III. GTAW Equipment

Safety First

Even though the majority of welding done is in the direct current mode, welding power is most often obtained from the local power company out of an AC wall socket.

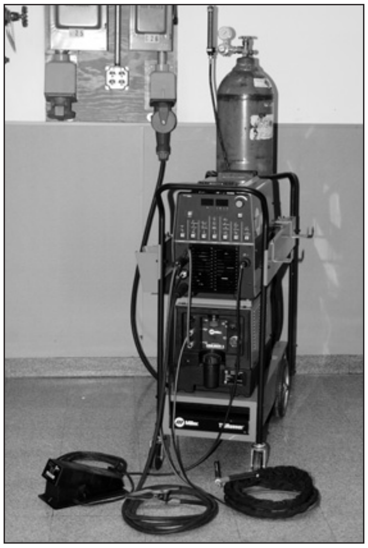


Figure 3.1 GTAW power source plugged into wall connection. Primary connection to the commercial power.

Notice the fuse box on the wall, where primary power to the machine must be shut off if work needs to be done on any part of the welding equipment. Also, the primary power at the fuse box should be shut off when the machine is idle for long periods of time.

Caution should always be taken when installing any welding equipment. Should a welding machine be improperly connected, a dangerous situation could exist. Improper connections could lead to an electrically "hot" welding machine case, which could result in a severe shock to anyone touching it. Primary wiring should only be done by an electrically qualified person who is absolutely sure of the electrical codes in a given area. Before any primary power is connected to welding equipment, the equipment's operation manual should be read, and the instructions strictly followed.

Selecting a Power Source

With the many types of welding machines available, certain considerations must be made in order to fit the right machine to the job.

Rated output of the welding machine is an important consideration. The ranges of voltage and amperage needed for a particular process must be determined. Then, a welding machine can be selected to meet these output needs. Remember, the output must be within a proper duty cycle range.

Light welding, (low output requirements of about 200 amps or less) can often be done with single-phase welding machines. Duty cycles are often in the 60% or less range. These types of welding machines are especially suited for shops and garages where only single-phase power is available. Some of these smaller single-phase machines may be capable of using 115 volt AC primary power. Other machines may use 230 volt or higher primary power.

Larger DC TIG welding machines used for heavy plate, structural fabrication and high production welding generally need three-phase AC input power. Most industrial locations are supplied with three-phase power since it provides the most efficient use of the electrical distribution system and it is required by many electric motors and other industrial electrical equipment. These welding machines often have capacities of over 200 amps, and often have 100% duty cycles.

Figures 3.2 through 3.7 show some different types of welding machines and controllers.

Figure 3.2 An inverter-based welding machine which has the capability of modifying the frequency of the AC arc. This machine has multiprocess capability including GTAW, SMAW, and pulsing capability.

Figure 3.3 An electronically controlled AC/DC power source. Features include wave balance control to selectively unbalance the wave to optimize welding characteristics.

Figure 3.4 An AC/DC machine which was specifically designed for GTAW. It includes many built-in components that make it adaptable to a wide variety of applications.

Figure 3.5 An AC/DC machine of the type commonly used for Stick electrode (SMAW) welding. With the addition of other components, it will meet the requirements of many GTAW applications.

Figure 3.6 A multiprocess engine-driven welding generator capable of AC and DC GTAW welding when fitted with an optional high-frequency arc starter.

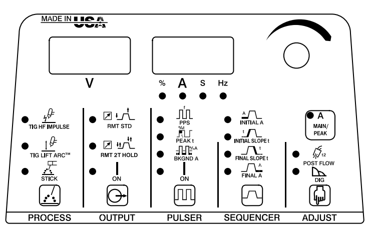


Figure 3.7 An advanced power source with a built-in programmer that enables the operator to program the entire welding sequence. This is recommended for automatic welding or whenever repeatability is required.

In order to best understand the arc welding power source and its requirements, it is best to start at the arc and work back to the wall receptacle. The GTAW process requires the welder to maintain the arc length. Any variation in arc length will affect the voltage. The longer the arc the higher the voltage, and the shorter the arc the lower the voltage. The welder will have difficulty maintaining the arc length, the voltage will change, as the arc is moved across the part being welded. This change in voltage (arc length) causes the output current (amperage) to fluctuate. This output current should be kept as constant as possible with the TIG process. The amperage creates the heat that melts the metal and allows for consistent welding.

The Constant Current Power Source

Arc welding power sources are classified in terms of their output characteristics with regard to voltage and amperage. They can be constant current (CC), constant voltage (CV) or both.

A constant current machine, the kind used in GTAW welding, maintains close to a constant current flow in the weld circuit no matter how much the voltage (arc length) varies. Processes like GTAW and Shielded Metal Arc Welding (SMAW) require the welder to maintain the arc length not the equipment.

