DESIGN GUIDE

Sheet Metal Cutting

Xometry
WHERE BIG IDEAS ARE BUILT

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SHEET METAL CUTTING

Introduction

Introduction

What is Sheet Cutting?

Sheet cutting is a category of processes that slice through flat stock material following a profile to produce a shape. Sheet stock is cut using a high-powered CNC laser or waterjet. The material's gauge determines the thickness of the part. From a one-off batch to mass production, custom designs can be cut in various materials ranging from plastics, elastomers, composites, metals, and more. Sheet cutting is also typical for blank preparation in other manufacturing processes like sheet metal fabrication or metal stamping.

Xometry's sheet cutting services utilise the top laser cutting and waterjet suppliers in the US and globally. Fabricators first convert CAD and drawing data into machine code. A laser cutting, waterjet, or plasma cutting machine will then precisely remove sheet material. If any assembly or post-processing is required, our manufacturers will provide turnkey finishing to the part.

The efficiency and high precision of these CNC-controlled cutting tools, coupled with Xometry's variety of materials, range of suppliers, and post-processing options means you can get parts for any application. Sheet cut applications include aerospace, defence, automotive, energy, industrial, medical, dental, art, robotics, and consumer products.

Introduction

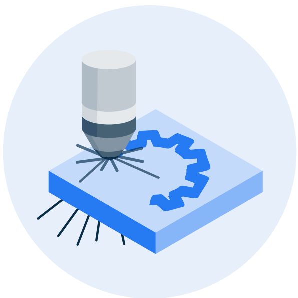
Sheet Cutting Methods

Laser Cutting

Laser cutting involves using a focused, high-powered beam of coherent light to cut through materials. Material hit by the laser is vaporised and blown away by gases to ensure a clean cut. Several types of lasers are used depending on the material that needs shaping, but all of them rely on programming to carry out a specific pattern of cuts for creating one or more finished parts. Laser cutting is the most common form of blanking or creating a profile cut of a two-dimensional shape in common stock material. The thickness of the path carved is called kerf and is typically around 0.3 mm with this method.

Waterjet Cutting

Unlike lasers, waterjet cutting takes advantage of the fact that water cannot be compressed, so when a thin stream of water is shot out of a nozzle at very high pressure, it can cut through just about anything. A water jet uses an abrasive granular material (often garnet or aluminium oxide) in its high-pressure stream to cut hard materials like metals. A waterjet's kerf has a cut thickness typically between 1 mm and 1.2 mm.



Plasma Cutting

Plasma cutting, or plasma arc cutting, uses an accelerated jet of hot plasma to cut through electrically conductive materials. Plasma cutters are a good all-around sheet metal fabrication tool, though they lack the material cutting diversity of waterjet cutters and don't have the precision of laser cutters. For larger sheet metal parts, plasma cutting machines are more cost-efficient than CNC laser cutters and can cut thicker materials easily. Plus, they are easy to operate and can cut at high speeds while maintaining precision. The kerf of a plasma cutter starts at approximately 3.8 mm.

SHEET METAL CUTTING

Preparing a File For Sheet Cutting

Preparing a File

Raster vs. Vector

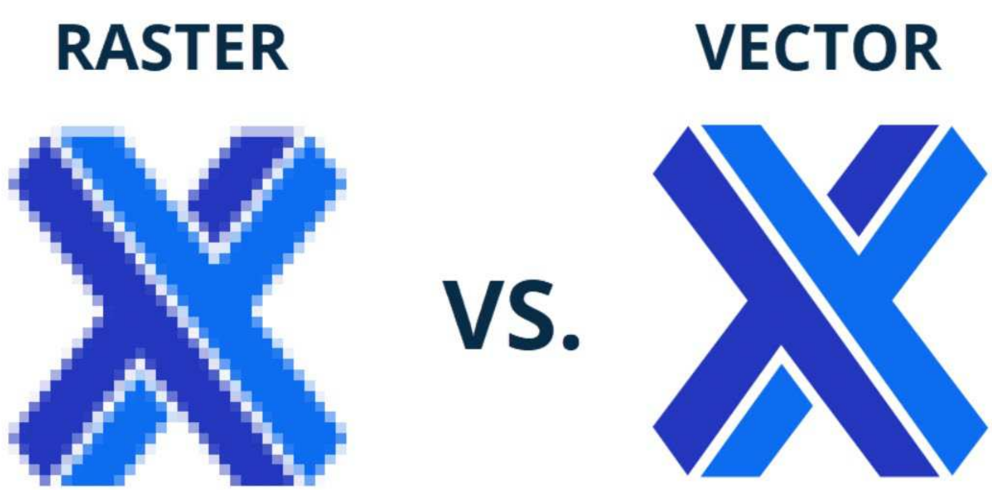
With sheet cutting, it is possible to get away with creating a part from two-dimensional designs, such as from images, since the cutting path follows a profile to produce the part. If you decide to go this route, it is important to understand the differences between raster and vector file types.

