*Techtips* is a collection of useful ideas, techniques, and procedures designed to further EDM knowledge.

TechTips

by Roger Kern

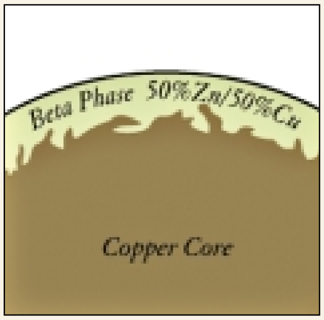
# EDM wireselection

## Your choice of EDM wire for any given job can make the difference between:

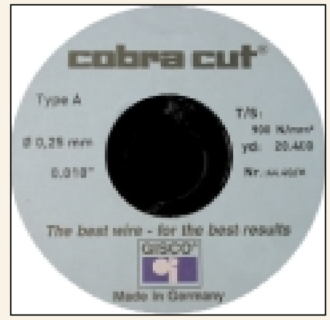
a. success
b. failure
c. profit
d. loss
e. all of the above ✓
f. none of the above

**In other words, it's not that simple.**

In fact, for certain limited situations it doesn't matter at all. However, in most instances, choosing the best wire for any given job requires the evaluation and balancing of a number of factors. There is no simple rule. This article will attempt to enumerate and examine those factors with the goal of helping you make informed choices.






## Prohibited Contamination

The physics of the electrical discharge process dictates that there will be some degree of interchange of material between the wire and the workpiece. However, in some applications, even the slightest degree of contamination of the workpiece surface with certain alloys or compounds present in the wire is not allowed. While this is not a common restriction, those of you with customers in the military, aerospace, and medical industries should be aware that for certain applications the following two types of elemental contamination are strictly prohibited:

• **Mercury:**
In the confines of a submarine, the combination of an enclosed environment, fire, and mercury (even in minute quantities) is lethal. Therefore, if you Wire EDM components for submarines, you will likely be required to certify that the wire you use is mercury-free.

• **Zinc:**
Although, for most applications, Zinc is considered to be a rather benign element, for a limited but growing number of aerospace or medical applications, Zinc is considered to be a surface contaminant and therefore prohibited. Unfortunately, this requirement rules out both plain brass wires and all coated wires, since both are constituted of brass which contains Zinc. With brass out of the picture, the remaining choices are all very poor cutting performers: Moly, Tungsten, or Copper.

## Minimum Corner Radius

The minimum internal corner radius of the contour will determine the maximum wire diameter that can be used. Obviously, the wire diameter needs to be at less than double the minimum inside corner radius. However, one also has to account for the amount of final overcut, plus a small amount of "maneuvering" room, so that the CNC can generate the corner. This is analogous to CNC contour milling, in which accurate internal corner radii are generated by machine motion, rather than just plunging an end mill into a corner and accepting the result. Usually, "the bigger, the better" for wire diameters up to .010". It is important to note that the new "twin wire" machines can employ a different strategy for these conditions, however, most of us do not have this luxury. Recommendations for small diameter wires include:

- **High Tensile Brass wire for .006" diameter**
- **Steel Core wire from .002" to .004" diameter**
- **Moly wire from .002" to .004"**
- **Tungsten wire from .0008" to .002"**

## Workpiece Material

What we are cutting can often dictate the preferred wire material. Based upon my experience, the following workpiece materials benefit from specific wire types, either for performance or surface finish considerations:

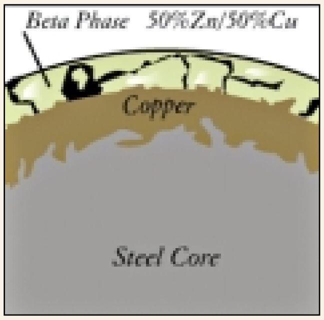
- **Carbide: Zinc or Gamma Coated Brass wire**
- **Aerospace alloys: Copper core, Beta or Gamma coated wires**
- **Graphite: Zinc or Gamma Coated Brass wire**

## Workpiece Cross-Sectional Area

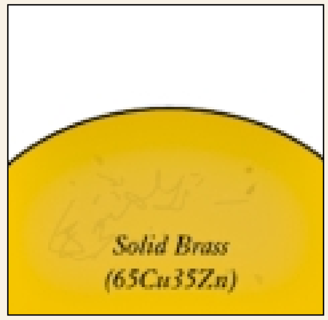
It's not a good idea to cut very thin materials with standard diameter wires. The power pulses will often overwhelm the ability of the thin workpiece to dissipate the heat and leave a combination of thermal distortion and poor surface quality. I am responsible for quality control testing of small tubes with very thin wall sections, often smaller than .004". In order to measure the I.D. of these tubes, I have to cross-section them with a Wire EDM. In order to get a precise, undistorted cut, I use a .006" wire, with the lowest possible power setting, to get a good surface finish.

