SERVICE TO THE WELDING COMMUNITY

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SPECTRUM

Mr. N.K.Sarkar, Co-ordinator of AWS lecture series being felicitated by Mr. Asit Shah of IIW India - Varodara branch. Mr. Walter J. Sparko - faculty of the lecture series, looks on.

HIGHTLIGHTS

Techniques for joining 1 ¼ Cr - ½ Mo steels

Wave Form Control technology

Tips for better welding

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INSIDE

Editorial

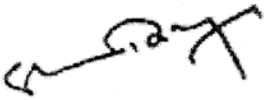
Dear Reader,

The all-round efforts in India to augment generation of power is visible in the order books of all the fabricators involved in manufacturing of power generating equipments like boilers, turbines, etc. The heartening news is that the technologies to be used to generate the power are latest with low carbon emission. Adaption of such technology demands better welding processes and consumables meeting very stringent technical requirements. Fortunately globalisation and ease of import has come to the rescue of the fabricators who need such consumables meeting the stringent requirements.

The well known chrome-moly group of steels is the most popular choice for the fabrication of power plant boilers using super critical technology which involves higher operating temperature and pressure. The lead article describes some of the important features of one of the chrome-moly steels (1¼Cr - ½Mo steel) including Bruscato factor (X factor), which influences temper embrittlement, has been discussed. The technical section provides a number of important tips for better welding by either GTAW or SMAW process or for cutting by plasma. These tips are expected to help a welder achieve higher quality weld and improved productivity. With gaining popularity of higher productive processes the need to monitor both current and voltage became necessary and to remember specific welding procedures more difficult. The use of advanced power sources blended the sophistication of computers with the power of inverter technology to take care of this problem by controlling the wave shape of the current to deliver the exact characteristic as needed at any given instant in the welding process. The education section describes this Wave Form Control Technology for your benefit. The regular features included the major welding events like AWS Lecture series and reporting of news of interest to welding fraternity.

We again welcome you to send us feedback so that the contents and the presentation of your news letter could be further improved.

With regards



Dr.S.Bhattacharya
Editor

Events

AWS Lecture Series - V, 2010

In continuation to the efforts of The Indian Institute of Welding and The American Weling Society to promote and exchange technology and knowhow related to welding and joining of metals the AWS Lecture series - V was held between 3^{rd} September and 11^{th} September 2010 at seven venues under the aegis of IIW-India. The subject was 'The Secrets to using ASME Section IX' - one of the most relevant subjects to the Indian fabrication and construction industry to enable them to compete in the world market. The guest faculty was Mr. Walter J Sparko, Chairman, ASME Section IX and President, Sparko Engineering Services, INC., Greensboro, North Carolina, USA. The lectures were attended by a total of about 700 delegates. The lecture was found to be extremely useful and a number of queries and doubts were resolved. Each delegate was handed over a CD containing the complete presentation for future reference, and these also included the latest modifications to ASME Section IX that were accepted as recently as in August, 2010. The question-answer session at each venue was very lively and informative. It was interesting to note that intricate and detailed questions asked by the young engineers were patiently and satisfactorily replied to by Mr. Sparko. The lecture series was sponsored by a number of welding related organizations including Weldwell Speciality Pvt. Ltd., Mumbai.

TECHYARD 2010

The Naval Dockyard, Mumbai, was set up in 1735 as a Marine Yard servicing ships of the East India Company, after the acquisition of Bombay by the English from the Portuguese. While the English were quick to see the potential of Bombay as a port, the credit for transforming the marine yard into a professional dockyard that acquired a worldwide reputation for shipbuilding goes to the Wadias, a family of Parsi master carpenters and shipbuilders, from Surat.

To celebrate the 275^{th} year, the Naval Dockyard organized an exhibition - Techyard 2010, to showcase its achievements and invited its vendors as exhibitors to promote business avenues. The exhibition had widened the ambit of exhibitors to include firms dealing in naval and marine equipment, spares and services, as well as, related industries including IT. Techyard 2010 was held at the centrally located and prestigious Nehru Centre, Worli, Mumbai - spread over 2,300 sq. metres in two large air-conditioned halls on 7^{th} and 8^{th} October 2010. The exhibition was inaugurated by HE Hamid Ansari, Vice-president, Govt. of India. Nivek Agencies participated in a big way in the exhibition to display welding equipments with latest technology and its accessories. The exhibition was attended by more than 2500 visitors. About ninety exhibitors participated in the exhibition.