What is a raster file?

A raster image is one that is formed by a compilation of many pixels. Pixels are the tiny coloured dots that can be seen when zooming in closely on images such as photographs or scans. The quality of a rasterised image depends on its number of pixels, with quality increasing as the number of pixels does. Common file types include JPEG, GIF, and PNG, among others.

What is a vector file?

Vector files do not contain pixels. Instead, mathematical formulas and algorithms are used to connect fixed points with lines and curves to produce shapes, borders, and fill colours to build up the image. This allows the image to be infinitely scaled and manipulated without sacrificing quality. DXF, DWG, and AI are examples of vector file formats.



Which can be used for sheet cutting?

Raster files cannot retain the information necessary to define properties such as coordinates and dimensions. On the contrary, vector files can store this type of information due to their mathematical-based structure. This makes vector files the appropriate choice when designing sheet cut parts in a two-dimensional space. At Xometry, we recommend DXF files for sheet cuts parts since our quoting engine can automatically quote this vector-based format and is readily supported by the software manufacturers use to program their cutting machines.

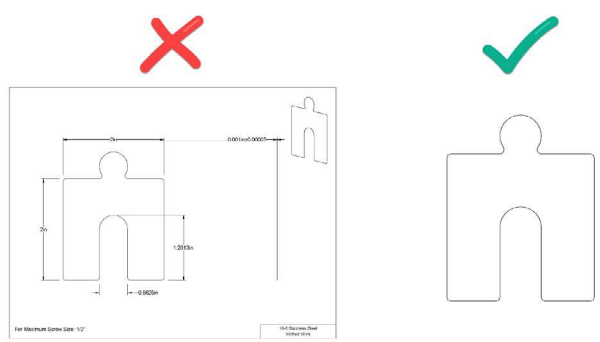
Preparing a File

File Optimisation and Guidelines

Before you upload or send in your design files, you should ensure that all preliminary steps have been taken to prepare the files to be used in manufacturing. In the sections below, we will go over a few steps and guidelines you should follow to ensure an optimal file and reduce the likelihood of downstream issues.

Remove Excess Information

The design file you submit for quoting should only include the cut-path information for the part itself. You should remove excess information such as title blocks, notes, dimensions, etc. Extra-drawn features can be confused with cut geometry and will cause the file processing to fail.



Convert Text

If your design includes text, be sure that the text is part of the geometry itself and not simply an active text box. This is especially important in 2D files, where it can be more difficult to distinguish. Make sure to convert text to a shape with an outline or "explode" the text so it can be cut on the model.

Common Issues and Errors

Certain issues and file errors can impact part production and sometimes even result in higher part prices. Use the checklist below to ensure your design has none of the following problems.

Your Design Should **NOT** have:

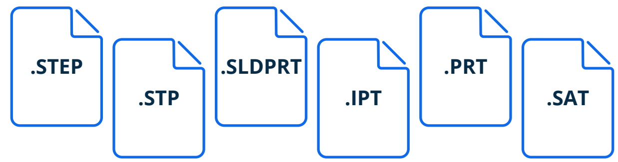
- Duplicate or overlapping lines, curves, points, etc.
- Open curves or broken paths
- Lines with a length of less than zero
- Extraneous curves preventing the detection of boundaries
- Stray points or empty objects

Scale

Designs will be quoted at the scale they are submitted at, so it's crucial that you verify your part dimensions are submitted at a 1:1 scale. Once you've uploaded a part, our part viewer displays its bounding box dimensions, which is another way to confirm your scaling is correct.

File Types

When exporting your file, it is good practice to use a common and widely supported format. This ensures the manufacturer can easily work with your file and avoid file conversions that sometimes introduce errors. For two-dimensional vector files, we recommend and directly support .DXF for auto-quoting. For 3D formats, recommend any of the following:



Recommended Design Software

Software Name	Design Environment	Export File Format
SOLIDWORKS	2D, 3D	.DXF, .STEP, .SLDPRT
onshape®	2D, 3D	.DXF, .STEP, .SLDPRT
AUTODESK® FUSION 360™	2D, 3D	.DXF, .STEP, .IPT
AUTODESK® INVENTOR®	2D, 3D	.DXF, .STEP, .IPT
Ai	2D	.DXF

