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CHOOSE WITH CONFIDENCE

Comparing 2-Axis Precision Cutting Methods

About

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We are an independent metal fabricating company specializing in the burr-free abrasive cut-off of metal parts and the related grinding, lapping, polishing, turning, EDM and metrology capabilities required to meet our customers' tight tolerance requirements.

Since 1967 we have provided precision metal components for a very diverse range of industries. Over the years we have continuously improved our products and processes. We have never lost sight of the simple fact that we do it for you. Meeting your quality, price and delivery requirements is what it is all about

Close Tolerance Cutting Methods Get a Closer Look.

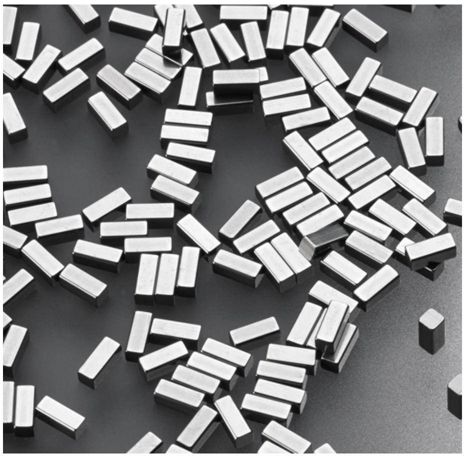
This guide looks at the five most common methods of 2-axis metal cutoff and provides a basic comparison to help you make the best decision for your specific application.

In a perfect world, determining the right 2-axis precision cutting method for your close tolerance metal components would be a snap — a relatively easy choice among the many decisions you must make before production begins. The simple goal is tight tolerance rods, tubes, or extrusions, cut to the correct length and always burr-free. The reality is that the different 2-axis metal cutoff options vary in characteristics and appropriate applications, making the choice not quite so simple. The wrong decision can result in production delays, material waste, or other quality issues that can cost you time and money. Across the spectrum of methods for 2-axis cut-off of metal parts, no one method is suited to all dimensions, materials, tolerances, or capacity, speed, and cost needs. So, how do you make the right choice for your requirements? This guide looks at the five most common methods of 2-axis metal cutoff and provides a basic comparison to help you make the best decision for your specific application.

SO, HOW DO YOU MAKE THE RIGHT CHOICE FOR YOUR REQUIREMENTS?

Key Parameters for Decision Making

Having a clear and thorough understanding of several key parameters will help you successfully assess which methods excel at your critical requirements.



For burr-free, 2-axis cutoff of metal parts, the top five cut-off methods range from fast and simple to slow and specialized, in this order:

1. **Shearing**
2. **Cold sawing**
3. **Abrasive cutting — thin-wheel abrasive cutoff and electrochemical cutoff (ECC)**
4. **Wire EDM**
5. **Laser cutting**

While there are other methods of separating metal, none are ideal for simple 2-axis cut-off (essentially the process of taking something long and making it short). Amongst these five methods, there are respective benefits and drawbacks depending on the job, so your challenge is to balance the trade-offs with how well suited a method is to your cut-off requirements.

Selecting the right method begins by considering the following parameters:

1. Part Type

Is the part a rod, tube, or extrusion?

2. Material Type

For purposes of this comparison, we will look at a range of hard and soft metals with representative examples such as stainless steel, titanium, high nickel-content ferrous alloys, nickel-titanium alloys (e.g., nitinol/NiTi), and tungsten.

3. Part Dimensions:

+ **Lengths:** very short = under 0.125" (3.175 mm), short = 0.125" (3.175 mm) to 1" (25.4 mm), long = 1" (25.4 mm) to 1' (304.8 mm), and very long = 1' to 6' (304.8 mm to 1828.8 mm)

+ **Diameters:** ODs from 1" (25 mm) maximum to 0.001" (0.025 mm) minimum, requirements specific to tubes, such as the inside diameter (ID) and wall thicknesses required for capillary tubing

+ **Tolerances and Kerf:** the tighter the better, ideally at or below +/- 0.005" (0.127 mm). Similarly, the minimum amount of kerf is the goal.