A constant voltage power source maintains voltage at close to a preset value no matter how much current is being used in the process. This is the type of power source that is used in Gas Metal Arc Welding (GMAW) or Metal Inert Gas (MIG) welding. Processes like GMAW and Flux Cored Arc Welding (FCAW) require the equipment to maintain a specific arc length.

You'll notice that in both cases we say these machines maintain current and voltage values close to preset values respectively. They will vary slightly due to the fact that no power source is perfectly efficient.

The relationship between voltage and current output is best represented by plotting these values on a graph.

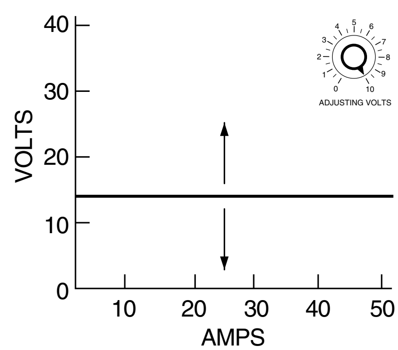


Figure 3.8 Volt-amp curve of a perfect battery.

Figure 3.8 shows the volt-amp curve of a perfectly efficient battery. This would be considered a CV power source because no matter how much current is produced, the voltage remains constant at twelve volts.

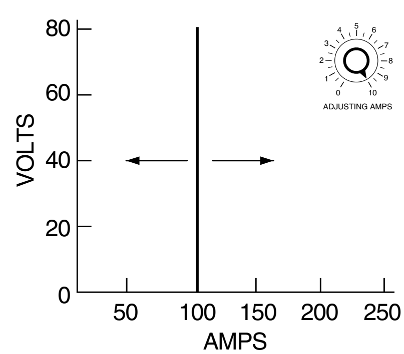
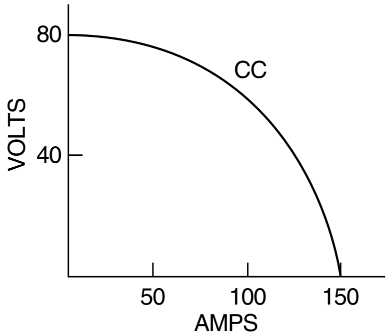
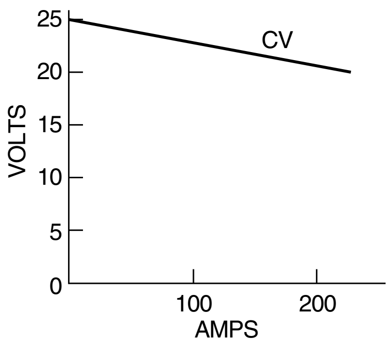


Figure 3.9 Volt-amp curve of a perfect CC power source.

A perfectly efficient power source of the CC variety as seen in Figure 3.9 would exhibit a volt-amp curve where a constant current of 100 amps is output no matter what the voltage.



Figures 3.10 CC volt-amp curve.



Figures 3.11 CV volt-amp curve.

The volt-amp curve shown in Figure 3.10 is indicative of those seen in GTAW power sources, and the volt-amp curve seen in Figure 3.11 represents the output of a constant voltage or GMAW power source. The sloping line on the constant current graph represents the output of a magnetic amplifier power source. Because of this sloping characteristic, these power sources are often referred to as droopers.

Figure 3.12 is an example of a basic DC power source for TIG welding. The single-phase high voltage, low amperage is applied to the main transformer. The transformer transforms this high voltage to low voltage and at the same time transforms the low amperage to high amperage for welding. It does not affect the frequency, 60Hz in and 60Hz out. This low voltage high amperage is now rectified from AC to DC in the rectifier. This produces a fairly rough DC unlike the power provided by a battery. The filter is used to smooth and stabilize the output for a more consistent arc. The filtered DC is now supplied to the TIG torch. These line frequency type power sources tend to be large and very heavy. Their arc performance is slow and sluggish and won't allow them to be used for advanced wave shaping or pulsing.

The true constant current power sources are an advantage in that what current is set is what is delivered to the welding arc. These electronically controlled power sources are desired over the older-style power sources and find applications in manual through automatic welding. The current settings are very accurate and welds are very repeatable. The electronically controlled and inverter-type power sources have special circuits that maintain their output very consistently. This is accomplished with a closed loop feedback circuit. This circuit compares the output current going to the arc against what has been set on the machine. It acts much like a car with the cruise control activated — if going up and down a hill the speed is maintained. If the welder raises and lowers the arc, the amperage is maintained. Figure 3.13 shows a block diagram of this closed loop feedback sense circuit. This feature is also helpful for line voltage compensation. By law the power company must supply a consistent voltage. However they are allowed a range, which can be as much as plus or minus 10% of the nominal voltage. If the primary voltage to a non-compensated GTAW power source changed up to 10%, the power going into the arc can fluctuate from 10 – 20%. With the line voltage compensated machine, a plus or minus fluctuation of up to 10% on the primary will only have a plus or minus 2% change in the arc, thus a very consistent weld. Most electronically-controlled power sources can also be used to provide pulsed welding current. Due to their fast response time and great control over the current level setting, two different heat levels pose no difficulty for these type power sources. These machines can also be remotely controlled and these controls can be very small and compact. They are small enough to be mounted directly on the torch or built into the torch handle. Limitations of this design can make them more complex to operate, and are relatively expensive in comparison to simpler control designs.