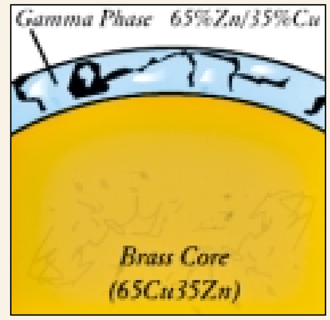
## Workpiece Thickness

Workpieces in the thickness range .015-2" can be successfully cut with just about any type and size wire. Once the thickness becomes larger than 2", both performance








and accuracy requirements may have a greater influence on wire choices. Wire diameter may be increased to better withstand higher wire tension demands for thicker workpieces. A larger wire diameter may also better handle the higher current requirements of taller parts. Thin Zinc coatings may burn away before the wire reaches the bottom of the part. Different core materials may be considered to better conduct higher current levels, or composite wires may be required to withstand the tension needed to cut workpieces up to 48” thick. Please consider the following recommendations for thick parts:

- **.012-.014 Brass — Depending on machine brand**

- **.012 Coated wires**

- **80:20 or 100% Copper core thick Beta Brass or Gamma Brass Coated wires**

- **Steel core composite wires with Beta Brass over Copper Coating**

## Interrupted Cut

Cutting through an interrupted cross-section, such as a part with a cross-hole, puts a tremendous stress upon any wire, due to the interruption of the continuous flushing stream. As a result, wire breaks can be very troublesome, even with some of the newer technology power supplies. This situation calls for increased wire strength to resist breakage. There are only two recommendations in this case:

- **Larger wire diameter — .012” and above**

- **Steel core composite wires with Beta Brass over Copper Coating**

If auxiliary water can be introduced into the interrupted section of the cut, this situation can be considerably improved. This can be accomplished by either submerged cutting or introducing pressurized water into the cavity.

**Safety note:**

*Interrupted cross-sections with trapped air pockets can be the source of Hydrogen explosions. The spark erosion process liberates Hydrogen gas from the water. The Hydrogen can combine with the air in the pocket to create an explosive mixture that is readily ignited by the sparks at the entrance and exit to the pocket. I have witnessed clamped parts being blown off the fixture by such explosions.*

## Poor Flushing

This factor is treated similarly to an interrupted cut, although the cause of the poor flushing is different. The primary causes of poor flushing conditions are:

- **Flush cups not properly sealed to workpiece due to either a stepped part, circular cross-section, or fixture constraints.**

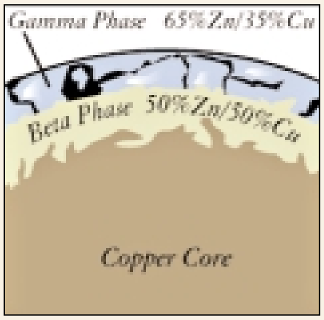
Here, the recommendation is again for a more robust wire to better withstand the effects of the poor flushing, specifically larger diameter or composite steel cored wires.

- **Flushing steams not in line with the cut in taper cuts.**

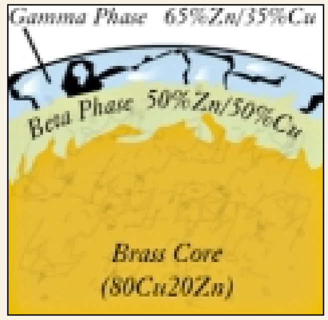
In this instance, both of the alternatives listed above might be counter-productive, as either of the recommended wires might resist the necessary wire bending at the outlet of the guides to effect the taper. Here, fully submerged flushing combined with lower wire tension might be in order.

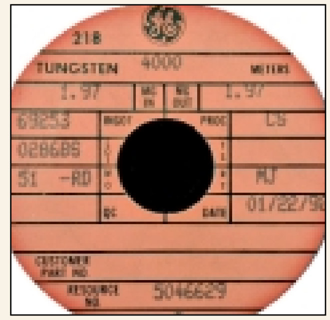
***Please note that I do not recommend a higher tensile strength wire!***

*High tensile strength wires are not more resistant to flushing related breakage. In fact, they are often less resistant to flushing related breakage than half hard wires.*








## Tapering requirements

Taper cutting requires the wire to take an immediate bend at the surface of the guide related directly to the taper angle. Any wire property that stiffens the wire will cause it to resist this bending and cause tapering errors — that is the wire will not follow the mathematically correct path assumed by the CNC controller. My recommendations for tapering are listed below:

- **Wire diameter .010” or smaller**
- **Hard wire (900 N/mm$^2$) for tapers no greater than 5º**
- **Half hard wire (490 N/mm$^2$) for tapers no greater than 15º**
- **Super soft wire (390 N/mm$^2$) for tapers greater than 15º**

While there may be some debate in the industry about exactly where the cut-off points within these recommendations lie, there is no disagreement that softer wires give more accurate tapers.