Concurrent with the exhibition a seminar on Life Cycle Support of ships was held on 6^{th} and 7^{th} October. The seminar provided a platform for discussion on various aspects and issues that defined the support element of a warship through the various stages of its life - design, equipment selection, trials and testing, operations, repair, refits, spares, upgrades etc.

Techniques for joining 1 ¼ Cr - ½ Mo steels*

INTRODUCTION

Successful welding of Cr-Mo steels requires proper design, material selection and quality control throughout all the phases of engineering and construction. Early welding of Cr-Mo materials, pre 1950s, varied little in techniques from welding of low-carbon steels. Producing high quality weld was difficult. That quickly generated research into the effects of hydrogen, material chemistry, vessel design and post-weld heat treatment (PWHT). Past half century yielded significant achievements in consumables and methods to reduce hydrogen effect in welding. Modern welding techniques, including pre-heat, post-heat, PWHT, provided repeatable methodology producing high quality welds in both the shop and field construction. The lessons learned throughout the industry provide the base knowledge for the construction code and standard practices such as API 934 C – Material and construction of 1¼ Cr - ½ Mo Steel Heavy Wall Pressure Vessels for High Pressure Hydrogen Service Operating at or below 825°F (441°C).

APPLICATION

ASTM SA387 Grade 11 defines the 1¼ Cr - ½Mo steels. Minor additions of the elements like Cr and Mo, to standard carbon steels provide creep resistance at elevated service temperatures. Typical plate structure utilizing SA387 Grade 11 material, include reactor vessels and coke drum for refinery operations and basic oxygen furnaces for steel mills. These large structures have wall thickness from 1 to 3 in (25 to 75 mm), are 22 - 36 ft (6.7 to 11 m) in diameter and between 80 to 120 ft (24 to 36 m) high. Coke drum endure the most severe thermal cyclic services with temperature reaching as high as 1000°F (538°C) followed by a water quench. Typical service allow two thermal cycles per day and an estimated vessel lifespan of 3000 cycles. Bulging of coke drums is a common problem. It is caused by thermal fatigue exacerbated by the differential yield strength of the base metal and the weld. Higher-strength weld metal has a stiffening effect, resulting in stress concentrations and ultimately leads to distortion and later cracking. The lifespan can be prolonged without changing the base material, by lowering the quench rate, matching the weld metal yield strength to the base metal, and minimising residual stresses. Current design for vessel design, fabrication and construction, have developed from more than 60 years of experience.

EARLY WELDING

Early Cr-Mo vessels, including stainless steel clad, were welded and placed in service beginning in the mid 1940s. Plate material was not standerdised, but was typically designated as SA301 which later evolved as SA387 grade. Low-hydrogen shielded metal arc welding (SMAW) electrodes were not manufactured at that time; therefore, cellulose covered electrodes such as E7010, E8010 and E9010 electrode containg additional Cr and Mo were used. Clearly weldability was poor compared to modern standards but quality weld was still possible with highly trained welders. By 1954, low-hydrogen electrodes were introduced that vastly improved the weldability and crack resistance of the materials.

Radiography, still in the infancy, was used extensively for Cr-Mo vessels. Some of the first vessels with 100% radiography were coke drums and reactors.

Historical construction documents show that obtaining uniform preheat was difficult but was considered an important factor in producing acceptable welds. Repairs were specially prone to cracking, due to localised heating and relatively high hydrogen content of the cellulose coated electrodes.

After the first decade of Cr-Mo welding, three major consideratioins were identified

- *Hydrogen contamination*
- *Temper embrittlement*
- *Stress concentration*

Recognition of these common factors, which often led to cracking during construction and a shorter unstable vessel lifespan, prompted research to imrove the welding processes.