SHEET METAL CUTTING

Design Guidelines For Cut Features

Design Guidelines For Cut Features

General Tolerances

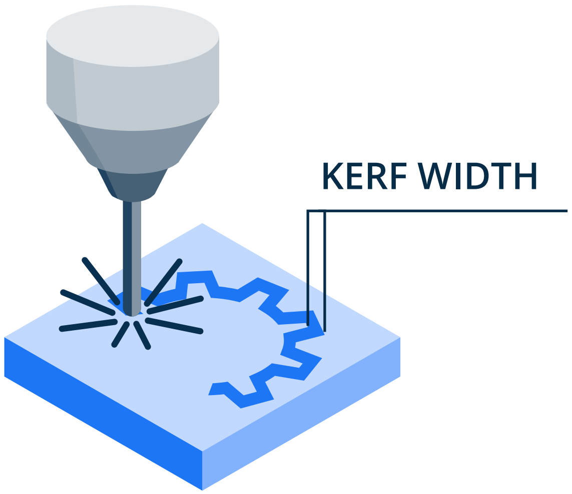
Designing for standard process tolerances of ±0.3 mm and ±0.5 mm will help reduce cost and lead time. Precision tolerances may require additional operations such as post-machining to achieve and should be avoided when possible. Thicker materials may have a tolerance deviation on the bottom face due to tapers inherent in laser, waterjet, or plasma cutting.

Tips:

- Design for edge-to-edge tolerances of ±0.25 mm nominal on the top-cut surface.
- Designate which is the top face on your drawing, as this face will typically be cut with higher accuracy.

Kerf

Kerf refers to the material that is burnt or cut away by the cutting tool, whether that be a laser, waterjet, or saw blade. Kerf is the gap thickness created by the cutting tool and varies depending on the process and material thickness. Keep the kerf in mind when designing your part, as small holes, thin gaps, and relief cuts may be slightly larger than dimensioned if their design is close to the kerf thickness. When designing mating parts, you should compensate for the kerf by adding half the kerf width to the inner part and subtracting half the kerf width from the outer part. Typical kerf thicknesses per process can be seen in the chart below.

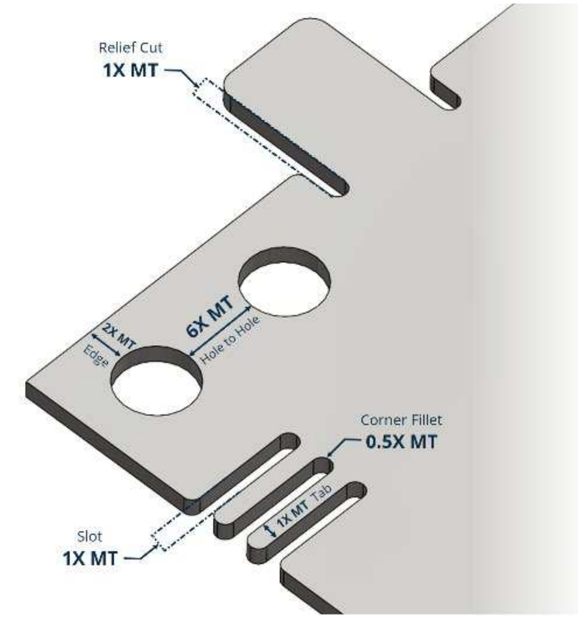


Cutting Process	Typical Kerf Width
Laser	0.2 - 0.4 mm
Waterjet	1 - 1.2 mm
Plasma	3.8 mm+

Design Guidelines For Cut Features

Distance Between Features

A minimum distance between features should be maintained to ensure the integrity of the cut. Following the guidelines below will ensure reliable results no matter the sheet cutting method.



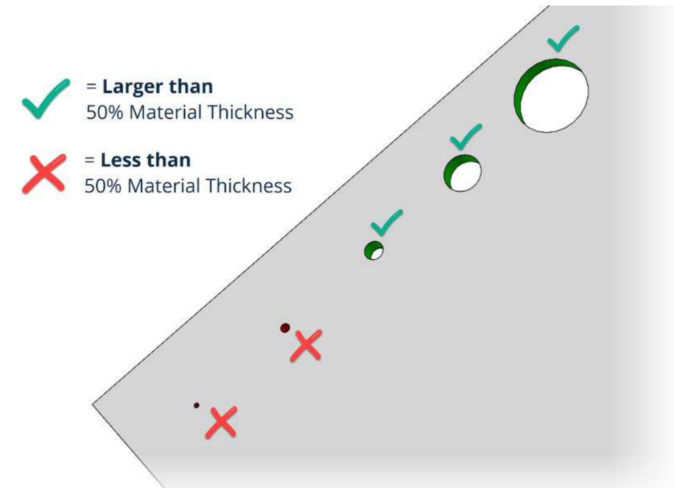
MT = Material Thickness

- Minimum Hole to Edge Distance = 2X MT or 3 mm, whichever is smaller
- Minimum Hole to Hole Distance = 6X MT or 3 mm, whichever is smaller
- Minimum Relief Cuts = 0.25 mm or 1X MT, whichever is greater
- Minimum Corner Fillets = 0.5X MT or 3 mm, whichever is smaller
- Minimum Tab Thickness = 1.6 mm or 1X MT, whichever is greater
- Minimum Slot Thickness = 1 mm or 1X MT, whichever is greater