Squarewave Silicon-Controlled Rectifier (SCR) Power Sources

These type power sources were introduced to the welding industry in the mid 70s. They have now virtually replaced all the AC sine wave power sources for the GTAW process. The block diagram shown in Figure 3.14 is a representative of this type of control. These type power sources use the large bulky 50 or 60 Hz transformer. They are typically very similar in size and weight to the older style mechanically or magnetically controlled power sources. They do have simple wave shaping technology and possess closed loop feedback for consistent weld output.

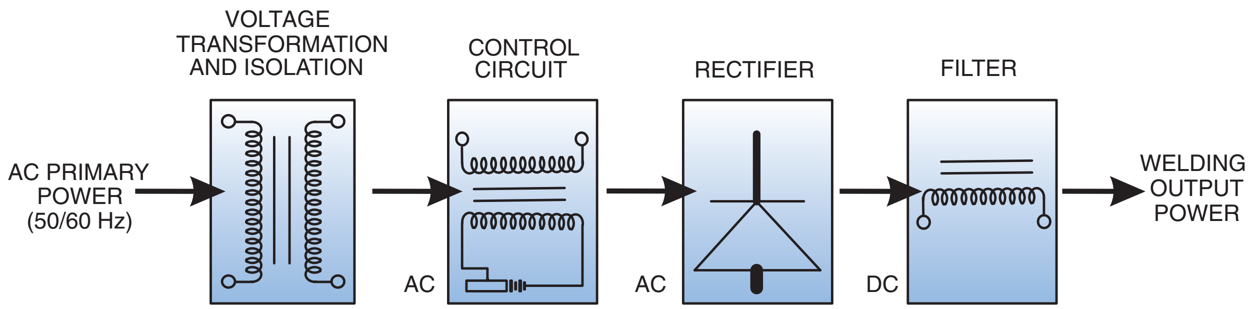


Figure 3.12 A conventional line frequency power source block diagram.

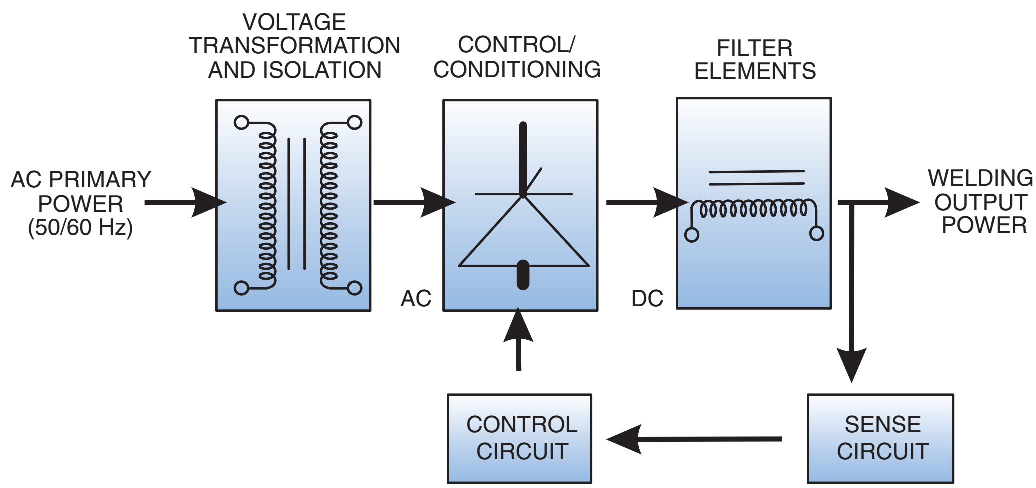


Figure 3.13 The closed loop feedback keeps the output consistent when the arc voltage is varied and to compensate for primary line voltage fluctuations.

