Metal Cored Tubular Welding Wires
The Standard of Excellence in Tubular Welding Electrodes
In this era of reduced profit margins, shrinking bottom lines and increasing costs, fabricators, shipbuilders and other manufacturers are seeking an improvement in one key area - productivity. In 20th century welding, improvements in productivity hinged on graduation from covered electrodes to solid electrodes (wire) to, finally, flux cored electrodes (wire). The advent of metal cored electrodes (wire) in the 1980's aroused curiosity, but the lack of process and product understanding by manufacturers and end users hindered the ability to create general improvements in productivity.

The 21st century brings an enlightenment regarding the benefits of metal cored wire. Everyone has charts and graphs showing deposition rate comparisons, along with total welding cost comparisons. These are quite valid means of proving the cost advantages of metal cored over other welding processes and are used every day. However, the true benefit of metal cored electrodes is the ability to solve problems, which occur daily in welding and fabricating.

Select-Arc’s complete line of metal cored wires is the answer to a problem which has existed for years-how to combine the efficiencies of solid wire (GMAW) with the higher productivity of flux cored (FCAW) electrodes. Metal cored wires offer all the advantages of solid wires; low fume generation rates, high efficiencies, no slag to remove or clean, with all the advantages cored wires have over solid wires; no lack of sidewall fusion (cold lap), total spray transfer or complete transition, and faster travel speeds for a given fillet size.

Select-Arc’s offering of metal cored wires ranks at the top in quality and performance. New technology in manufacturing equipment provides the ultimate in consistency of fill, diameter control and surface finish. These electrodes provide a smooth spray transfer, negligible spatter and a flat bead profile with virtually no slag islands. Minimal spatter and the absence of slag promote extremely high deposition efficiencies, 95-98%, resulting in high deposition rates and subsequently lower welding costs.

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The tubular construction of metal cored electrodes is the cornerstone of reasons which account for the many advantages this product offers over solid, and in some cases, flux cored electrodes. Even though the fill ingredients are virtually all metallic, the core does not carry very much of the current. Nearly all the current is conducted through the "tube" or strip. This creates a wider, shallower path of penetration than solid wire, which enhances fusion into the sidewalls and eliminates a condition known as "cold lap". In fact, the sidewall fusion with metal cored is nearly as good as with flux cored electrodes.

Couple this with the extra deoxidizers that can be added to the core ingredients and metal cored electrodes offer a further advantage of welding over hot rolled or scaled carbon steels with hardly any subsurface porosity or defects. Solid wire weldments are quite susceptible to subsurface defects, particularly on heavy plate sections. An attribute often overlooked is the capability of metal cored electrodes to weld joints with poor fit up or gaps, with minimal problems of burn through or arc outages. The same phenomenon, utilization of current density (due to the tubular nature of the wire), accounts for these technical advantages.

The biggest advantage of all, which metal cored offers over solid electrodes, is the most cost effective - productivity! For a given fillet size, solid wires exhibit a deep, narrow penetration nugget, which not only increases the risk of cold lap, but uses more weld metal than necessary to fill the joint. Metal cored wire, with a wider, shallower penetration pattern, uses less weld metal than solid wire for the same size fillet (See Example 1). In effect, the cross sectional area of a metal cored weld is less than that of a solid wire weld for equal fillet sizes.

If deposition rates are equal, and metal cored wire is usually higher, the metal cored product will deposit more length of fillet per unit time than the solid electrode. Welding speeds up to fifty percent faster are achievable with the metal cored process, depending on the application. This translates into big savings in welding costs due to the increased productivity.
Assemblies with gaps, poor fit up, or both, create quite a problem for solid wires. Solid electrode GMAW is plagued by the inability to bridge the gaps and a propensity to burn through on the poor fit up areas. Metal cored welding solves both problems. The wider, shallower penetration pattern facilitates bridging gaps and handling poor fit up with no burn through or porosity. Quality is improved and productivity is enhanced. Typical applications are refrigerant compressors, auto frames and front and rear cradles.

The metal cored wire produces a much more uniform weld in a lap (bottom) than the solid wire (top), which is quite uneven. Both lap joints were welded with the same parameters and travel speed.

The fillet made with metal cored wire (top) is flatter than the solid wire (bottom), with metal cored also exhibiting much better fusion.

Note the performance of metal cored wire on a lap weld, with a 1/16” gap (top). The bead ties in better than the solid wire lap weld (bottom), with no burn through. The solid wire has burned through and melted the corner at the top of the lap.
Many joints and weldments successfully made with flux cored electrodes (wire) are limited by the need to remove and clean up flux residue and the maximum travel speeds of flux cored, which are somewhat faster than solid wire, but slower than desired. Use of metal cored electrodes eliminates the slag and flux residue, and travel speeds can be 30 to 50 percent faster than solid electrodes. Typically, these welds can be found on earth moving machinery and power transmission poles.