Minimum Detail Sizes

Before a feature is cut, the tool (e.g. laser beam, waterjet stream, etc.) must pierce through the material at the start point of the cut. Holes and other internal shapes should be sized appropriately to allow for this action.

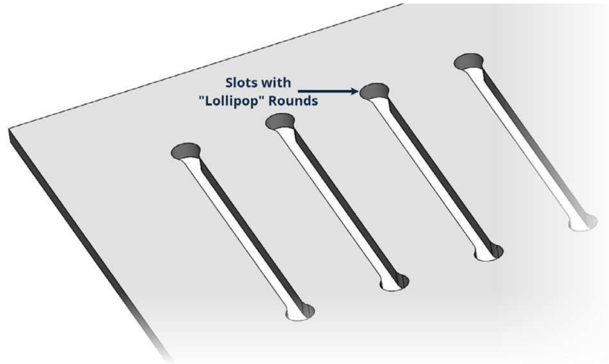
A good rule of thumb is to design your details to be at least 50% of the material's thickness or larger. Also, remember to account for kerf width, as features that are designed below the kerf width will become blown out or lost.



Design Guidelines For Cut Features

Notches and Slots

Notches and slots must be designed in the file, even if they are at the kerf thickness of the sheet cutting process. For example, a waterjet cut notch or slot of 1 mm should be designed to that width. It is recommended for slot features to have exaggerated "lollipop" rounds on at least one side to help compensate for the pierce-hole, which will be slightly larger than the cutting thickness (kerf).



Assembly Features

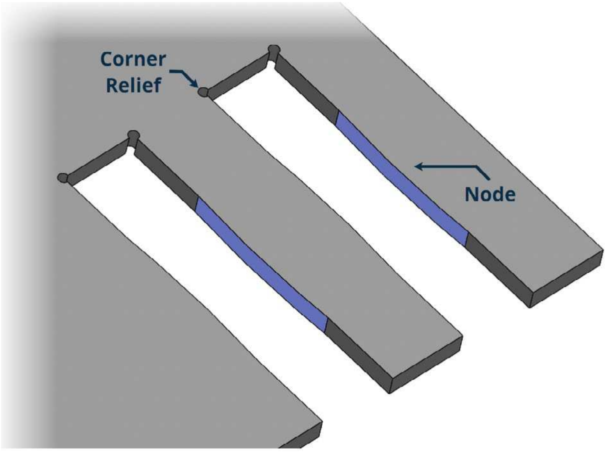
For designs that are part of an assembly, there are certain design features you can incorporate to make the assembly more effective.

Nodes

If your assembly has interlocking components, nodes are recommended additions to the mating faces. Nodes are gradual protrusions or bumps along the interlocking faces, as seen in the figure to the right. They are useful for increasing friction between parts for a tighter connection and to better control where internal stresses between parts are concentrated.

Inside Corner Reliefs

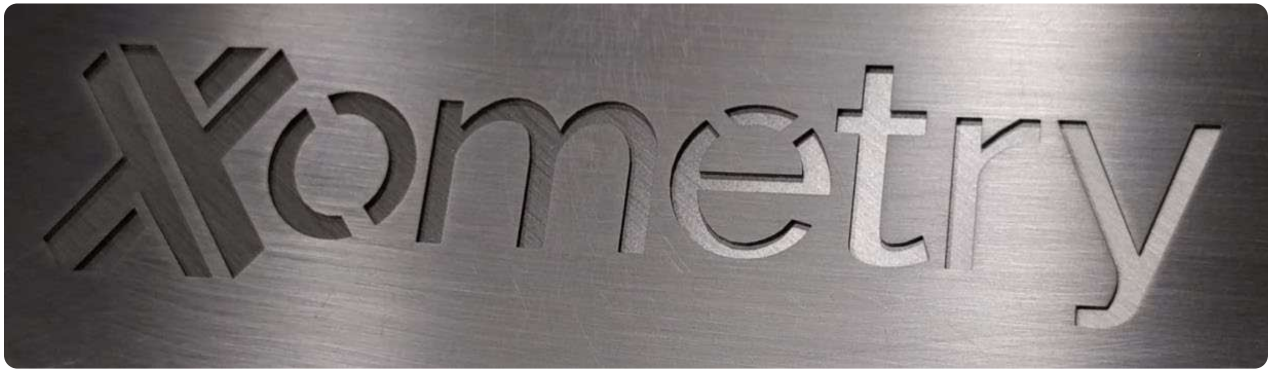
Sharp internal corners can not only make assembly more difficult due to kerf, but also cause greater stress buildup in those corners. Adding relief cuts helps compensate for kerf and more evenly distributes stress.