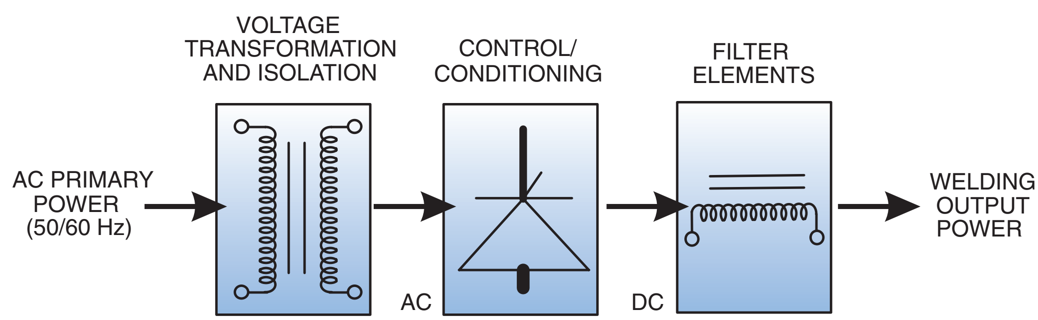


Figure 3.14 Block diagram of an SCR controlled power source, utilizes a line frequency weld transformer.

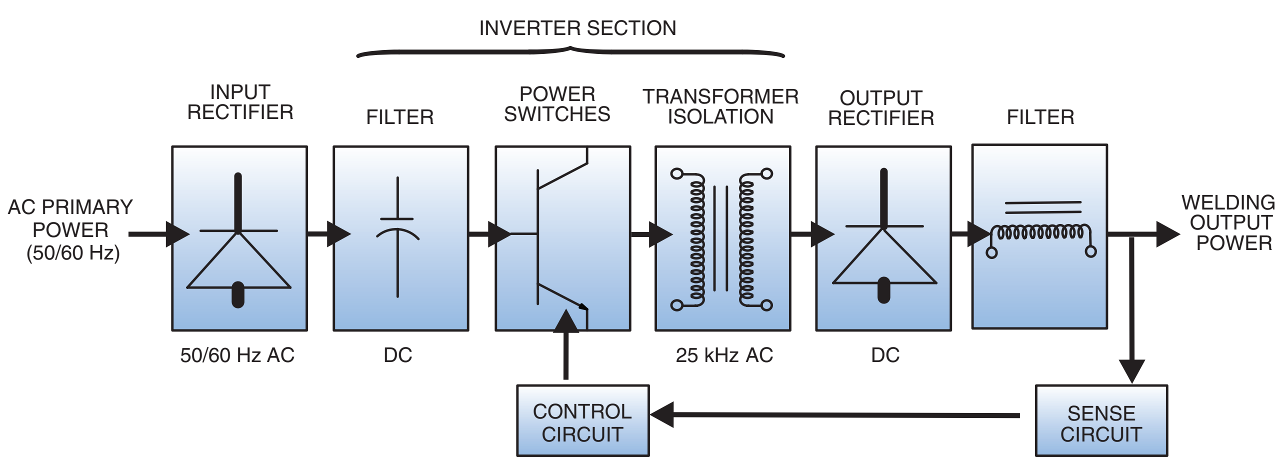


Figure 3.15 An inverter power source block diagram.

The Inverter Power Source

Inverter power sources were first conceived in the 1940s, but weren't successfully marketed until the 1970s.

Instead of operating at a common input power frequency of 50 or 60 Hz, inverters boost the frequency as much as 1000 times that of input frequency. This allows for a drastic reduction in the number of transformer coil turns and reduced core area resulting in a machine much smaller and lighter in weight than a conventional transformer rectifier power source. Another major advantage of this type of machine is its primary power requirements. Some inverters can be used on either three-phase or single-phase input power, and either 50 or 60 Hz. This is due to the fact that incoming primary power is rectified and converted to the extent that it is not a critical factor. Some inverters due to their unique circuitry, are multiprocess machines capable of GTAW, GMAW, SMAW, FCAW (Flux Cored) and Carbon Arc Gouging. Although these inverters are capable of accomplishing these multi-processes, some are specifically designed for and specialized for the TIG process.

Figure 3.15 is a block diagram of an inverter type power source. Machines of this type can run on single or three-phase power, which will be covered later in this section. The first thing the inverter does is rectify the high voltage low amperage AC into DC. It is then filtered and fed to the inverter's high-speed switching devices. Just like a light switch they turn the power on and off. They can switch at a very fast rate, up to 50,000 times per second. This high voltage, low amperage fast DC switching looks like AC to the transformer, which is many times smaller than a 60 Hz transformer. The transformer steps the voltage down and increases the amperage for welding. This low voltage high amperage is filtered for improved DC arc welding performance or converted to AC through the electronic polarity control. This AC or DC power is then provided to the TIG torch. This AC is fully adjustable as described in the section on Advanced Squarewave AC. The DC is extremely smooth and very capable of being pulsed or sequenced.

The Engine-Driven Power Source

Some of the first electric arc welding power sources invented were the motor generator type that produced welding current by means of a rotor moving inside a stator. This is the same principle of current generation by means of moving a conductor through a magnetic field. The movement in these machines was provided by an electric motor.

