EDM Wire

A Reference to Understanding, Selecting and Using Wire on Wire-cut EDM Machines

Intech EDM®

Second Edition —
Revised & Updated

Introduction

Introduced in the late ‘60’s, wire-cut EDM was a unique, breakthrough technology. Although a slow and relatively limited process by today’s standards, its use spread quickly as its accuracy and effectiveness became apparent.

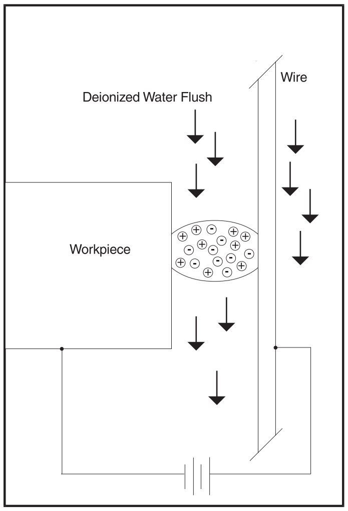
Originally, the process was fairly simple and uncomplicated; wire choices were limited to copper and brass; and there were relatively few suppliers.

Since then, wire-cut EDM has experienced explosive growth; in application, sophistication of equipment, and in the demands made on the basic tool of the process, the wire.

Now users demand and need maximum productivity and throughput, increased accuracy, and predictable performance. Higher angles of taper, thicker workpieces, automatic wire threading, and long periods of unattended operation, make choosing the optimum wire a much more critical factor in achieving a successful operation.

Machines and job requirements vary greatly, which can make selection of the correct wire a daunting task. As a result, experimentation with wire types is necessary if optimum results are to be achieved. Although this reference is not intended to be all-encompassing, it should be a useful guide to selecting the right wire for the job.

How it Works



Essential to selecting and applying wire is an understanding of how the wire-cut process works.

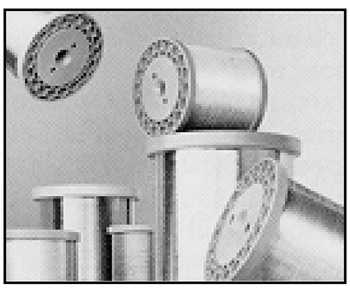
The workpiece and the wire represent positive and negative terminals in a DC electrical circuit, and are always separated by a controlled gap, constantly maintained by the machine. This gap must always be filled with a dielectric fluid, in this case deionized water, which acts as an insulator and cooling agent. Of equal importance, it flushes away the eroded particles from the work zone.

Sparks are formed through a sequence of rapid electrical pulses, generated by the machine's power supply thousands of times per second. Each spark forms an ionization channel under extremely high heat and pressure, in which particles flow between the wire electrode and the workpiece, resulting in vaporization of localized sections.

The vaporized metallic debris created by this process, from both the workpiece and wire material, is subsequently quenched and flushed away by the flow of dielectric fluid through the gap.

As the machine advances the wire through the workpiece, it cuts a slot slightly larger than the wire diameter. Since the wire is also eroded away and used up in this process, the machine constantly feeds new wire into the cut as "fresh" electrode material.

The Role of the Wire



The ideal wire electrode material for this process has three important criteria: high electrical conductivity; sufficient mechanical strength; and optimum spark and flush characteristics. As will be seen, there is no "perfect" wire that excels in every criteria, and some compromises become necessary, depending upon the desired results and application. And all three factors are very closely related and interdependent.

A high conductivity rating is important because, at least theoretically, it means the wire can carry more current, which equates to a "hotter" spark and increased cutting speed.

Mechanical strength, typically stated as tensile strength in PSI, needs to be sufficient to maintain wire straightness, with minimal vibration, under the tension applied by the machine's wire feed mechanism. There are some practical limitations, since the high hardness sometimes associated with cold-drawn, high tensile strength wires can result in a "kinky" or "springy" wire which is not suitable for high taper angles or automatic wire threading.