Design Guidelines For Cut Features

Designing Text For Cutting

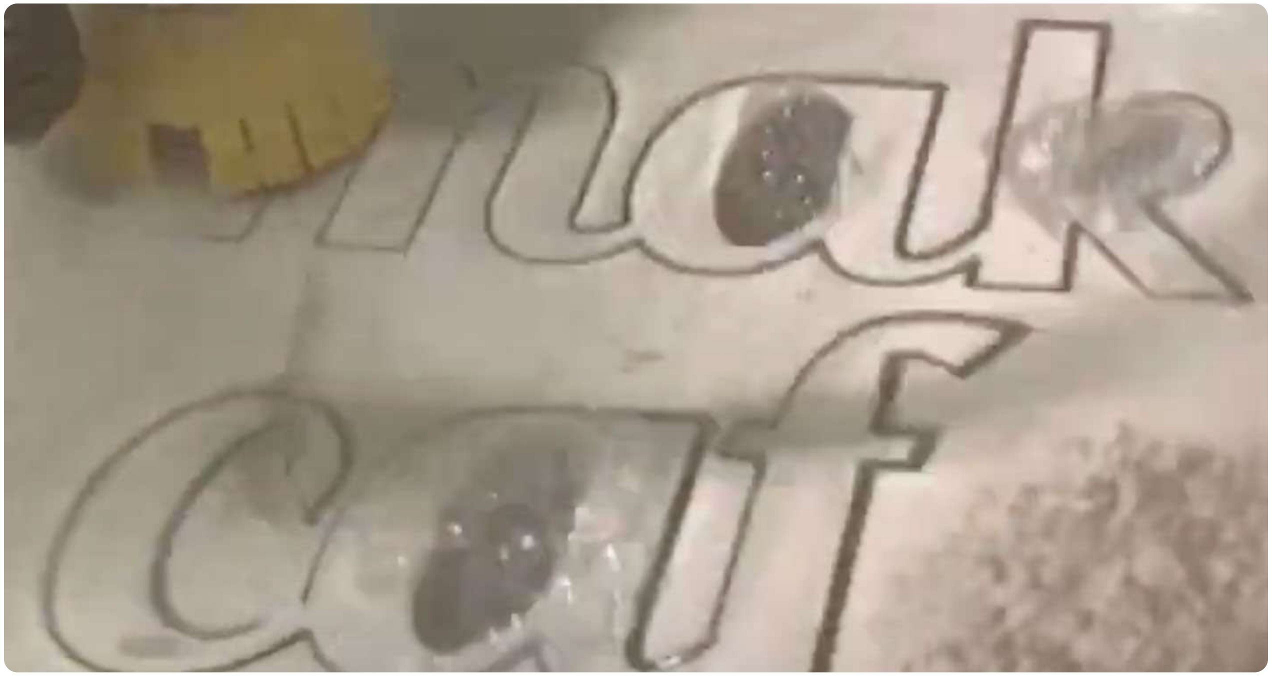
It is important to “stencilise” text or add joining bridges on free-floating text features, such as the holes in D, O, P, Q, or other closed-loop characters. Otherwise, the features will be lost, and all that will be left is a letter-shaped hole! This guideline also applies to reversed shapes containing holes; bridges should also be used in those instances.



Text and Graphics For Engraving

You will need two files to specify laser engraving. The first file is the CUT file, uploaded as your part in Xometry’s instant quoting engine (this is your line item). The ENGRAVE file should be uploaded as an attached drawing. Engraving or other artwork files are preferred to be DXF but can also be SVG or PDF as long as they are vectored. Xometry cannot laser mark with raster or pixelated files.

NOTE: Be sure to check “Laser Mark” under Part Marking options to notify our team that laser engraving services are required.