+ **Capacity, speed, and cost:** determining whether a method is cost-effective for your required volume and time-line.

LENGTH

Some methods have real limitations when it comes to part length.

Just imagine the consequences of factoring in a particular method that excels at one aspect of your spec, but can't produce the length.

DIAMETERS

Consider the OD, ID and wall thickness.

For solid parts considering only the OD is relevant, but for parts such as capillary tubes

which require exceptionally clean, thin walls some 2-axis cutting methods won't work.

TOLERANCES & KERFS

When it comes to tolerances and kerfs less is more.

2 axis cutting methods are ideal for difficult-to-achieve tolerances, but some are more effective in certain ranges. Kerf is also a consideration as it can drive up material costs.

COST EFFECTIVENESS

Capacity, speed and cost.

One of the most overlooked considerations when choosing a cutting method is the relationship between volume, speed and cost. Be sure to prioritize appropriately.

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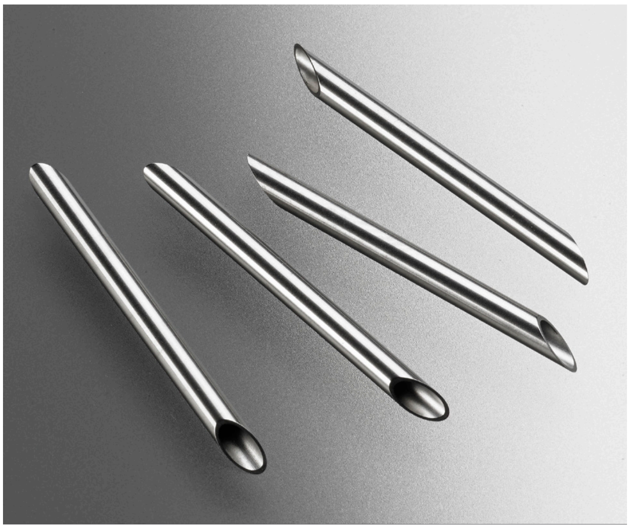


A Comparison of Method

It's important to understand the advantages and drawbacks of each of these methods in order to evaluate how they stack up against your priorities.

01 Shearing

Since shearing cuts without forming chips or burning or melting the material, the process works well with most softer metals.

Also known as die cutting or multi-slides, shearing is often used to cut simply shaped parts, such as rods and tubes, quickly and inexpensively. While there are many different types of shears, the basic process is the same — the application of extreme pressure by a moving blade (shear or punch) pushing the workpiece against a fixed blade (die or anvil). With advances in technology, high volume shearing has extended beyond its cam driven roots and benefits (as do all the other methods in this survey) from CNC advances.

Since shearing cuts without forming chips or burning or melting the material, the process works well with most softer metals. However, it is less ideal with harder metals. For example, shearing tungsten is simply a bad idea as it is extremely hard and often brittle, it can cause delamination or fracturing of the tungsten part, as well as significant wear on the tool itself.

Shearing can be used with virtually any diameter part and is especially cost-effective for high-output operations producing thousands of pieces per hour. However, shearing is not ideal for lengths under 0.125" (3.175 mm). When shearing a rod, the typical tolerance is +/- 0.005 (0.127 mm).

Perhaps the biggest advantage of shearing is that it produces minimal or no kerf, with virtually no loss of material. However, shearing also has some notable disadvantages. Since the force of the shearing action often creates burrs and end deformation, it may not be the best choice for applications where a clean end finish is required. For larger diameters with large clearance (i.e., separation between the blades), there may be heavy burring if the parts twist or are not securely clamped in place during shearing.

For cutting tubes, shearing doesn't easily allow a mandrel to be put in place, resulting in an unsupported cutoff that can cause the tube to be crushed. In some cases, a mandrel can be "floated" to support the tube ID; however, the method is imperfect and often results in imperfections in concentricity or end finish. This is especially true for small IDs, such as those required for capillary tubes.