Lighter gauge structural steel warps when welded with solid wire due to the deep, narrow penetration nugget, but flux cored welding has been ignored because the clean up of flux residue is unwanted. The metal cored process provides several improvements here. The shallower, wider penetration pattern distributes the heat flow more evenly and eliminates the warpage. Travel speeds can be increased by 30 percent or more over the solid wire. Lastly, there is no flux residue to clean up and remove.

The fume emissions of flux cored electrodes (top photo) are objectionable when welding in confined spaces or enclosed areas, especially when using up to 3/32” diameter (or larger). Converting to 1/16” metal cored electrodes affords virtually the same deposition rates with a fraction of the fumes (bottom photo) when used with argon-carbon dioxide shielding of at least 75 percent argon. Typical applications would be subassemblies for earth moving and logging machines.

Solid wire welds on heavy (1” or more) plate sections generally experience lack of fusion (cold lap) problems and are plagued with subsurface porosity on hot rolled steels. Normally, solid wire was chosen in such applications because of lower fume emissions than flux cored electrodes with no flux residue to clean up after welding. Metal cored electrodes are the perfect answer to this dilemma. They offer the increased penetration and elimination of cold lap associated with FCAW, fume emissions as low as solid wire and weldments free of flux residue. The metal cored process also provides higher deposition rates, approaching those of flux cored electrodes, without the susceptibility to subsurface porosity of solid electrodes. The results are big savings due to increases in productivity by reducing labor and increasing deposition rates and efficiencies.

Welding of low alloy steels, such as 1, 2 and 3 percent nickel, B2, B3, B6, B8 and B9 chrome-moly, 1/2 percent moly, and chrome-nickel- moly grades can be a problem with solid electrodes. Solid wires in these grades are expensive, difficult to obtain in small quantities and hard to find domestically. Metal cored versions of these grades are readily available, easily manufactured in smaller lot sizes, and perform well on both argon-carbon dioxide and argon-oxygen gas mixtures. Special alloy types can be formulated and standard grades can be tailored to certain gas mixtures or applications.

In the world of low alloy and high strength, low alloy steels, metal cored low alloy steel electrodes are the perfect solution to the problem known as solid wires.
The metal cored process is, in some ways, the best-kept secret in the welding industry. Welding with metal cored carbon and low alloy steel electrodes offers increased productivity, more flexibility in applications, reductions in fume generation rates and other advantages to solve specific welding problems.

Metal cored electrodes are also available in diameters up to 5/32" for carbon and low alloy steel submerged arc applications.

Select-Arc is a leader in advancing the technology of the metal cored process. It is by far our fastest growing product line and affords the biggest gains in the welding industry in terms of cost reduction through increased productivity, reduced training time, less rework, less spatter cleanup, no slag cleanup and higher electrode efficiencies. Select-Arc is a responsive company—well poised to cultivate and promote the advantages of the metal cored process to improve productivity in the marketplace. It is an absolute certainty that we have only scratched the surface of the improvements that are inherent with the use of metal cored electrodes.

In closing, this text should help us to realize that the major cost of welding is not filler metal pricing—it is labor and burden which totals 80% of welding cost. Filler metal cost totals only 13% on average. Obviously, the use of metal cored wire is the answer to achieving cost savings through gains in productivity.

Discussion

The advantages of using metal cored electrodes can be summarized as follows:

- Process is easy to master and requires less training.
- Affords ease of operation for the welder.
- Higher productivity than other processes.
- No spatter or slag to clean up.
- Major reduction in rework.
- Less grinding.
- Minimizes overwelding.
- Increased travel speeds.
- Bridges gaps better than solid wire.
- Elimination of cold lap.
- Reduction of subsurface porosity.
- Low fume generation rates.
- Reduction of total welding cost.

Summary
Select 70C-3

This electrode exhibits a perfectly smooth spray transfer and virtually no spatter emission. The composite metal cored process offers advantages over solid wire, such as faster welding speeds for increased productivity, better fusion on the sidewalls of plate eliminating cold lap and less tendency toward subsurface porosity.

The versatility of Select 70C-3 makes it an ideal choice for applications where solid wire is inadequate or the slag from flux cored wire is unwanted. Typical areas of appeal are propane and air compressor tanks, farm machinery frames and assemblies, heavy gauge sheet metal and general steel fabrication. The absence of slag and spatter residue facilitates painting after the welding operation is completed.

Select 70C-6

Select 70C-6 is a premium metal cored electrode that delivers higher manganese and silicon contents than Select 70C-3, providing more deoxidization and a flatter bead geometry. The extra deoxidizers allow this electrode to be used on higher levels of mill scale than can be tolerated by the E70C-3X class of metal cored product. The use of 70C-6 offers many advantages over ER70S-6 solid wires, such as faster travel speeds and increased productivity, better sidewall fusion on heavy plate and more porosity-free weldments.