LIMITING HYDROGEN CONTAMINATION

Hydrogen control begins with consumable

Adapted from an article by James Brenan and Ben Pletcher – Welding Journal, Vol. 89, No. 4, April 2010.

manufacturers. The SMAW consumables are supplied in hermetically sealed container with tested hydrogen levels. Once opened, proper electrode storage must be followed as per manufacturer's guidelines. Uncontrolled exposure to the atmosphere may lead to hydrogen absorption by the flux that could get introduced into the weld. Now common E 8018-B2 electrodes, used in conjunction with ovens, introduce minimal hydrogen into the weld. By 1990, field construction organisations were using electric resistance heater to maintain a continuous preheat of 150°C. The low hydrogen electrodes coupled with preheat techniques vastly improved the weldability, while lowering the risk of delayed (hydrogen-induced) cracking. Preheat eliminates hydrogen sources such as condensates, from the mineral surface and slows the cooling rate giving entrapped hydrogen time to diffuse from the weld. Preheat, that is holding the weldment at interpass tempeture after the welding is completed, proves additional diffusion time for hydrogen to escape. The PWHT, standardised at 670° - 680°C for 1 hour / 25 mm of plate thickness, provides stress relief of the vessel, lowers the weldmetal hardness, and allows more time for hydrogen to diffuse from the weld metal. Caution must be taken to ensure that the PWHT does not exceed the tempering temperature applied to the steel mill. Exceeding the tempering temperature may degrade the mechanical properties of the base material.

CONTROLLING TEMPER EMBRITTLEMENT

Base material and electode chemistry play an important role in vessel constructibility and service application. Temper embrittlement is defined as decrease in toughness when the material is heated or cooled through the 300° – 600°C temperature range. This temperature range coincides with the thermal cycle that a coke drum experiences in service. In addition, the unintentional additions of silicon, phosphorus, antimony, tin and arsenic can increase the susceptibility to temper embrittlement.

In the late 1960s, Robert Bruscato examined Cr-Mo weld deposits and quantified the effect of trace impurities and on temper embrittlement. The now common Bruscato factor, $\overline{X}$, can be calculated using the following formula, where elements are given in part per million (ppm):

$$\overline{X} = \frac{10\ P + 5\ Sb + 4\ Sn + As}{100}$$

The accepted limits is $\overline{X} \leq 15$ for coke drums; however, for critical application of higher Cr-Mo alloy steels the limit may be $\overline{X} \leq 12$. Modern material processing facilitates production of base materials and consumables with low level of these trace elements. Fabricators and end users must be vigilant in defining material limits for proper procurement of high quality products.

MINIMISING STRESS CONCENTRATION

Stress concentrations are responsible for a variety of crack-related failures and must be minimised by design. Eliminating circumferential or girth seams in the vessel shell of the coke drum eliminates the strength mismatch between the weld and the base metal, therby lessening the effect of thermal fatigue. 'Vertical Plate Coke Drum' technology allows for a shell section upto 14 mtr. in height. Vertical plate design whether applied to a vessel replacement or a new process unit will outlast conventional 'can section' design due to elimination of stress concentrations at the girth seams.

A weld profile can also affect local stress concentrations. All welds must be profiled to eliminate sharp concentrations and excessive reinforcement. Grinding interior weld joints, specially girth joints, to flush, smooth and blended finish is common practice in coke drum fabrication.

1¼ Cr - ½ Mo WELDING CHALLENGES

Advancements in the processes used in manufacturing welding consumables, driven by the need to limit trace elements and lower diffusible hydrogen, have given the industry many good options for welding chrome-moly materials. Most Cr-Mo SMAW consumables can easily meet the $\overline{X} \leq 15$ requirements, while providing excellent weldability. Modern submerged arc welding (SAW) electrodes also have excellent chemical makeup. When used in conjunction with significantly improved SAW fluxes these consumables result in minimal cracking, smooth weld beads and good operator appeal. The AC waveform control used in

contd. on Page 6...

Wave Form Control Technology*

Tighter control of welding process variables, ease of equipment use with a high degree of process versatility, and improved weld consistency are just a few of the benefits of applying Wave Form Control Technology to a wide range of welding requirements.

INTRODUCTION

In the past welding parameters to the specific material being welded were matched by guess works. When most welding was done by the SMAW process, the operator only had to worry about one variable – the welding current. As more productive welding processes were introduced, the need to monitor both current and voltage became necessary. With hundreds of different material types, plus an ever-growing choice of electrodes, it has become extremely difficult for the operators to remember and set specific welding procedures. Add to this the need to control welding results more closely than ever, to achieve consistency in the strength and metallurgy of welded joints much better control of the welding is a necessity. To achieve these results development of new power sources took place that actually control the electrode current throughout the welding cycle. These advanced power sources blend the sophistication of computers with the power of inverter technology. The concept of precision wave form control began in 1985. The new machines controlled the wave shape of the current to deliver the exact characteristic as needed at any given instant in the welding process.

WHAT IS WAVE FORM?