Shearing at a Glance

Pros	Cons
Fast and cheap	Produces deformations and burrs
Suitable for most metals	Can produce crushed or closed tubing
No kerf	Cannot cut diameters under 0.125" (3.175 mm)
Suitable for any diameter	Less cost-effective for short runs
Fast, high volume production	Diameter/Thickness impacts volume/speed

02 Cold Sawing

Cold sawing is capable of high throughput on larger and heavier metals, even in certain circumstances as tight as +/- 0.005" (0.127 mm) tolerance.

Cold sawing uses a circular blade to cut in a process that transfers the heat generated by cutting to the chips created by the saw blade — keeping the workpiece, as well as the saw blade, cold. This enables cold saws to perform cutoff without damaging any protective coating on the workpiece.

During cold sawing, the metal is released in a shearing action by the saw teeth as the blade turns and a feed mechanism moves the blade forward. To achieve the best results, the appropriate number of saw teeth, blade type, cutting speed, and feed rate must be carefully selected based on the type and size of material being cut.

Cold sawing is capable of high throughput on larger and heavier metals, even in certain circumstances as tight as +/- 0.005" (0.127 mm) tolerance. It can be used for cutting many different shapes, including rods, tubes, and extrusions. However, cold sawing is not ideal for lengths under 0.125" (3.175 mm), and it can produce heavy burrs on ODs under 0.125" (3.175 mm) and on very small IDs, where the tube would be closed by the burr produced by the cold saw. While it is capable of cutting most ferrous and non-ferrous alloys, cold sawing is not recommended for very hard metals — specifically, those harder than the saw itself.

Cold saws use either a solid high-speed steel (HSS) or tungsten carbide-tipped (TCT) blade. Contrary to the name, HSS blades are rarely used at very high speeds; instead, their main attribute is hardness, which gives them high resistance to heat and wear. TCT blades are extremely hard and capable of operating at even higher temperatures than HSS, allowing TCT saw blades to cut at faster rates.

Both types of blades can be resharpened and may be used many times before being discarded. With a good, sharp blade, a fast circular cold saw can nearly eliminate burrs and produces no sparks, discoloration, or dust.

The downside is that increased hardness makes cold saw blades brittle and subject to shock. Any amount of vibration — for example, from insufficient clamping of the part or the wrong feed rate — can easily damage the saw teeth. In addition, cold saws usually cause significant kerf loss, which translates into lost production and higher costs.

Cold Sawing at a Glance

Pros	Cons
Fast and high volume	Large kerfs
Produces tight tolerances	Heavy burrs on rods and small tube IDs
Long blade life reduces production costs	Potential damage to saw teeth)
No sparks, discoloration or rust	Cannot produce very short lengths or small diameters

03 Abrasive Cutting

Modern technology has advanced abrasive cutting to produce high material removal rates and exceptional precision.

Using either a very thin, non-reinforced abrasive wheel or an electrochemical cutoff (ECC) wheel, abrasive cutting works by removing material from a rod, tube, extrusion, or other component through grinding and/or erosion by sub-micron cutting particles rather than by cutting with saw teeth. Modern technology has advanced abrasive cutting to produce high material removal rates and exceptional precision, lending itself to precision applications requiring high volume at a moderate price.

+ Thin-wheel abrasive cutoff uses wheels composed of countless tiny abrasive particles embedded in a bonding material. These wheels are self-dressing — that is, as the wheel cuts the material, the tiny, sharp abrasive particles are worn off, always exposing new ones and continuously presenting a fresh cutting edge. Notable advantages are that the metal being cut does not load the wheel, as occurs with diamond wheels; the kerf is small — 0.012" to 0.020" or 0.3 to 0.5 mm) — and burrs get pushed through the kerf and ejected. Thin-wheel abrasive cutoff allows the use of mandrels for supported tube cutting and the method can cut dielectric materials, so that composites and coated metals can be cut without any compromise or limitations.

Thin-wheel abrasive cutoff cuts at much faster rates than other precision methods such as EDM and laser and even ECC. Material can be bundled together which becomes an extremely efficient advantage as diameters get smaller and the number of parts within a bundle increases, providing cost savings on high-volume requirements. Even when cutting extremely hard materials, properly cooled thin-wheel abrasive cutoff generates little heat and produces the best end cut surface finish of all the methods surveyed in this comparison.

