500](#); [ViewMatePro](#)

Once you've converted your design to Gerber format for plotting, be sure to verify that it looks like you expect. An excellent free program to use for this purpose is called [ViewMate with Smart DFM](#).

For further reference, please check out these links:

1. [LinkCAD Drawing Design Rules](#)
2. [ASM 3500 Drawing Design Rules for DXF to GDSII](#)
3. [Numerical Innovations DXF/DWG to Gerber conversion guidelines](#)
4. [Design Rules for Drawing Masks using AutoCAD - PDFCast.org](#)

### TIPS & TRICKS

Our most common issue: What is Dark Field (DF) or Clear Field (CF)? The term Field refers to the area outside every part of the design. In other words, it's the background. This is the area between the image and the edge of the film.

Our next most common issue: Right Reading Up (RRU) vs. Right Reading Down (RRD). The film has a thickness of about 0.007". The image is plotted on only one side of the film. When the film is used to replicate the image on your substrate, the emulsion side of the film (that which contains the image) must be facing the substrate that you're printing onto. In order to achieve this, you will need to specify Right Reading Down (RRD) when you place your order. This will tell us to mirror the data before plotting. If you have a different process, then the RRD designation may not apply.

We can easily plot 7 micron wide lines and spaces at 50,800 dpi resolution, and 8 micron wide lines and spaces at 40,640 dpi resolution. However, round and round-ish pads are a bit more challenging. For 7 and 8 micron diameter clear round pads in a black background, we advise designing them as squares. They will actually end up as round clear pads on the photoplot, with a diameter very close to the width of the square. By contrast, dark pads smaller than 10 microns are difficult to image on our film. This is because the film requires a certain amount of energy from the laser beams to properly create an image, and at this size the energy level is just below that threshold level for consistent results.



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For tapered patterns with acute angles, we recommend terminating the narrow end with a [fillet](#) having a radius of between 3.5 and 5 microns. This will ensure that the image on the film doesn't come up short on the length.

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If you have a specific question about these recommendations, please contact us via the contact information posted under the Contact tab on our website at [www.Fineline-Imaging.com](http://www.Fineline-Imaging.com), or by calling the number below.

Thanks for your attention!