A wave form is a representation of the dynamic, ever changing output response of an arc welding machine to the actions of the electric arc itself. This means that the wave form (the shape of the wave) changed with the requirement of the arc characteristic of the welding process. Every arc welding machine has a wave form characteristic. Simple machines rely on the design of a transformer and choke to produce a useable wave form (usually sinusoidal wave). More sophisticated machines combine hardware design with electronics to produce optimized control of the wave form. Many modern industrial machines have made switches that offer the user multiple wave form options from one machine. Through the use of computer software programmes and advanced electronic control Wave Form Control Technology manages all aspects of the wave form to produce output dynamic characteristics tailored to the needs of a specific application. Some of the common waveforms are shown in Fig.1.

BENEFITS

Performance benefits of the wave form controlled inverter based welding machines include positive arc starting, exceptionally smooth arc welding performance, and multi-process welding output (CC/CV and pulse). Kemppi has a large number of inverter based models which provide such facilities. Another performance benefit of these machines is their adaptive control capabilities. While most pulse machines do not consider the differences between material types, these power sources maintain arc consistency even when longer stick-outs are required, such as when vertical welding in tight corners. The machine literally juggles multiple variables simultaneously to produce the ideal arc for the situation. The consistent repeatability that this degree of control produces makes machines ideal for use in robotic arc welding applications. This technology allows for more advanced seam tracking and precise control of weld penetrations. The machine's software eliminates the need for an additional wire feed control box, which is traditionally needed for robotic welding. Yet this versatile technology also applies to small fabricating shops that want the flexibility of using one power source for all their GMAW welding needs.

Presently, such wave form controlled machines incorporates large number of welding programmes (some more than 60) that include GMAW, pulse GMAW, FCAW, SMAW and air arc gouging. Programmes are optimized for mild and low alloy steel, stainless steels, aluminium and silicon bronze.

**Lincoln Electric website*

Other programmes are also available for higher performance metals such as nickel alloys, copper-based alloys, and custom wave forms can be developed to address very special applications.

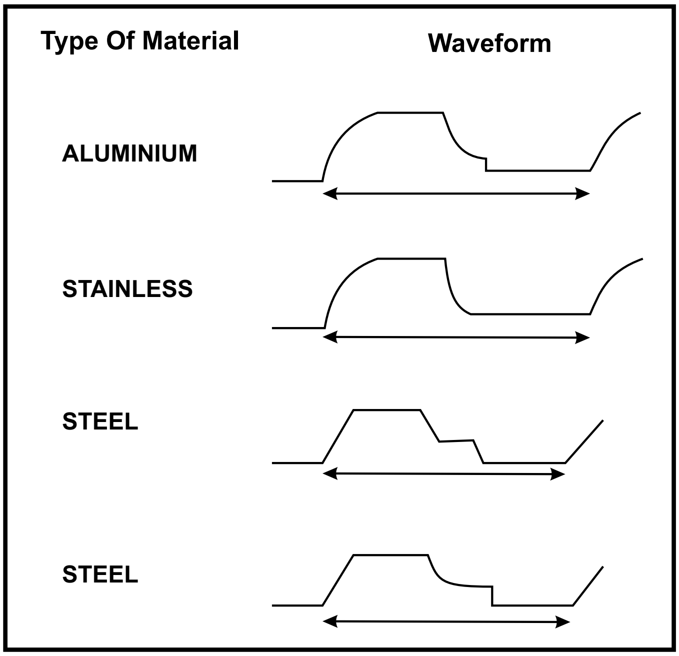


Fig. 1 Typical Welding Waveform

Some of the additional performance benefits of the wave form controlled inverters include:

- *Stable arc welding on thin materials.*
- *Premier arc stability at low currents.*
- *Features "variable inductance control".*
- *Determines Metal Transfer Mode.*
- *Affects Heat Input.*
- *Determines how intermittent events are handled.*

It is a thousand times better to have common sense without education than to have education without common sense. - Robert G. Ingersoll

He who opens a school door, closes a prison. - Victor Hugo

Education is a progressive discovery of our own ignorance. - Will Durant

... 1¼ Cr - ½ Mo Welding - contd. from Page 4

SAW is a recent modification to the process. This AC waveform technology allows greater control of the depth of penetration and deposition rates, while using the same consumable / flux combination. These techniques are easily applied to shop-built vessels decreasing production time. While significant improvements have already created good consumables for SMAW and SAW, flux cored arc welding (FCAW) remains a new product to the market. History shows that careful evaluation of material are required to ensure that all design requirements are met by any new product.