Thin Wheel Abrasive Cut off At a Glance

Pros	Cons
Can cut all metals	Cannot cut large diameters--over 1" (25.4 mm) for solids and 3" (76.2 mm) for tubes
All small diameters under 1" (25.4 mm) for solids and 3" (76.2 mm) for tubes	Raw material must be in straight lengths (cannot be cut from a spool)
Self-dressing wheels	Non-diamond wheels cannot cut carbide
Small kerf	
Burr-free	
Tight tolerance	
Smooth end finish	

CRITICAL FACTS: THIN WHEEL ABRASIVE CUTTING

+Provide cut length tolerances down to 0.001" (0.025 mm)

+Cut diameters from 0.0005" to 3.00" (0.0125-75.0 mm)

+Produce cut lengths as short as 0.008" (0.20 mm)

+Work with any tube ID and cut tube walls as thin as 0.001" (0.025 mm) — without deformation

+Cut coated parts without damaging the coating

+Hold exceptionally tight tolerances on long-length cuts of ± 0.005" over 6.0' (± 0.125 mm over 2 m)

+Produce the best "as cut" surface finish compared with all other cutting choices

+ Electrochemical Cut off (ECC)

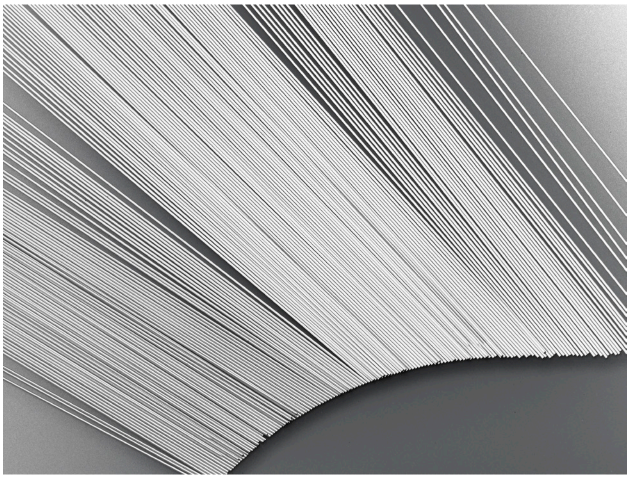
The ECC process combines electrochemical grinding and erosion to produce a burr-free, shiny surface to a tight tolerance of +/- 0.005" (0.127 mm). In this process, a positively charged workpiece in a conductive fluid is eroded by a negatively charged conductive grinding wheel. The cut is a balance between the unsupported grinding action and the electro-chemical erosion, with the trade-off being between the speed of the grinding wheel and the burr removal of the far slower chemical action.

Because ECC requires specific chemistry and conductivity for each metal type, the chemistry of the workpiece material affects the process, and vice versa. That means ECC does not work with all metals. For example, the particular and often slow chemical reactions of materials such as the refractory, nobel, and light alloys make them inappropriate for ECC. However, ECC works well with ferrous metals and stainless steel.

On the downside, ECC is not ideal for very short cuts under 0.125" (3.175 mm) nor any circumstance where a dissimilar or dielectric mandrel is needed to support the cutting of tubes. Bundling for multiple parts per cut cycle is possible but because erosion occurs as long as there is contact, the bundles have to be carefully constructed to prevent residual erosion from causing unwanted length variations. ECC wheels are wide and therefore there is a significantly large kerf. The process can also cause changes to the mechanical, physical, and chemical properties of the workpiece, such as reduced strength, loss of magnetic property, and susceptibility to corrosion. Composite or coated metals present the insurmountable problems of different erosion chemistries and a dielectric barrier, respectively.