The concept is still being put to good use by modern power sources that replace the electric motor with gasoline or diesel engines. The most important feature of these electro-mechanical devices is that they free the welder from dependence on commercial power, and allow them the mobility to accomplish tasks nearly anywhere in the world. Most of these machines are welder generators that along with welding output produce AC/DC current for the operation of lights and power tools.

Engine driven welding power sources are usually referred to as rotating power sources of which there are two basic types. The ALTERNATOR, which produces alternating current, and the GENERATOR, which produces direct current. Most manufacturers produce machines that provide both AC and DC from the same unit.

Figure 3.16 Maintenance welding on agricultural equipment with an engine driven power source.

Duty Cycle

As mentioned earlier in this section, duty cycle is of prime importance in the selection of a welding machine. The duty cycle of a welding power source is the actual operating time it may be used at its rated load without exceeding the temperature limits of the insulation in the component parts. The duty cycle is based on a ten minute time period in the United States. However, in some parts of the world, Europe for example, the duty cycle is based on a five minute time period. Simply stated, if a power source is rated at a 50% duty cycle and it is operated at its rated output for five minutes, it must be allowed to cool for five minutes before operating again. The duty cycle is not accumulative. For example, a power source with a 50% duty cycle cannot be operated for thirty minutes then allowed to cool for 30 minutes. This violates the ten minute rule. Also a machine rated at 50% should not be operated at maximum for five minutes and then shut off. The cooling fan must be allowed to operate and cool the internal components, otherwise the machine might incur damage.

A power source with a 100% duty cycle may be operated at or below its rated output continuously. However if the machine is operated above its rated output for a period of time, it no longer has a 100% duty cycle.

Single-Phase — Three-Phase

DC welding machines normally require either single-phase or three-phase power. Three-phase power sources are quite popular in the welding industry because, generally speaking, a three-phase machine will deliver a smoother arc than a single-phase machine.

Most AC/DC TIG machines operate from single-phase power. Some power sources can be powered by either single-phase or three-phase power. These are usually inverter-type power sources.

A typical example of a three-phase rectified sine wave is shown in Figure 3.17.

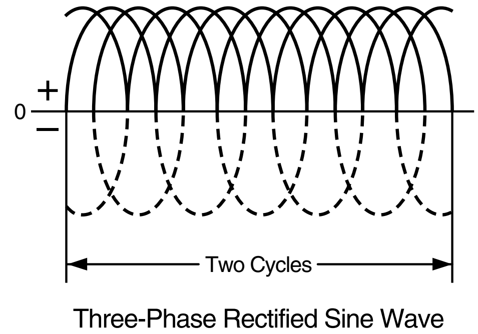


Figure 3.17 Three-phase DC current.