Preheat and postheat methods are always being pushed for faster application while providing improved enery efficiencies. Heating rates and temperature controls can be improved with modern gas burners and electric resistance heater formed to fit the vessel shell. As previously noted, PWHT must consider the temper of the plate material, as surpassing this temperature may have detrimental effect on the material properties. Owners and end users often require multi thermal cycles, allowing for subsequent repair followed by PWHT, thereby increasing the life of the vessel. Retaining mechanical properties after several PWHT operations is difficult for both the base material and the weld. Ultimately, the vessel is limited by the material to which it was deseighned and the conditions of its operation.

SUMMARY

Singificant advancements over the past half-century have made the 1¼ Cr - ½ Mo steels readily weldable. Ongoing research is pushing to increase productivity by enhancing the deposition in AC waveform-controlled SAW welding and FCAW consumables. Material and design improvements are continually pushed by the desire for steel plate structure with larger lifespans. Innovative designs, such as vertical plate coke drum, provide fundamental engineering improvements while quality consumable limit the introduction of detrimental elements. Whatever the future holds, three basic factors must be controlled to produce quality products: hydrogen contamination, temper embrittlement and stress concentrations.

AWS revises specification for stainless welding electrodes

MIAMI, FL., March 4, 2010 - A revised edition of the American Welding Society's AWS A5.22, Specification for Stainless Steel Flux Cored and Metal Cored Welding Electrodes and Rods, has been published. The standard known as A5.22/A5.22M:2010 supersedes the 1995 edition.

The 66-page book prescribes requirements for the classification of flux cored stainless steel electrodes for flux cored arc welding, flux cored stainless steel rods for root pass welding with the gas tungsten arc process, and metal cored stainless steel electrodes for gas metal arc welding, gas tungsten arc welding, plasma arc welding, submerged arc welding, and any other process to which they may be applied. This document is the first of the A5.22 specifications to make use of both U.S. Customary Units and the International System of Units (SI).
AWS A5.22/A5.22M:2010, Specification for Stainless Steel Flux Cored and Metal Cored Welding Electrodes and Rods, is available at (888) WELDING or www.aws.org/standards for $52. American Welding Society members can purchase the standard for just $39.

AWS revises specification for nickel electrodes

MIAMI, FL., March 15, 2010 - A revised edition of the American Welding Society's AWS A5.11, Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding, has been published. The standard known as A5.11/A5.11M:2010, supersedes the 2005 edition.

The 50-page book prescribes requirements for the classification of nickel and nickel-alloy covered electrodes for shielded metal arc welding. It includes those compositions in which the nickel content generally exceeds that of any other element. This document is the third revision of A5.11 specifications which makes use of both U.S. Customary Units and the International System of Units (SI).

The publication is the joint effort of the A5 Committee on Filler Metals and Allied Materials. The committee is made up of volunteer industry suppliers, end-users, and researchers.

AWS A5.11/A5.11M:2010, Specification for Nickel and Nickel-Alloy Welding Electrodes for Shielded Metal Arc Welding, is available at (888) WELDING or www.aws.org/standards for $52. American Welding Society members can purchase the standard for just $39.

AWS revises specification for gas tungsten arc welding of aluminum

MIAMI, FL., August 9, 2010 – The American Welding Society and the Welding Research Council have joined in a cooperative effort to generate standard welding procedures for industry by producing AWS B2.1-22-015:2011, Standard Welding Procedure Specification (SWPS) for Gas Tungsten Arc Welding of Aluminum (M/P-22 to M/P-22), 18 through 10 Gauge, ER40403 or R4043, in the As-Welded Condition, with our without Backing.

The 18-page book is an outgrowth of the coordinated work of the Welding Procedure Committee of the Welding Research Council and the AWS B2 Committee on Welding Procedure and Performance Qualifications.

AWS B2.1-22-015:2011, Standard Welding Procedure Specification (SWPS) for Gas Tungsten Arc Welding of Aluminum (M/P-22 to M/P-22), 18 through 10 Gauge, ER40403 or R4043, in the As-Welded Condition, with our without Backing., is available at (888) WELDING or www.aws.org/standards for $248. American Welding Society members can purchase the standard for just $186.