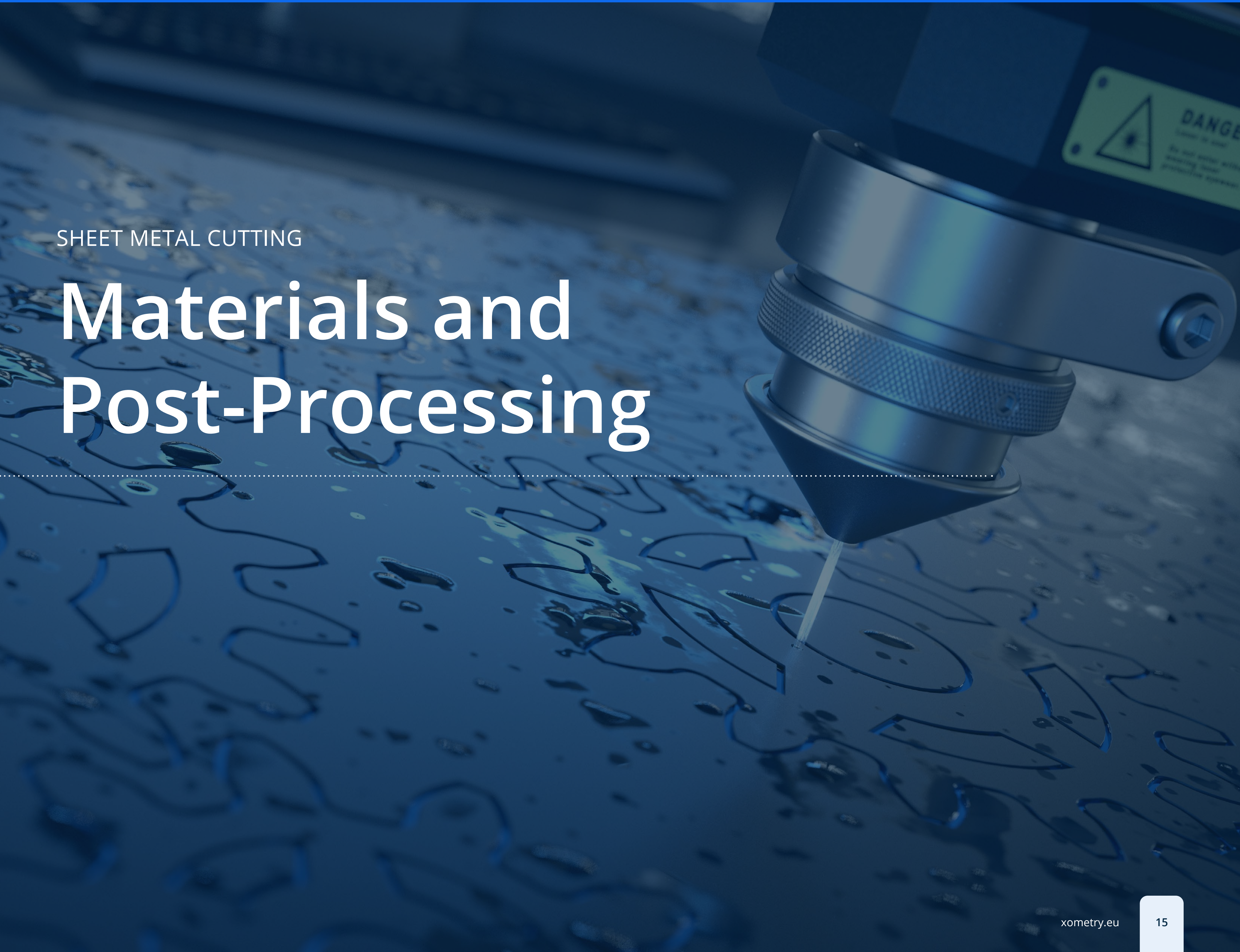


Design Guidelines For Cut Features

Standard Sheet Thickness

As the name suggests, in sheet cutting, you are cutting a part from a piece of stock material in sheet form. This means thickness is generally pre-defined by what is commonly available from material suppliers. When designing your part, use a commonly available thickness or gauge for the chosen material. We've prepared a table of popular materials and their commonly available thicknesses for reference.

Material Name	Available Thickness
Aluminium 5083 / 3.3547 / Al-Mg4.5Mn	1.5 mm, 2 mm, 3 mm, 4 mm, 5 mm, 6 mm, 8 mm, 10 mm
Aluminium 6061 / 3.3211 / Al-Mg1SiCu	1 mm, 2 mm, 3 mm, 4 mm, 5 mm, 6 mm
Aluminium 6082 / 3.2315 / Al-Si1Mg	2 mm, 3 mm, 4 mm, 5 mm, 6 mm, 8 mm, 10 mm
Stainless Steel 304 / 1.4301 / X5CrNi18.10	0.5 mm, 1 mm, 1.5 mm, 2 mm, 3 mm
Stainless Steel 316L / 1.4404 / X2CrNiMo17-12-2	0.8 mm, 1 mm, 1.25 mm, 1.5 mm, 2 mm, 2.5 mm, 3 mm, 4 mm, 5 mm, 6 mm, 7 mm, 8 mm, 10 mm, 12 mm
Steel 1.0038 / S235JR	2 mm, 3 mm, 4 mm, 5 mm, 6 mm, 8 mm, 10 mm, 12 mm, 16 mm