ECC At a Glance

Pros	Cons
Produces a burr-free, shiny surface	Special chemicals needed for each metal
Can cut ferrous metals and stainless steel	ID burr contamination risk
Very long lengths	Wide kerf



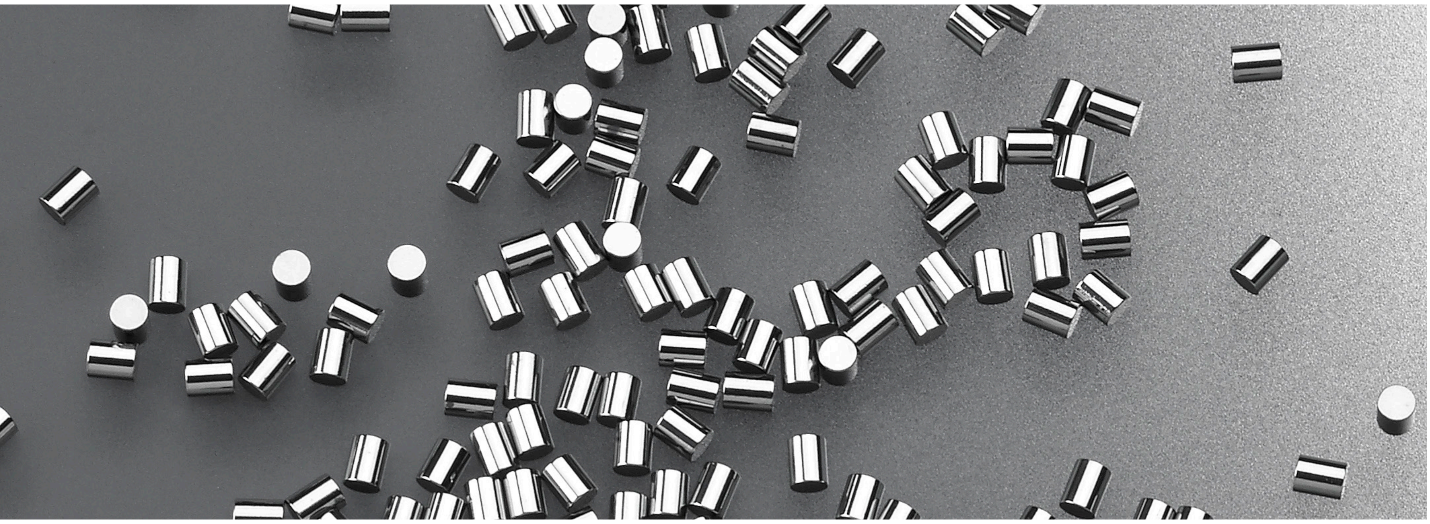
04 Wire EDM

Highly accurate for the right applications, EDM works especially well for cutting small parts with tight tolerances at high volumes.

Wire EDM uses controlled sparks along a single strand of metal wire to remove material from electrically conductive materials. Repeating rapidly — up to 250,000 times per second — the electrical charges erode the workpiece along a cut line. Wire diameter and material varies with the application; for instance, zinc-coated brass wires cut more quickly, while stronger wires (such as molybdenum) cut more accurately.

Highly accurate for the right applications, EDM works especially well for cutting small parts with tight tolerances at high volumes. It is ideal for small diameter solids — under 0.020" (0.50 mm) — at high volume and with high Ppk/Cpk. For example, a precious metal wire of 0.004" (0.1 mm) diameter cut to 1" (25 mm) length using EDM can provide a length tolerance of +/- 0.001", and radiused ends; remarkably, the Ppk will be well over the standard minimum of 1.33.

Wire EDM can also cut the hardest conductive materials, such as molybdenum and tungsten, with relative ease. However, any material that is a composite or coated with a dielectric is not appropriate for EDM.



Having no wheel or saw teeth, wire EDM generally leaves no burrs. The kerf width is usually from 0.004" to 0.012" (0.1 to 0.3 mm). Wire EDM can cut diameters ranging from a few thousandths of an inch to several inches. The highly repetitive cut part length can be from 0.5" (12 mm) to 18.0" (450 mm) with high dimensional accuracy.

On the downside, wire EDM is extremely slow. The process is also limited to cutting only materials that are solid and that conduct electricity. The total environment — including wire, deionized water, and workpiece — is charged. The wire's repeated electrical discharges can heat the target area of the workpiece to thousands of degrees, resulting in thermal stress to neighboring portions and causing some amount of waste. The wire itself also suffers damage during processing, so the EDM machine is constantly feeding new wire.