The ability of the wire material to enhance spark formation and the flushing process has become increasingly important with the growing need for both higher productivity and accuracy. It is highly desirable for the wire to erode, or wear, because the vaporized wire material aids in the formation of subsequent spark ionization channels. In addition, a higher degree of vaporization into microscopic particles, rather than melting, greatly improves the efficiency of the flushing process and, by suppressing arcing, the stability of the cut.

These characteristics are enhanced by a wire material whose surface has a relatively low melting point and high vapor pressure rating. And in fact, these factors are important enough to sacrifice some degree of conductivity. They also greatly improve cutting stability and resultant efficiency.

As both wire EDM machines and the science of wire manufacturing have matured, a variety of new wire materials and types have become available. Each type has its own distinct characteristics, and recent developments give the user a variety of choices.

Copper

Copper was the original material first used in wire EDM. Although its conductivity rating is excellent, its low tensile strength, high melting point and low vapor pressure rating severely limited its potential. Today its practical use is confined to earlier machines with power supplies designed for copper wire.

Brass

Brass was the first logical alternative to copper when early EDM'ers were looking for better performance. Brass EDM wire is a combination of copper and zinc, typically alloyed in the range of 63–65% Cu and 35–37% Zn.

The addition of zinc provides significantly higher tensile strength, a lower melting point and higher vapor pressure rating, which more than offsets the relative losses in conductivity.

Brass quickly became the most widely used electrode material for general purpose wire EDM. It is now commercially available in a wide range of tensile strengths and hardness.

Coated

Since brass wires can not be efficiently fabricated with any higher concentration of zinc, the logical next step was the development of coated wires, sometimes called plated or "stratified" wire. They typically have a core of brass or copper, for conductivity and tensile strength, and are electroplated with a coating of pure or diffused zinc for enhanced spark formation and flush characteristics.

Originally called "speed wire" due to their ability to cut at significantly higher metal removal rates, coated wires are now available in a wide variety of core materials, coating materials, coating depths and tensile strengths, to suit various applications and machine requirements.

Although more expensive than brass, coated wires currently represent the optimum choice for top all-around performance, and their relative economics are covered in a later section.

Fine Wires (Moly & Tungsten)

High precision work on wire EDM machines, requiring small inside radii, calls for wire diameters in the range of .001–.004". Since brass and coated wires are not practical, due to their low load carrying capacity in these sizes, molybdenum and tungsten wires are used.

However, due to limited conductivity, high melting points and low vapor pressure ratings, they are not suitable for very thick work and tend to cut slowly.

A composite wire called MolyCarb does offer significant advantages for small diameter work, since it coats moly wire with a mixture of graphite and molybdenum oxide to improve its flushing characteristics.

MolyCarb is a trademark of General Electric Co.

Selecting the Right Wire

Although offering solutions for every application, the wide variety of wire choices can sometimes be confusing. In a later section, we have provided application and machine selection tables to guide the user, and the following aspects should be considered:

Application

Workpiece thickness, final tolerances and finish desired (and resultant trim cuts), size of inside radii, high taper angles, and workpiece material; all require careful consideration when selecting the optimum wire. For example, although coated wire is generally superior to brass, its advantages are minimized when cutting thin materials (typically less than 3/8" thickness).

Machine

Considerable variations in design concept exist between brands of machines; in how they tension and handle the wire, in their power supply design, and whether or not they have automatic wire threading. The machine manufacturer's recommendations, regarding tensile strength in particular, should be the starting point for determining which type of wires to try.

Performance

Simple economics require users to get the most out of their machines, and cutting speed has become the dominant criteria for wire selection. It is not uncommon for a change in wire, and minor adjustments of power settings, to result in cutting speed improvements on the order of plus 20–40%.

Producing more work in less time is so important, that many shops will even change wire mid-job; using high performance wire for the initial cuts and perhaps a smaller diameter wire for the remaining small radii, for example.