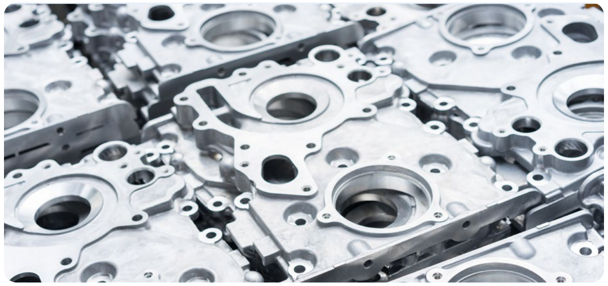


SHEET METAL CUTTING

Materials and Post-Processing

Standard Materials

Choosing the right material for your project can be crucial to it's success. At Xometry, we have a dedicated team of engineers and industry experts that can help you make the right choice. The table below highlights the different sheet cutting materials we offer.



Aluminiun

- Aluminium 5052 / 3.3523 / Al-Mg2,5
- Aluminium 5083 / 3.3547 / Al-Mg4.5Mn
- Aluminium 5754 / 3.3535 / Al-Mg3
- Aluminium 6060 / 3.3206 / Al-MgSi
- Aluminium 6061 / 3.3211 / Al-Mg1SiCu
- Aluminium 6082 / 3.2315 / Al-Si1Mg
- Aluminium 7075 / 3.4365 / Al-Zn6MgCu

Stainless Steel

- Stainless Steel 304 / 1.4301 / X5CrNi18.10
- Stainless Steel 316L / 1.4404 / X2CrNiMo17-12-2

Steel

- Steel 1.0038 / S235JR
- Steel 1.0044 / S275JR
- Steel 1.0117 / S235J2 / S235J2G4
- Steel 1.0117 / S235J2 / S235J2G4, pickled and oiled
- Steel 1.0330 / DC01
- Steel 1.0503 / C45
- Steel 1.0570 / S355J2G3
- Steel 1.1191 / XC48H1 / C45E
- Steel 1.2379 / X153CrMo12 / SKD11, annealed
- Steel 1.2510 / 100MnCrW4 / SKS3, annealed
- Steel 1.7218 / 25CrMo4
- Steel 1.7225 / 42CrMo4

Materials and Post-Processing

Finishes

Applying a finish to your sheet cut parts can not only improve their cosmetic appeal but also provide surface protection and increased performance. Below you will find some of the post-processing options and finishes we offer.

Anodising

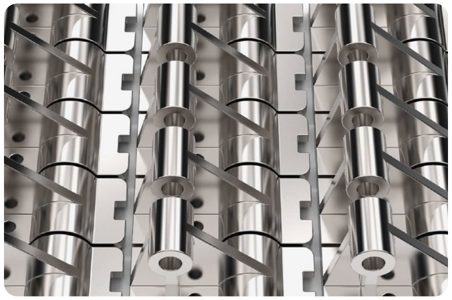
- Type II Anodise
- Type III Hard coat
- Type III w/ PTFE

Metal Plating

- Electroless Nickel
- Zinc
- Gold
- Silver

Adhesives and Coatins

- Black Oxide
- Powder Coat



Conversion and Pretreatments

- Chem Film
- Heat Treat
- Case Harden
- Passivation
- Pickle and Oil
- Bead Blasting
- Electropolishing

Inserts

Features like boss standoffs, threads, and nuts are typically installed via press-fit inserts. The most popular are PEM® Fasteners. Using inserts guarantees and standardizes features like:

- Nuts
- Pins and studs
- Standoffs
- Cable-tie mounts
- Captive hardware

Designing for Inserts

Follow the guidelines specified by the instructions included with the off-the-shelf inserts. Make sure to note the part ID and install direction in an accompanying print for reference.

Part Marking

Part marking is a great way to add high-contrast markings, part numbers, logos, and more. The table below compares the different types of marking methods we offer.

Marking Method	Common Uses	Pros	Cons
Laser Marking and Engraving	• Graphics • Part Numbers • Text	• Extremely durable markings • Crisp Detail	• Cannot produce colored markings
Bag and Tag	• Serialization • Part Numbers • Bulk packaging	• Very low cost • Can speed up inventory and receiving processes	• Non-permanent solution

NOTE: For markings with special font, graphics or logos, please provide artwork files in the form of a vector file such as a DXF; pixelated or raster files are not suitable.