Select 70C-6 excels in general purpose welding, but is equally superior in higher demand situations as in heavier sheet metal fabrication, structural work, pipe welding and welding of hot water heaters.

Select 70C-6LS

Select 70C-6LS is specially formulated to minimize ‘slag islands’ left on the weld bead surface. This product provides a smooth spray arc transfer with virtually no spatter. Weld beads are flat, with excellent tie in. Plate with mill scale or mild contaminants is easily welded. The use of Select 70C-6LS offers many advantages over ER70S-6 solid wires, such as faster travel speeds and increased productivity, better sidewall fusion on heavy plate and more porosity-free weldments. Select 70C-6LS is well suited for applications such as thin-walled tanks and certain structural steel and earthmoving equipment.
### Select 70C-7
Select 70C-7 is a lower fume version of the Select 70C-6 electrode. This product has been formulated to produce substantially lower fume generation rates than conventional E70C-6M electrodes. The arc transfer is a soft spray transfer with a clear weld puddle. Bead geometry is excellent, exhibiting a flat, equal legged profile with very few slag islands. As with Select 70C-6, Select 70C-7 offers increased productivity, better sidewall fusion on heavy plate material and more porosity-free weldments.

This electrode is capable of welding heavy sections and plate with mild contaminants. Select 70C-7 excels in plate fabrication, structural welding and heavier sheet metal fabrication. Typical applications include car and truck frames, structural steel, trailers and earthmoving equipment.

### Select 70C-10
Select 70C-10 is specially formulated to perform high speed filler and lap welds on materials from 0.090 to 0.250" in thickness. There is more than adequate deoxidation to allow welding over thin films of oil or metal forming lubricants.

Select 70C-10 is ideally suited for those applications requiring higher travel speeds on thin gauge carbon steels than attainable with solid or conventional metal cored electrodes such as in the automotive or structural steel industries. This product excels in the welding of automotive and truck frames, automotive cradle assemblies, farm machinery and other general purpose welding of light gauge components.

### Select 70C-T
Select 70C-T is a microalloyed version of Select 70C-6, offering superior CVN toughness values at subzero temperatures as low as -50°F. This electrode exhibits a true spray transfer with virtually no spatter. The bead profile is superior; fillets are equal legged with little if any convexity. The deoxidizer content of Select 70C-T allows it to weld over mill scale and rust with no surface porosity of any significance. This product has superior crack resistance in certain restrained joints.

The excellent CVN toughness of Select 70C-T makes it an ideal selection for welding fine grained steels. Such steels would be ASTM A515 Grade 70, A516 Grade 70, and 1% Ni steels. These materials would be used in the fabrication of railcars, mining machinery, earthmoving equipment, pipeline material and fabrications utilized in cold climates.

### Select 70C-8
Select 70C-8 is a carbon steel composite metal cored electrode with the ability to weld over heavy rust, mill scale, paint and other contaminants. Its advantages over welding with solid electrodes include increased travel speeds, better fusion into base material and sidewalls and the virtual elimination of subsurface porosity.

Select 70C-8 is ideal for those difficult-to-weld items such as heavily rusted and scaled surfaces or when the steel is coated with oil or paint. Strength levels and CVN toughness make it well suited for welding ordinary and fine grained steels such as ASTM A36, A285, A516, Grade 70 and A515 Grade 70.
Select 80C-B2
A metal cored, low alloy steel electrode, Select 80C-B2 is designed to weld certain chromium and molybdenum steels. This product delivers lower spatter, faster travel speeds, higher deposition rates and increased penetration with greater deposit weld consistency than solid wire.

Select 80C-B2 is intended to weld materials such as ASTM A335-11 pipe and A387 Grade 11 plate. The weld metal is designed to withstand the high temperature service of the base materials.

Select 80C-W
Select 80C-W is a premium low alloy steel, metal cored electrode, which wets in a pure spray transfer. Select 80C-W generates less fumes than flux cored electrodes and is useful where slag removal and cleanup are problems. Faster travel speeds are achievable than with solid electrodes, thus increasing productivity. Spatter emission is quite low.

Select 80C-W is intended for those applications requiring the coloration and corrosion resistance of the weathering type of structural steels, such as ASTM A242 and A588.

The addition of approximately 1/2% copper imparts these “weathering” properties, while the strength, ductility and notch toughness are achieved by chromium and nickel additions. These steels are used typically in bridges, transmission towers and poles and some building construction.

Select 80C-Ni1
A low alloy steel, composite metal cored electrode designed for welding certain low temperature or low alloy steels, Select 80C-Ni1 provides excellent welder appeal with low fume generation and virtually no spatter.