Wire diameter should also be considered when cutting speed is critical. Since smaller diameter wires can not carry as much current, use the largest diameter wire possible for maximum speed.

Economics

As noted, operational economics frequently dictate wire selection. Although the cost of wire used in the process is not insignificant, it is much less than the other costs associated with wire EDM, including machine cost of ownership and depreciation, shop overheads and labor, and the cost of scrap and rework if the wrong wire is selected for the job.

As a result, the user should not hesitate to experiment with higher grades of wire at additional cost, even for seemingly modest increments of performance improvements.

Coated Wire vs. Brass Wire

Even though coated wires have been in existence since the early 1980's, brass wire still commands the dominant share of overall wire usage. Although somewhat understandable, considering that the cost ratio of coated wire over brass is almost 2:1, this lingering preference for brass wire continues to mystify wire manufacturers, since the performance advantages of coated wire are truly compelling.

Not only do they outperform brass wire by a considerable margin, the refinements and improvements in their fabrication and metallurgy make them appropriate for over 95% of the jobs currently being run on machines produced since the early 1980's.

Let's look at the economics of why almost every shop should be using coated wire:

1. The average wire EDM machine running cost is about $40/Hour, taking into consideration original cost, depreciation, maintenance, downtime, consumables (incl. brass wire), electricity, labor and shop overhead rates.

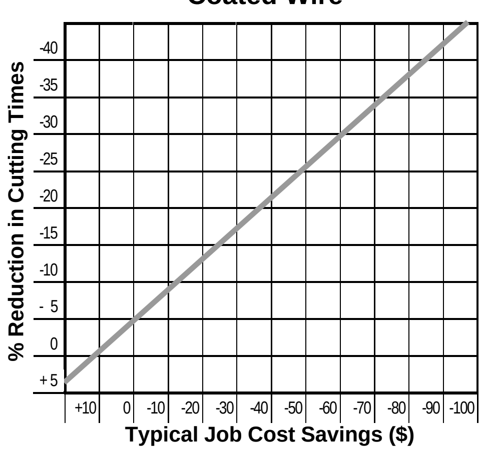
2. At a wire feed rate of 400m/hour, typical brass wire costs around $2.20/Hour. A typical coated wire, at the same feed rate, costs around $4.05/Hour.

3. The additional $1.85/Hour cost of coated wire increases *total cost* per hour only 4.6%! And more importantly, pays for itself with less than a 5% improvement in performance.

If an average job requires 6 hours of cutting time to produce using brass wire, the total machine cost for the job is $240. If coated wire reduces total running time by 15%, a not unreasonable expectation, the result is an 11% reduction in total cost, resulting in a net savings of over $26 per job!

The accompanying graph compares the cost-per-job savings of coated wire compared to brass wire at various levels of performance improvements. If you add the capability of turning out more work and more jobs per week/month/year, *and* the ability to respond to your customer's requirements faster, the cost benefits and increased profit potential become even greater.

Job Cost Savings with Coated Wire



a) *Comparing using coated wire, with a total machine running time cost of $41.85/Hour, to using brass wire at a total cost of $40.00/Hour.*

b) *Comparison calculated using an "average" job requiring 6 hours of cutting time with brass wire.*

c) *Ignores minor increases in electricity and non-wire consumable costs associated with faster cutting speeds, which do not significantly alter the basic comparison.*

d) *Ignores greater efficiency of coated wire, which results in lower wire feed rates (and resultant consumption) of up to 20% less than brass wire.*