"Education is an ornament in prosperity and a refuge in adversity." - Aristotle

"I have never let my schooling interfere with my education." - Mark Twain

Tips for Better Welding*

(This is in continuation of the technical tips provided in the last issue of Weldwell Spectrum (Vol. 17, No. 3, July-Sept. 2010) for better welding)

Tips for a better welding are always welcomed. In the previous issue we covered tips for better welding using MIG process including FCAW process. Following are some of the tips offered by expert welders for TIG, SMAW and Resistance Spot welding. Since cutting goes hand-in-hand with welding some tips for better Plasma cutting has also been included in this section.

TIG WELDING

1. Use Argon shielding for steel, stainless, and aluminum.
2. Use DC-Straight Polarity (DCEN) for steel and stainless. Use AC for aluminium
3. Always use a push technique with the TIG torch
4. Match the tungsten electrode size with the collet size
5. For Aluminium - use a pure tungsten, AWS Class EWP (green identifying band). Will form a balled-end in AC
6. Steel and stainless steel - use a 2% thoriated tungsten, AWS Class EWTH-2 (red identifying band). Prepare a pointed-end for DCEN welding. (Refer to Fig. 1. Tungsten Electrode Tip Preparation)
7. When welding a fillet, the leg of the weld should be equal to the thickness of the parts welded. (Refer to Fig. 2. Recommended Fillet Weld Thickness)

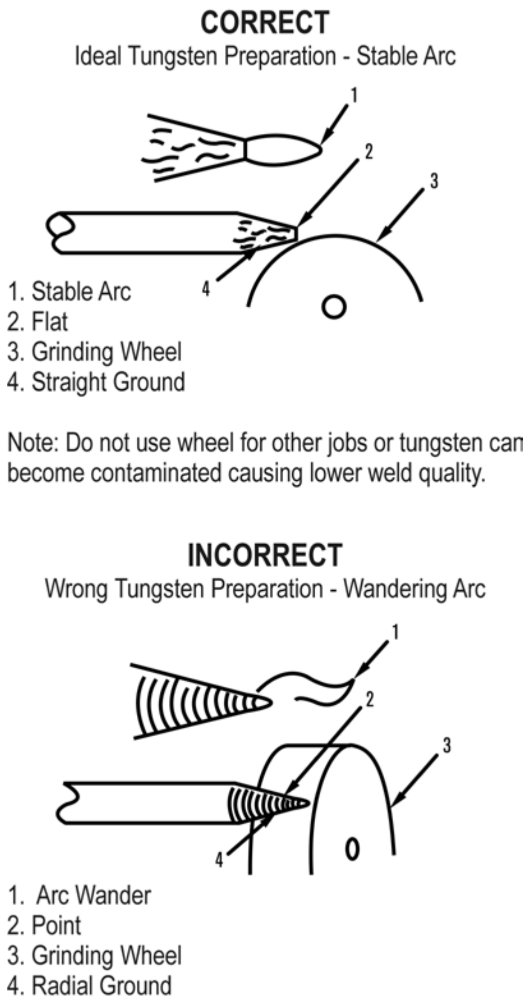
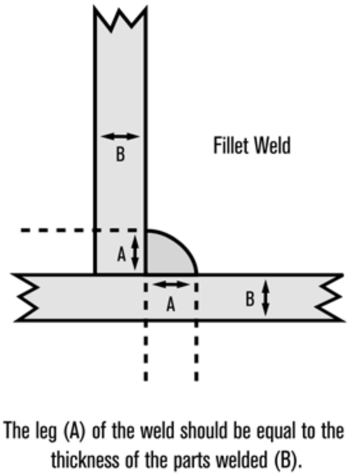


Fig. 1. Tungsten Electrode Tip Preparation

STICK WELDING

1. Take precautions with flying materials when chipping slag.
2. Keep electrodes clean and dry - follow manufacturer's recommendations.
3. Common steel electrodes: (Refer to Fig. 3. Recommended Stick Electrodes)
4. Penetration: DCEN - Least penetration, AC - medium (can be more spatter also), DCEP - most penetration.
5. When welding a fillet, the leg of the weld should be equal to the thickness of the parts welded. (Refer to Fig. 2. Recommended Fillet Weld Thickness)
6. To set your amperage control, first determine recommended amp range for your electrode type and diameter. Then pick an amperage within the range based on your metal thickness (thinner metal, less amps). (Refer to Fig. 4. Example of Good and Bad Stick Welds)