Select 80C-Ni1 is ideal for fine grained or low alloy steels requiring moderate tensile strength and good subzero CVN toughness, such as ASTM A203, Grade E, A302, A575 and A633. Typical applications include the fabrication of earth-moving machinery and buckets, offshore equipment and mining machinery.

Select 80C-Ni2
This composite metal cored electrode is designed for welding carbon and low alloy steels requiring 80,000 psi minimum tensile strength and good Charpy V-notch toughness at subzero temperatures. Select 80C-Ni2 operates in a smooth spray transfer, with virtually no spatter and very little fume emission. Weld beads are flat, with good tie-in, and few slag islands. This electrode provides superior penetration into sidewalls, minimizing lack of fusion.

Good CVN values at lower temperatures make Select 80C-Ni2 an excellent choice for those applications where low temperature toughness is essential, such as construction equipment, piping systems, shipbuilding and colder climate fabrications.
Select 80C-D2

Select 80C-D2 welds certain high strength, low alloy steels where a minimum tensile strength of 80,000 psi is required in the deposited metal. This premium electrode, which offers a smooth low spatter spray transfer, faster travel speeds of 30 to 50% and the elimination of cold lap, provides a productivity-enhancing welding alternative to ER80S-D2 solid wires.

Select 80C-D2 is ideal for those applications requiring weld metal which matches the mechanical properties of high strength, low alloy pressure vessel steels such as ASTM A302, Grade B and HSLA steels and manganese molybdenum castings such as ASTM A49, A291 and A735.

Select 90C-B3

Select 90C-B3 is alloyed with approximately 2 1/4% chromium and 1% molybdenum. This produces a high strength weld deposit which is generally post weld treated. This composite metal cored electrode provides faster travel speeds—hence, higher productivity, better fusion into base metal, less susceptibility to subsurface porosity and greater tolerance for mill scale compared to solid electrodes.

Select 90C-B3 is intended for welding the 2 1/4 Cr-1 Mo steels used in high temperature and pressure piping, as well as pressure vessels. ASTM A387 - Grade 22 and ASTM A335-P22 are the standard grades of steel used in many of these applications. This electrode may also be used to weld Cr-Mo steels to carbon steel.

Select 90C-B9

Select 90C-B9 is designed for the welding of 9% chromium and 1% molybdenum steels. It also contains small additions of niobium, vanadium and nitrogen to improve long term creep properties. Select 90C-B9 offers excellent welder appeal with a smooth, stable spray, minimal spatter and increased deposition rates.

Select 90C-B9 is used to weld 9Cr-1Mo creep resistant steels, such as A387 Grade 91 plate; A335-P91 and A369-FP91 piping; A199-T91, A200-T91 and A213-T91 tubing; A182-FP91 forgings; fittings and castings of similar composition. Typical applications include power plant turbine casings, valves, headers and piping.

Select 90C-M2

Where a minimum tensile strength of 90,000 psi is required in the deposited metal, Select 90C-M2 is the electrode. This premium, composite metal cored electrode exhibits superb welder appeal, excellent mechanical properties and a pure spray transfer with virtually no spatter emission. Advantages over solid wire include: faster travel speeds, hence increased productivity; enhanced sidewall fusion.

Select 90C-M2 is well suited to joining low alloy, high strength steels such as HY-80, A710 and A514. These materials are used in shipbuilding, earthmoving equipment and mining machinery. This electrode is an ideal choice for those weldments where distortion must be minimized and de-slagging is not desirable.
**Select 100C**

Select 100C is designed to weld some carbon and certain low alloy steels, where a minimum tensile strength of 100,000 psi is required in the deposited weld metal. Select 100C delivers a pure spray arc transfer with low spatter, faster travel speeds and enhanced sidewall fusion.

Select 100C is well suited to joining low alloy, high strength steels such as HY-80, A710 and A514. These materials are used in shipbuilding, earthmoving equipment and mining machinery applications. Like Select 90C-M2, Select 100C is an ideal choice for those weldments where distortion must be minimized and deslagging is not desirable.

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**Select 110C-M2**

Select 110C-M2 is designed for those applications where the slag residue and fume emissions of flux cored electrodes are unwanted and a minimum tensile strength of 110,000 psi is required. Select 110C-M2 provides an arc transfer that is a pure spray with low spatter. Its higher deposition rates increase productivity and the enhanced fusion into sidewalls eliminates “cold-lap”.

Select 110C-M2 is an ideal choice for joining low alloy, high strength steels such as HY-100 and A514. Earthmoving equipment, mining trucks and machinery and heavy equipment trailers are some areas where these steels may be utilized. This electrode may also be used for overlay or surfacing in certain applications.
Typical Welding Parameters: Metal Cored - Argon/Carbon Dioxide

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Recommended Welding Parameters: Metal Cored - Argon/Oxygen

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*indicates that mechanical properties are in the stress-relieved condition

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