Wire Characteristics & Specifications

Intech Brands	Type	Core	Coating	Tensile Strength	Elongation (%)	Sizes (inch/mm)	Spool Sizes (lbs/kg)
Betacut X™	Coated	Copper	Diffused Zinc	70,000 psi 500 N/mm²	1	0.012/0.30 0.010/0.25	8.4/3.8 14.3/6.5 33.0/15.0
Charmilles SW25X	Coated	Copper	Diffused Zinc	70,000 psi 500 N/mm²	1	0.010/0.25	8.4/3.8
Charmilles SW25, SV25	Coated	Copper	Un-annealed Zinc	63,000 psi 450 N/mm²	1	0.010/0.25	8.4/3.8 17.6/8.0
Alphacut D™	Coated	Brass (90/10 CuZn)	Diffused Zinc	97,000 psi 690 N/mm²	1	0.012/0.30 0.010/0.25	6.6/3.0 8.4/3.8 11.0/5.0 14.3/6.5 33.0/15.0 44.0/20.0
Alphacut 800™	Coated	Brass (64/36 CuZn)	Zinc	126,000 psi 900 N/mm²	1	0.012/0.30 0.010/0.25 0.008/0.20 0.006/0.15 0.004/0.10	4.0/1.8 6.6/3.0 8.4/3.8 11.0/5.0 14.3/6.5 33.0/15.0
Alphacut 500™	Coated	Brass (64/36 CuZn)	Zinc	70,000 psi 500 N/mm²	18	0.012/0.30 0.010/0.25 0.008/0.20	4.0/1.8 6.6/3.0 8.4/3.8 11.0/5.0 14.3/6.5 33.0/15.0
Super Brass 900 Plus™	Solid	Brass (64/36 CuZn)	—	140,000 psi 1,000 N/mm²	1	0.010/0.25	11.0/5.0 14.3/6.5
Super Brass 900™	Solid	Brass (64/36 CuZn)	—	126,000 psi 900 N/mm²	1	0.012/0.30 0.010/0.25 0.008/0.20 0.006/0.15 0.004/0.10	4.0/1.8 6.6/3.0 8.4/3.8 11.0/5.0 14.3/6.5 33.0/15.0 44.0/20.0
Super Brass 500™	Solid	Brass (64/36 CuZn)	—	70,000 psi 500 N/mm²	18	0.012/0.30 0.010/0.25 0.008/0.20 0.006/0.15	4.0/1.8 6.6/3.0 8.4/3.8 11.0/5.0 14.3/6.5 33.0/15.0
Hi-Tensile OKI P Brass 2300	Solid	Brass (65/35 CuZn)	—	142,000 psi 980 N/mm²	3	0.012/0.30 0.010/0.25 0.008/0.20	6.6/3.0 11.0/5.0 44.0/20.0
Multicut 900™	Coated	Copper-clad Steel	Alpha/ Beta Brass	125,000 psi 890 N/mm²	1	0.012/0.30 0.010/0.25	6.6/3.0
Molybdenum 15	Solid	Mo	—	280,000 psi 1900 N/mm²	5	.010/0.25 to .001/0.03, in .001" increments	.010 - .007" - 3,300' .006 - .001" - 9,900'
MolyCarb 150	Coated	Mo	Molyb-denum Oxide Graphite	280,000 psi 1900 N/mm²	5	.010/0.25, .008/0.20 to .001/0.03, in .001" increments	.010 - .007" - 3,300' .006 - .001" - 9,900'

Notes: All diameters are not available in all spool weights listed; consult Intech EDM for details and spool sizes. Spool sizes for Molybdenum & MolyCarb are shown in feet/spool. MolyCarb is a trademark of General Electric Co.