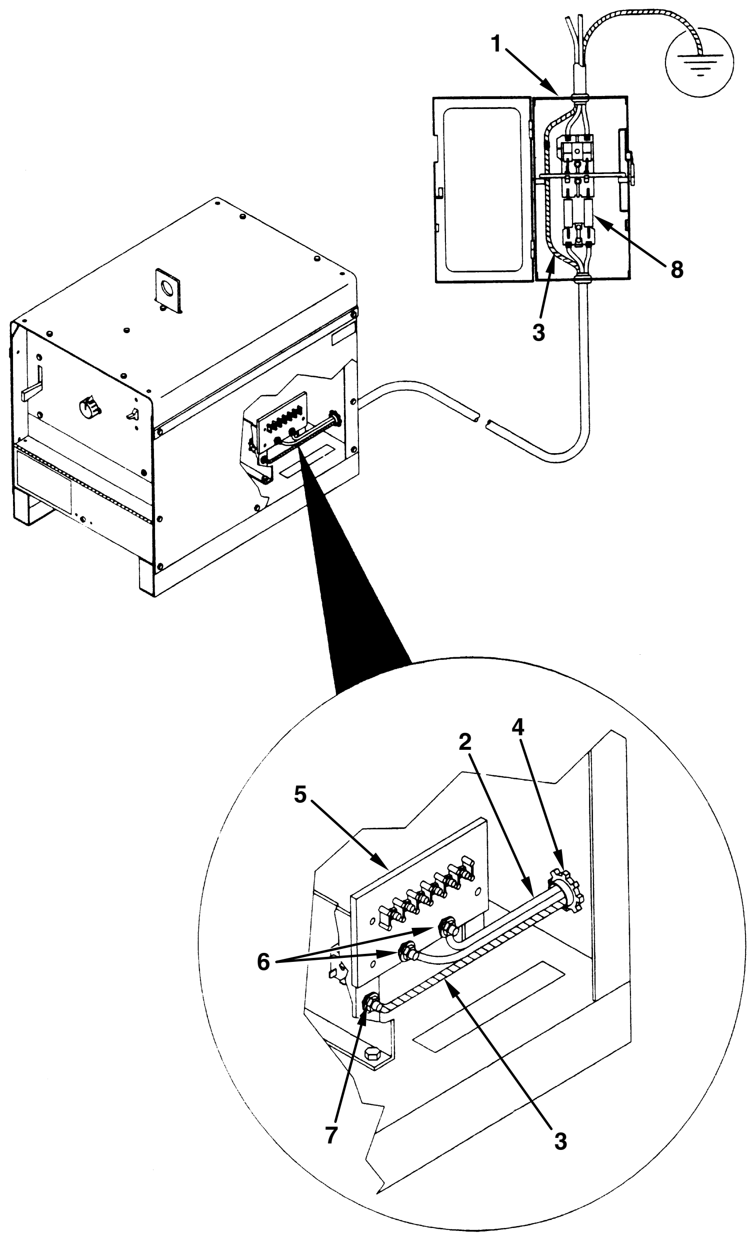


Figure 3.18 Typical input conductor connections and component locations—single-phase.

Single-Phase Input Connections

AC and AC/DC transformer power sources operate from single-phase primary power. DC power sources may be either single or three-phase. Check the nameplate, literature, or owners manual to obtain this information.

Figure 3.18 shows connections for a single-phase connection to primary power. With single-phase power there are two current carrying conductors and a ground wire, as you can see in the electrical box, and the three connections on the terminal board of the power source.

Three-Phase Input Connections

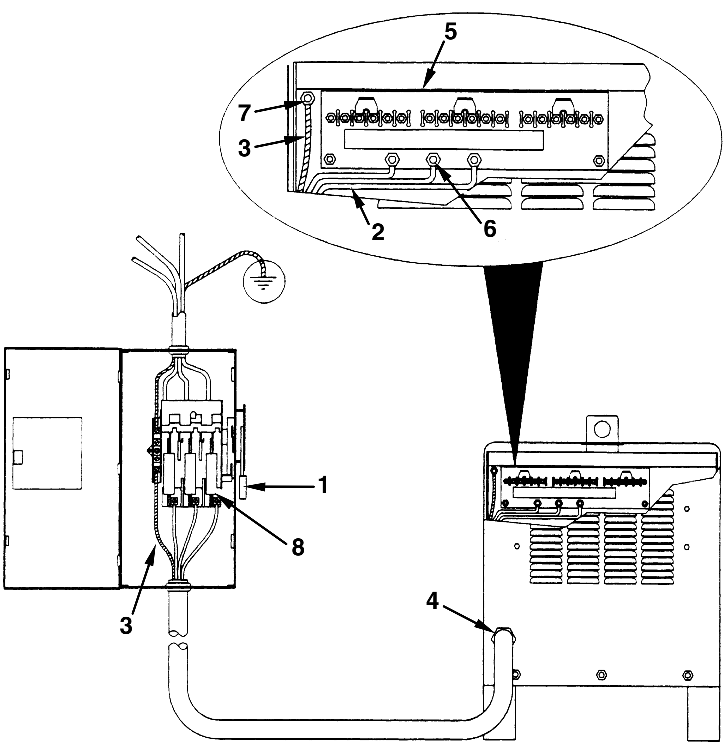
Many industrial DC welding power sources for GTAW utilize three-phase primary power. Three-phase DC power exhibits very smooth arc characteristics. This is because there are three separate sine wave traces within the same time span (1/60th of a second) as the single-phase sine wave trace.

Figure 3.19 shows how primary power is connected to the input of a three-phase power source. There are three current carrying conductors and a ground wire, as seen in the electrical box. The power source also shows three current carrying terminals and a ground terminal connection.

If a three-phase inverter power source is connected to a single-phase line the output rating will be reduced. Check the specific power source's specification for details.

Input Voltage

Most power sources are equipped with an input terminal board. This board is for the proper connection of the power source to the line voltage it is being supplied. This must be properly connected or severe damage can occur to the welding equipment. If the power source is moved from location to location with different input voltages, relinking this board will be required. Certain power sources are equipped with devices that will detect the input voltage and automatically set the equipment for proper operation. Two common types are



Have only qualified persons make this installation.

1. Line Disconnect Device of Proper Rating

2. Input Conductors

3. Grounding Conductor
Conductor rating must comply with national, state, and local electrical codes. Use lugs of proper amperage capacity and correct hole size.

4. Strain Relief Connector
Insert conductors through strain relief.

5. Input Terminal Board

6. Line Terminals

7. Ground Terminal
Connect grounding conductor and input conductors to line terminals and to ground terminal.

Install and connect grounding conductor and input conductors in conduit or equivalent to de-energized line disconnect device.

Be sure grounding conductor goes to an earth ground.

Reinstall side panel and top.