SHEET METAL CUTTING

Quick Reference Sheets

File Preparation Reference Sheet

File Types

- Use vector files such as .DXF for 2D designs as well as for artwork such as engravings and part markings
- Recommended 3D design formats:
    - .STEP
    - .STP
    - .SLDPRT
    - .IPT
    - .PRT
    - .SAT

File Optimisation

- Your design file should have cut-paths only
- Remove title blocks, notes, dimensions, etc.
- Text should be converted to shapes and outlines
- Your design should be submitted in 1:1 scale
- Check that your design file does NOT contain:
    - Duplicate or overlapping lines, curves, points, etc.
    - Open curves or broken paths
    - Lines with a length of less than zero
    - Extraneous curves preventing the detection of boundaries
    - Stray points or empty objects

Design Guidelines Reference Sheet

Tolerances

- Design for edge to edge tolerances of ±0.25 mm nominal on the top-cut surface
- Designate which is the top face on your drawing

Kerf

- Don't forget to account for the thickness of the cut
    - Typical kerf thickness for laser cutting: 0.2 - 0.4 mm
    - Typical kerf thickness for waterjet cutting: 1 - 1.2 mm
    - Typical kerf thickness for plasma cutting : 3.8 mm+
- Kerf width generally becomes larger as the material thickness increases

Distance Between Features

MT = Material Thickness

- Minimum Hole to Edge Distance = 2X MT or 3 mm, whichever is smaller
- Minimum Hole to Hole Distance = 6X MT or 3 mm, whichever is smaller
- Minimum Relief Cuts = 0.25 mm or 1X MT, whichever is greater
- Minimum Corner Fillets = 0.5X MT or 3 mm, whichever is smaller
- Minimum Tab Thickness = 1.6 mm or 1X MT, whichever is greater
- Minimum Slot Thickness = 1 mm or 1X MT, whichever is greater

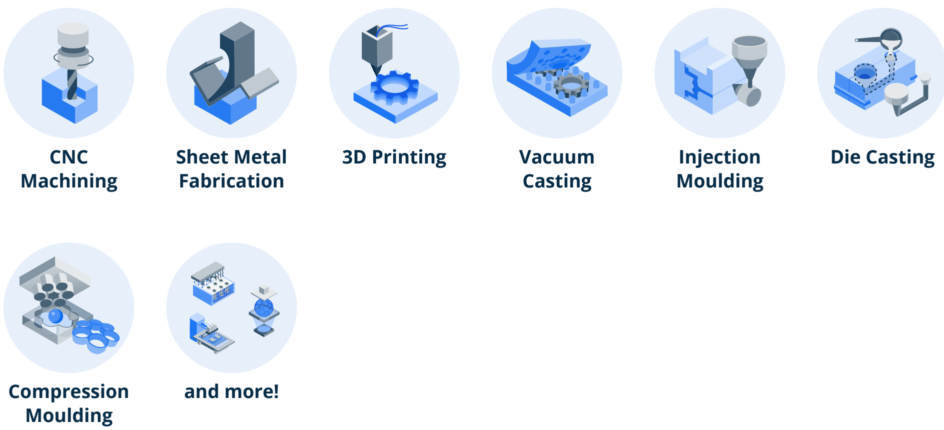
Other Design Guidelines

- Details and features should be no smaller than 50% the material thickness
- Compensate for material pierce through by adding a "lollipop" shape to at least one end of slots and notches
- Add relief cuts to sharp internal corners for mating parts
- Ensure text and reversed shapes are "stencilised" by adding connecting bridges to free-floating components
- Provide vector artwork files (.SVG , .DXF , .PDF) for graphics, logos, engravings, etc. that you would like to be added to the part via part marking methods such as Silk Screening or Laser Engraving
- Design your part thickness to match commonly available standard sheet sizes

Additional Resources at Xometry

Online Instant Quoting

- **Web:** Upload your CAD file at get.xometry.eu/
- **Accepted file types:** STEP (.step, .stp), SOLIDWORKS (.sldprt), Mesh (.stl), Parasolid (.x_t, .x_b), DXF (.dxf), Autodesk Inventor (.ipt), Dassault Systems (.3dxml, .catpart), PTC, Siemens (.prt), ACIS (.sat)
- **Other Capabilities:**



Other Sheet Cutting Resources

- Sheet Metal Finishes: Plating And Polishing Options
- Nesting Files for Sheet Metal Cutting: Tips & Best Practices
- Minimum Bend Radius Reference Table For Sheet Metal
- Sheet Metal Design Tips For Bending
- Subtractive Manufacturing Tolerance Standards Overview

Contact Details

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