Intech Brands	General Usage	High Taper Angles	Speed Cut	Trim Cut	Auto Thread	Cross Reference
*Betacut X™	✔✔	✔	✔✔	✔	✔	Bronco Cut X
*Charmilles SW25X	✔✔	✔	✔✔	✔	✔	Bronco Cut X
*Charmilles SW25, SV25	✔	✔✔	✔			Bronco Cut
*Alphacut D™	✔✔	✔	✔✔	✔✔	✔	Cobra Cut D
*Alphacut 800™	✔✔		✔✔	✔✔	✔✔	Cobra Cut A
Alphacut 500™	✔	✔✔	✔	✔✔		Cobra Cut A
Super Brass 900 Plus™	✔✔	✔	✔✔	✔✔	✔✔	Ameri-Brass
Super Brass 900™	✔✔	✔	✔✔	✔✔	✔✔	Megacut
Super Brass 500™	✔✔	✔	✔	✔		Megacut
Hi-Tensile OKI P Brass 2300	✔✔	✔	✔✔	✔✔	✔✔	Megacut
*Multicut 900™	✔	✔	✔✔	✔✔		Compeed
Molybdenum 15	✔	✔		✔✔		—
MolyCarb 150	✔	✔	✔	✔✔		—

✔✔ = Highly Recommended for this Application. ✔ = Acceptable Performance. ☐ = Not Recommended or Not Applicable.

Notes: Lower tensile strength wires are recommended for high taper angle cutting (approximately 5° and above), due to the high stress encountered as the wire bends at the guide. High tensile wires are recommended for automatic wire threaders, unless the application requires high taper angles. Wires indicated with * are specially recommended for poor flushing conditions. Molybdenum & MolyCarb wires are intended for small radius work and specific applications, and are not economically feasible for general usage. The brand cross references are for comparative purposes only and are not meant to imply that they are direct equivalents of Intech EDM products. Bronco Cut, Cobra Cut and Megacut are registered trademarks of Berkenhoff GmbH. Compeed is a registered trademark of Fujikura.

Intech Brands	Agie	Brother	Char-milles	Fanuc	Hans-vedt	Hitachi	Japax	Makino	Mitsu-bishi	Seibu	Sodick
Betacut X™		✔	✔	✔			✔				✔
Charmilles SW25X			✔								
Charmilles SW25, SV25			✔								
Alphacut D™	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔
Alphacut 800™	✔	✔	✔	✔				✔	✔		
Alphacut 500™	✔	✔	✔	✔	✔	✔	✔			✔	✔
Super Brass 900 Plus™	✔	✔		✔		✔	✔	✔	✔	✔	✔
Super Brass 900™	✔	✔		✔		✔	✔	✔	✔		✔
Super Brass 500™	✔	✔	✔	✔	✔	✔	✔			✔	✔
Hi-Tensile OKI P Brass 2300	✔	✔		✔		✔	✔	✔	✔		✔
Multicut 900 ™	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Molybdenum 15	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
MolyCarb 150	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Notes: Since EDM machine companies have manufactured a wide variety of models over time, with different operating characteristics, by necessity this is only a general guide to which wire types should be considered. For more specific information regarding your particular

Intech EDM & Electrotools

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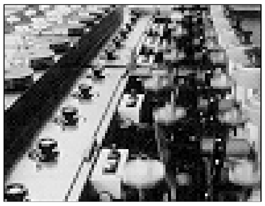
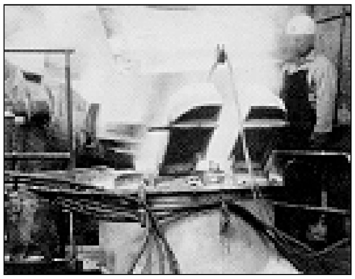


Intech EDM was formed in 1988 as a new parent company to its former principals and partners – Alectro® in Europe and Electrotools® in the U.S.A., two of the largest and most respected names in EDM wire, electrodes and supplies.

Started in 1972, Alectro was the first company to manufacture coated EDM wire, and has the largest single graphite machining facility in Europe. They headquarter in the Netherlands, and have subsidiaries in Germany, Switzerland, France and Great Britain.

Founded in 1961, Electrotools has become the preeminent supplier to the U.S. EDM industry of wire, machined and preformed graphite & metallic electrodes, tooling and supplies.



The resulting company, Intech EDM, is now the world's largest supplier of EDM tools and supplies, with seven locations and more than 120 distributors and representatives worldwide selling the Intech, Electrotools and Alectro product brands.

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