Fig. 2. Recommended Fillet Weld Thickness



**Adapted from Lincoln Electric website*

Fig. 3 Recommended Stick Electrodes

Common Steel Electrodes			
AWS Class	**Position**	**Polarity**	**Usage**
A6011	All	AC, DCEN, DCEP	All purpose stick electrode used for carbon and galvanised steel; 60,000 PSI tensile strength; deep penetrating and ideal for welding light to medium amounts of dirty, rusty or painted material.
E6013	All	AC, DCEN, DCEP	Light to medium penetrating all-purpose stick electrode; for use on carbon steel; 60,000 PSI tensile strength; good for general, all-purpose applications and joints with poor fit-up.
E7014	All	AC, DCEN, DCEP	For high-depostition requirements; 70,000 PSI tensile strength; ideal for applications requiring light penetration and faster travel speeds.
E7018	All	AC, DCEN, DCEP	Low-hydrogen electrode; for low, medium and high-carbon steels; 70,000 PSI tensile strength; ideal for out-of-position welding and tacking; not recommended for low-voltage AC welders.
E7018AC	All	AC, DCEN, DCEP	Low-hydrogen electrode; for low, medium and high-carbon steels; 70,000 PSI tensile strength; ideal for out-of-position welding and tacking; not recommended for low-voltage AC welders; specially formulated to operate with small 208/230 volt AC welders

Specialty Stick Welding Electrodes			
AWS Class	**Position**	**Polarity**	**Usage**
Stainless Steel 308L	All	AC, DCEP	For 301 , 302, 304, 305, 308 stainless base metal; good for build-up_or cladding; easy slag removal.
Stainless 312 Plus	All	AC/DC	For hard to weld or dissimilar metals, stainless, high carbon, cast, and high nickel steels; easy strike and re-strike, high moisture resistance,self-detachingslag.
Cutting! Chamfering	All	AC/DC	For cutting,bevehng gouging of all metals including stainless steels, aluminum, and copper; for removal of weld joints overlays, or other unwanted materials.
Flux Coated Brazing	-	-	Lowfuming type brazing alloyforgeneral purpose brazing of steel, cast iron, nickel, some nickel alloys, copper and some copper alloys; use oxyacetylene or other fuels suitable for brazing.
Aluminum 4043	-	DC	Aluminum welding for flat, horizontal and vertical applications.
Nickel 55 Cast Iron	All	AC/DC	55% nickel for cast iron; high strenght, stronger than Nickel 99; machinable.
Nickel 99 Cast Iron	All	AC/DC	99% nickel for cast iron; for light to medium weight castings; higher ductile strength than Nickel 55; easier to machine than Nickel 55.
Hard Surfacing Overlay	-	AC/DC	Abrasionand impact resistance; bulldozer blades, plow shears; metal to earth applications; for high chromium carbide alloy steel.
Hard Surfacing Buildup	-	AC/DC	Excellent impact; impact hammers, crusher rolls, railroad frogs; work hardens to 550-55 Rock-well C; for high chromium
DCEN - DC Electrode Negative (Straight polarity) DCEP — DC Electrode Positive (Reverse polarity)			

7. Select the correct electrode polarity and amperage as suggested in the following tables (Refer to Fig. 5 and 6 respectively – Electrode polarity chart and electrode amperage chart)

RESISTANCE SPOT WELDING

1. Resistance welding is not recommended for aluminum, copper, or copper alloys. Use this process for steel and stainless steel only
2. For more heat (amperage output), use shorter tongs
3. units without a heat control, tong length can be used for a control. For instance, for thin metals where you want less heat, longer tongs can be used.
4. Keep in mind that longer tongs can bend, and you may lose pressure at the weld
5. For the metals being welded, make sure there is no

gap between the pieces - this will weaken the weld

6. Keep the alignment of the tongs straight, so that the tips touch each other exactly. Also, maintain a proper pressure adjustment - not too much or too little pressure
7. When you need one side of the weld to have good appearance, you can flatten (machine) the tip somewhat on that side
8. Clean the tips on a regular basis, or you will lose output (amperage). Dress the tips with a proper tip dresser.

PLASMA CUTTING

1. Clean, dry, oil-free air is important.
2. Stay at recommended air pressure (more air is not necessarily better !)
3. Touch torch tip gently to workpiece.
4. When initiating a cut, start on the end of material to be cut and ensure arc has completely penetrated metal before proceeding further.
5. When completing cut, pause at the end to assure severance.
6. Torch should be perpendicular to workpiece.
7. Work cable should be attached as close to workpiece cut as possible.
8. If you can see the arc coming through the bottom of the cut metal, it will eliminate guessing if your travel speed is correct.