EDM is also not a good choice for cutting tubes. To maintain conductivity, the parts to be cut must be held firmly in place, which tends to deform tubing. While a tube can be fixtured so that it rotates in the EDM machine, the method is optimized for more complex shapes and not cost-effective for simple 2-axis cutoff of tubing.

Wire EDM at a Glance

Pros	Cons
Precise and versatile	Very slow
Excels at small, solid diameters	Very short cut lengths
Can cut hardnesses from Copper to Tungsten	Cannot cut tubes
Burr-free	Cannot cut composites or dielectric coatings
Small kerf	Does not produce quality surface finishes
High Ppk/Cpk	

"Example: a precious metal wire of 0.004" (0.1 mm) diameter cut to 1" (25 mm) length using EDM can provide a length tolerance of +/- 0.001" and radiused ends; remarkably, the Ppk will be well over the standard minimum of 1.33.

05 Laser Cutting

Because laser cutting is generally slow and expensive, there must be compelling advantages in order to justify the high cost of laser for 2-axis cutoff applications.

While laser cutting is versatile and precise, it is also the slowest and most expensive of the methods surveyed in this comparison. This means there must be compelling advantages in order to justify the high cost of laser for 2-axis cutoff applications.

Laser cutting uses a focused laser beam directed at a material, which then melts, burns, vaporizes, or is blown away by a jet of gas. There are a growing number of laser cutting machines that vary in laser beam delivery, speed of cutting, and capacity. In general terms, lasers range from large, powerful and aggressive to small, slow and precise. Large power lasers make fast cuts but produce rough end cut surface finishes and a wide, deep heat-affected zones. Lower power lasers cut with less damage to the metal -- although there is still some damage -- but take longer.

The workhorse for 2-axis cutting is the CO2 flying optic laser (and its hybrids), which can be used on a wide variety of materials. The neodymium (Nd) laser is used where high energy but low repetition is required, and the neodymium yttrium-aluminum-garnet (Nd-YAG) laser is used where very high power is needed. The ultraviolet (UV) laser is mainly used for production of non-metal parts.

Lasers used for cut-off can produce a small kerf — widths as small as 0.004" (0.10 mm) are possible — however, it depends on material thickness. On thin metal, lasers can cut precisely with tolerances as tight as +/-0.001". Lasers can also be used to cut tubing; however, the inside of the tube must be coated with antispatter fluid, an added step in the cutting process. In addition, materials must be laser-cut one at time and cannot be bundled together to achieve multiple cut-offs, which significantly adversely impacts production time and cost.

Cutting thicker materials requires a more powerful laser, which produces a rougher finish; therefore, lasers are not ideally used when cutting material thicker than 0.5" (12.7 mm). Lasers are also not well suited to cutting highly reflective metals such as aluminum and copper.

The heat produced with laser cutting is intense, so the laser must be carefully set, monitored, and adjusted to prevent heat stress damage to the workpiece. In addition, lasers consume large amounts of energy, adding to operational expense.

Laser Cutting at a Glance

Pros	Cons
Precise and versatile	Very slow and expensive
Produces tight tolerances	Produces a rough finish on thick parts
Small kerf	Cannot cut multiple parts at once
	Can only cut a maximum of 0.5 (12.7 mm) thickness
	Produces damage from heat stress

> "The workhorse for 2-axis cutting is the CO2 flying optic laser (and its hybrids), which can be used on a wide variety of materials.

Conclusion

Making the right choice requires an in-depth understanding of your unique applications and its specific parameters and applications.

Clearly, the efficiency of any cutting method can vary greatly depending on the job parameters and how well the method is matched to the work at hand.

For example, for cutting a simple hinge pin from solid 0.060" (1.5 mm) diameter low-carbon (i.e., non-stainless) steel wire, shearing might be your best option — providing short parts from a continuous coil for a lower per-part price than other methods, where there is no risk of tube crushing and where some level of deformation is acceptable. However, for extruded, thick wall tubes for plumbing, HVAC systems, and other pipes — where you want fast cut-off and where a jagged end finish and some burrs are acceptable — cold sawing would be preferable to shearing, which would damage the extruded profile.