## Autothreading Requirements

If your application requires reliable, unattended autothreading for either multiple cuts and/or multiple skims, it is important to recognize that only the harder wires can be threaded reliably in many machines. Softer wires, even though straight when off the spool, will lose that straightness when they pass over and between pulleys and rollers within the wire path. A wire that is not straight will not thread reliably. Experience has shown that wire tensile strength needs to be 780 N/mm$^2$ or greater, to ensure reliable autothreading, unless the machine has a built-in annealing and straightening capability.

## Eroded Wire Removal Requirements

Some machines utilize scrap choppers. Certain high tensile wires (above 1100 N/mm$^2$) and all steel core wires are not compatible with many scrap choppers. These wires will make short work of the chopper blades.

Some machines utilize a wire basket to contain the eroded wire in a natural coiling action. It has been determined that certain wires do not coil neatly within the basket, and “birdsnest” instead, sharply reducing basket capacity and machine runtimes. Often this is the result of worn or mis-adjusted final rollers, but occasionally just changing the wire type corrects the condition.

## High Performance Requirements

High performance cutting requirements almost always point in the direction of coated wires, since it is getting higher Zinc concentrations securely bonded to the surface of the wire that results in higher cutting speeds. Therefore, my recommendations, in the order of increasing effectiveness (and usually cost) are as follows:

- **Zinc coating on full hard brass core**
- **Zinc coating on half hard brass core**
- **Gamma phase coating on full hard brass core**
- **Gamma phase coating on half hard brass core**
- **Thick Beta phase coating on high Copper alloy brass core**
- **Thick Beta phase coating on pure Copper core**
- **Gamma phase over Beta phase coating on high Copper alloy brass core**
- **Gamma phase over Beta phase coating on pure Copper core**

***Please note:***

*Not all of these options are compatible with all machine types, since some will not autothread reliably in machines that don’t anneal and straighten the wire before threading.*

You'll note that I have placed certain half hard wires at a higher performance level than their counterpart full hard wires. My testing has demonstrated that softer wire can be pushed harder and cut faster than a hard wire. I believe that this is due to the softer wire's ability to "give" when its cross-section is overloaded by the action of both the erosion of its surface and the wire tension. However, softer wire won't give any advantage at all if autothreading is required and your machine can't thread soft wires.

## Ultra Precision Requirements

It is my opinion that when attempting to manufacture parts by Wire EDM to ultra precision tolerances (.0001" total tolerance or less), the only suitable wire for the final skim passes is a high quality, hard, plain brass wire. This is so because there are fewer variables in the manufacturing process employed to produce it. A high quality plain brass wire has the greatest possibility for being on size, straight, and clean. In the final skim passes where actual metal removal is slight, the performance penalty associated with plain brass in roughing operations is inconsequential.

## A Note Concerning "Plain" Brass Wires

Uncoated "plain" brass wires are identified with the word "plain" in order to distinguish them from coated wires. Plain brass wires are available in a number of different alloys:

- **Cu65:Zn35 — The standard alloy for wires from Asia**
- **Cu63:Zn37 — The standard alloy for wires from Europe**
- **Cu60:Zn40 — High performance alloy for wires from Asia**

In theory, the higher the Zinc content the faster the wire should cut. Under ideal conditions, a 60:40 brass wire will outperform a 65:35 brass wire by approximately 3-5%. However, this advantage is often not achieved unless the settings are optimized. In a normal job shop environment with a variety of work, the difference between brass wire performance is often not noticeable. The quality of a brass wire is far more important than its alloy content.

## Available Technology

Your wire choices may be limited by either the technology built into your machine, the printed technology that is available or has become available for your machine, or your willingness and ability to develop your own technology (See *EDM Today* March/April 2007) for the newer generation of wires. In many cases, high performance coated wires will provide significant performance gains using standard machine settings for similar types of wires. However, if you try one of the newer generation wires and are not satisfied with the performance gains, you may have to develop your own technology. Technology development is not the answer for every shop. You may need to learn to be satisfied with a slightly lower level of performance, rather than take men and machines off line for extended periods to develop technology.

## Conclusion: A Delicate Balancing of Often Conflicting Factors

As is readily apparent from a study of the foregoing factors, there may well be conflicts that have to be considered when choosing a wire:

- **Quality requirements**
- **Machine compatibility — What wire works with the machines you have and can you thread it?**
- **Performance requirements — Do we need a 25% increase in speed if the machine will sit idle for five hours before the day shift comes in to change jobs, or do we have to deal with a backlog of work piled up at the machine?**
- **Wire Cost**
- **Wire changeover cost — Do we change wire and guides to optimize a 20 minute cut?**

The bottom line to making the optimum wire selection is, as in most all shop decisions, informed common sense.

***Next issue:***
Sinker electrode material selection.

*Any suggestions for future topics are welcome.*

*Tell us what you would like to read about.*

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