Fig. 4. Example of Good and Bad Stick Welds

Good Weld

Travel Too Fast

Travel Too Slow

Arc Too Short

Arc Too Long

Amperage Too High

Amperage Too Low

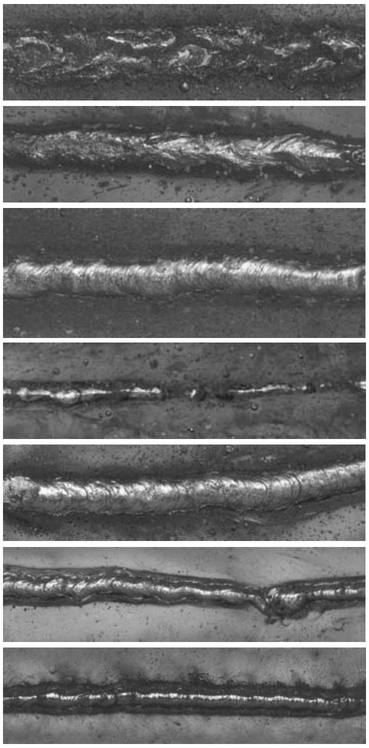


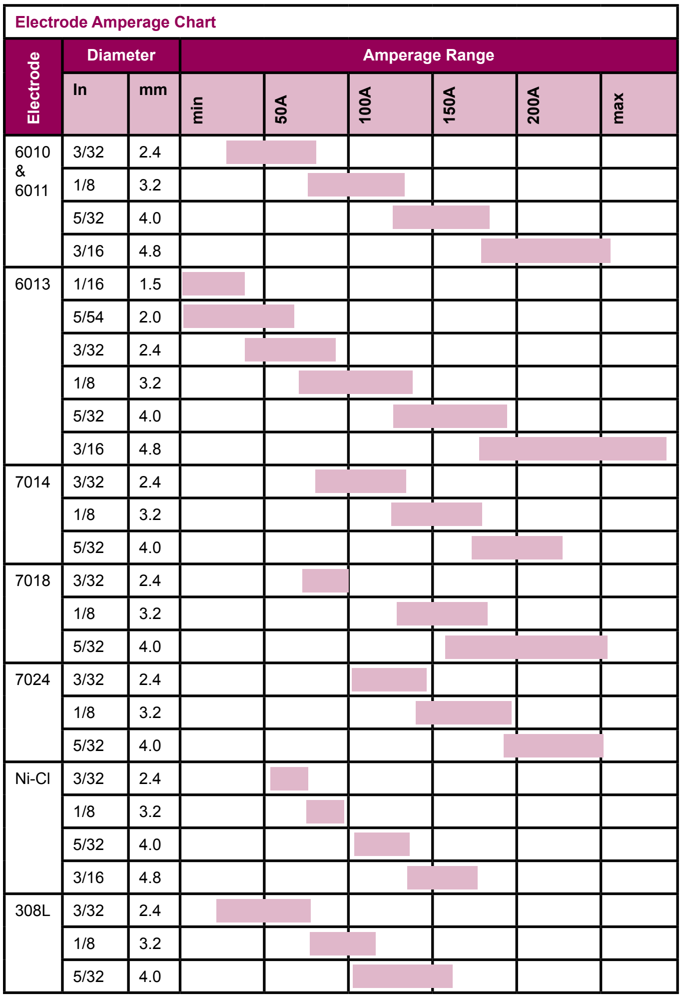
Fig. 5– Electrode polarity chart

Electrode Polarity Chart

Electrode	DC	AC	Position	Penetration	Usage
6010	EP	-	All	Deep	Min. prep., Rough, High spatter
6011	EP	✓	All	Deep	
6013	EP, EN	✓	All	Low	General
7014	EP, EN	✓	All	Med	Smooth, Easy, Fast
7018	EP	✓	All	Low	Low Hydrogen, Strong
7024	EP, EN	✓	Flat, Hori-zontal, Fillet	Low	Smooth, Easy, Faster
Ni-Cl	EP	✓	All	Low	Cast Iron
308L	EP	✓	All	Low	Stainless

*EP = Electrode Positive (Reverse Polarity)
EN = Electrode Negative (Straight Polarity)

Fig. 6 Electrode amperage chart



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