8. Line Fuses
Install into de-energized line disconnect switch.

Figure 3.19 Typical input conductor connections and component connections — three-phase.

referred to as Auto-Link® and Auto-Line™. Auto-Link uses a sensing circuit to mechanically relink the primary to the transformer as needed while Auto-Line electronically, on a sliding scale, constantly monitors and maintains the appropriate voltage to the transformer. Figure 3.20 represents how these two systems function.

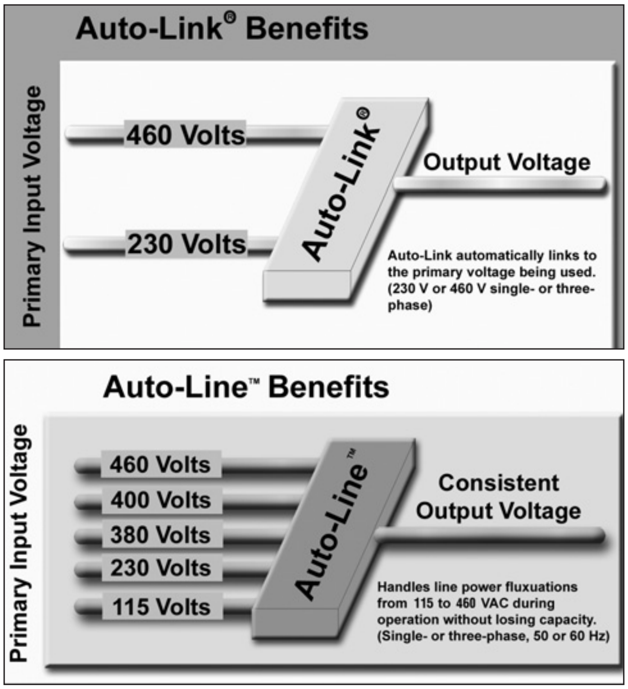


Figure 3.20 Note these automatic systems work on various voltages, frequencies, single- and three-phase power.

Accessory Items

Some of these items are required for the GTAW process while others are considered options.

Arc Starters/Stabilizers

High-frequency arc starters and stabilizers are for use with AC or DC GTAW welding power sources. (See the chapters on GTAW fundamentals, and GTAW techniques for more information on the use of high frequency for welding). These units are particularly useful when welding aluminum, magnesium, stainless steel, titanium, brass, copper and other hard to weld materials. Some DC GTAW power sources are not equipped with HF. They use Lift-Arc™ or touch start technology which allow them to function on specific metals. Some units will feature gas valves, time delay relays, and control circuits to regulate the flow of gas along with the high-frequency current.

Adding these type accessories to a power source not designed for TIG (especially the AC type sine wave machines) will require special precautions. An unbalanced condition occurs when the AC sine wave power sources are used for AC TIG welding. This unbalanced condition produces a circulating current that the power source must deal with. This "DC Component" generates additional heat in the power source. Some older GTAW power source designs used Ni-Chrome resistor bands to help balance and dissipate this heat, others used large capacitor banks built into the power source, while still others used battery banks connected in series with the arc. All were used to reduce this unbalance phenomenon. Since this phenomenon affects the AC sine wave power sources, it becomes an issue only on these type power sources. Since AC Squarewave power sources are designed to control the waveform, balance is not a concern with these type power sources.

Heating in the main transformer due to DC component causes at least two major problems:

1. Breakdown of insulation on the coils and core material.
2. A decrease in efficiency of the transformer due to the higher resistance of the heated coils and core.

When power sources not specifically designed for GTAW welding are used for welding aluminum or magnesium, DC component must be taken into account by derating the machines' duty cycle. The lowering of the current available will prevent overheating and damaging the main power transformer.

Derating Procedure

This derating procedure is necessary only with AC GTAW, and not with DC GTAW. It generally only applies to SMAW power sources that have had an HF arc starter added to them so they can be used for TIG welding.

Derate the AC sine wave power source by 30% from its rated amperage.

For example, a power source for SMAW is rated at 200 amps, 60% duty cycle. For GTAW, we lower the 200 amps by 30% to 140 amps at 60% duty cycle. It's important to remember with this method that the duty cycle for GTAW stays the same as it was for SMAW. If the GTAW welding will be done continuously, find the 100% duty cycle amperage rating for SMAW, then reduce this amperage by 30% for GTAW.

Remember, power sources specifically designed for GTAW do not have to be derated. This fact can usually be found on the machine's nameplate, or in its accompanying literature.

Figure 3.21 A high-frequency arc starter and stabilizer.

GTAW Torch

When welding with the TIG process it is true that the majority of heat goes into the arc, however a significant amount is retained in the torch. Consequently, some means must be provided to remove the wasted heat.

Torches used for GTAW welding may be either water- or air-cooled. High production or high amperage torches are usually water-cooled while lighter duty torches for low amperage applications may be air-cooled.