On the other hand, you would not want to use cold sawing for thin stainless steel tubing with a 0.002" (0.050 mm) thick wall, due to the risk of a torn wall and burrs on the ID and OD. Instead, you would choose thin-wheel abrasive cutoff, with its ability to cut any tube diameter under 3" (76.2 mm) cost-effectively with no burrs and to tight tolerance.

While there are many more variables than can be covered in an overview such as this, it is our goal that the information presented here provides a basis for comparison as you begin to look at the options. In addition, Appendix A provides a quick and easy overview of the pros and cons each of the cutting methods explored in this guide.

Making the right choice requires an in-depth understanding of your unique applications and its specific parameters and applications. The only way to achieve a completely successful and satisfying outcome is to take the time to carefully consider all of your project's distinctive variables and special challenges.

Appendix A: Cutting Methods at a Glance

Use this table to quickly compare cutting methods and determine which method is ideal given your unique requirements.

Precision Cutting Method	Pros	Cons
Shearing	Fast and cheap Can cut most metals Produces no kerf Can cut any diameter High volume/speed	Deformations/burrs Crushed/closed tubing Cannot produce cuts under 0.125" (3.175 mm) Less cost effective for short runs Diameter/thickness impacts volume/speed
Cold Sawing	Fast and high volume Tight tolerances Long blade life No sparks, discoloration, or dust	Bad kerfs Heavy burrs on rods and small tube IDs Potential saw teeth damage No very short lengths or small diameters
Thin-Wheel Abrasive	All parts and metals All small diameters under 1" (25.4 mm) for solids and 3" (76.2 mm) for tubes Self-dressing wheels Small kerf Burr-free Tight tolerance Smooth end finish	Large diameters over 1" (25.4 mm) for solids and 3" (76.2 mm) for tubes Raw material must be in straight lengths (cannot cut from spool) Non-diamond wheels cannot cut carbon
ECC	Burr-free, shiny surface finish Ferrous metals and stainless steel Tight tolerance	Special chemicals needed for each metal ID burr contamination risk Wide kerf
Wire EDM	Precise and versatile Small, solid diameters Hardnesses from copper to tungsten No burrs Small kerf High Ppk/Cpk	Very slow Subject to conductivity and correct settings No very short cuts under 0.125" (3.175 mm) Bad for tubes No composites or dielectric coatings Surface finish
Laser Cutting	Precise and versatile Small kerf Tight tolerances	Very slow and expensive Rough finish on thicker parts Cannot cut multiple parts at one time Max 0.5" (12.7 mm) thickness Damage from heat stress

About Metal Cutting Corporation

Excellence in precision metal cut off.

Metal Cutting Corporation manufactures burr-free tight tolerance parts from all metals. We provide the precision required by medical device, automotive, electronic, biotechnology, semiconductor, aerospace, fiber-optic, electrical and many other diverse industries.

Specializing in precision for over 45 years

We are specialists with over 45 years cutting, grinding, lapping, polishing and machining metal parts. Our experience, inventory and capabilities provide the skills and capacity to meet the needs of technology device manufacturers. Specialty metals, micron tolerances, low or high volumes, complex metrology--all these and more are the requirements we achieve every day for products shipped worldwide.

Burr free cutting is what we're built on

Metal Cutting has been perfecting the science and crafting the art of burr free cutting for over 45 years. All 46 of our proprietary Abrasive and EDM cut-off machines offer unmatched precision and high speed capability with burr-free results. That means you get what you want, when you want it--there is no order too small, and no quantity too large. Cutting is what we're built on; and as the centerpiece of our operation, we work continually to improve our methods to ensure the quality and service our customers depend on.

Questions? Call Metal Cutting today.

We hope you've found this guide to be a handy reference as you determine which 2-axis cutting method is ideal for your application. We invite you to consult with us on your precision cutting needs. We think you'll agree that hearing what we have to say will be one of the best decisions you make in researching precision cutting methods for your industry and application. Call Metal Cutting today at 973-239-1100 or email **info@metalcutting.com**.

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