Air-cooled torches are popular for lower amperage applications. They require no additional cooling other than the surrounding air. The higher amperage versions are less flexible and harder to manipulate than water-cooled torches. The power cable must be heavier than the cable in water-cooled torches, and may be wound around the gas carrying hose or located inside the gas hose to provide additional cooling. Figure 3.22 illustrates the typical air-cooled torch, showing the basic components.

The water-cooled torch is designed so that water is circulated through the torch cooling it and the power cable. Figure 3.23 shows an exploded view of a water-cooled torch.

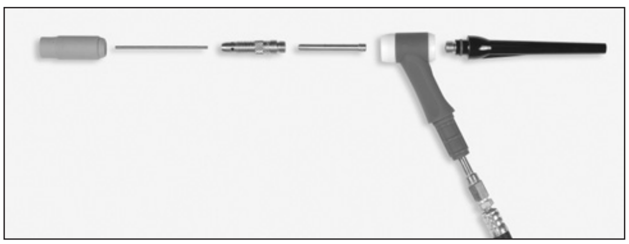


Figure 3.22 An air-cooled GTAW torch.

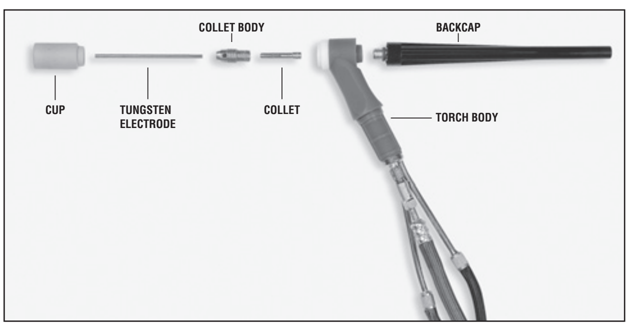


Figure 3.23 A water-cooled GTAW torch.

The power cable is contained inside a hose, and the water returning from the torch flows around the power cable providing the necessary cooling. In this way, the power cable can be relatively small making the entire cable assembly light and easily maneuverable by the welder. When using a water-cooled torch a lack of cooling water or no cooling water at all will cause the polyethylene or braided rubber sheath to melt or possibly burn the power cable in two. A torch manufacturer's specifications will designate the required amount of cooling water for a specific torch. A safety device known as a "fuse assembly" can be installed in the power cable. This assembly contains a fuse link, which is also cooled by the water. If there is no cooling water circulating, the fuse link will melt in two and prevent damage to other more expensive components. The fuse link is easily replaced. When the fuse link is replaced and water flow is maintained, welding can continue. Figure 3.24 shows a GTAW welding setup using a water-cooled torch and a radiator recirculating system.

Figure 3.24 A GTAW welding set-up with a water-cooled torch and radiator cooling system.

GTAW Torch Components

Collet Body

The collet body screws into the torch body. It is replaceable and is changed to accommodate various size tungstens and their respective collets.

Collets

The welding electrode is held in the torch by the collet. The collet is usually made of copper or a copper alloy. The collet's grip on the electrode is secured when the torch cap is tightened in place. Good electrical contact between the collet and tungsten electrode is essential for good current transfer.

Gas Lenses

A gas lens is a device that replaces the normal collet body. It attaches to the torch body and is used to reduce turbulence and produce a longer undisturbed flow of shielding gas. A gas lens will allow the welder to move the nozzle further away from the joint allowing increased visibility of the arc. A much larger diameter nozzle can be used, which will produce a large blanket of shielding gas. This can be very useful in welding material like titanium. The gas lens will also enable the welder to reach joints with limited access such as inside corners. Figure 3.25 is an example of a gas lens and its set up on a torch with a large nozzle and exaggerated tungsten extension.

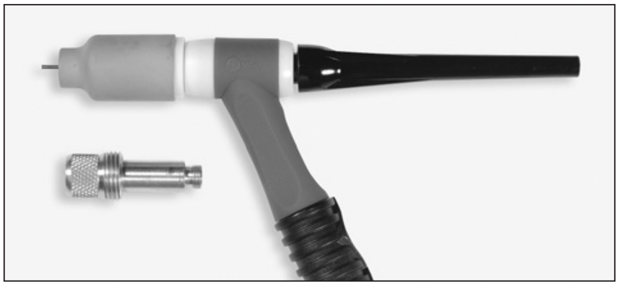


Figure 3.25 Gas lens and set up for welding on a TIG torch.

Nozzles

Gas nozzles or cups as they are better known, are made of various types of heat resistant materials in different shapes, diameters and lengths. The nozzles are either screwed into the torch head or pushed in place. Nozzles can be made of ceramic, metal, metal-jacketed ceramic, glass, or other materials. Ceramic is the most popular, but are easily broken and must be replaced often. Nozzles used for automatic applications and high amperage situations often use a water-cooled metal design.

Gas nozzles or cups must be large enough to provide adequate shielding gas coverage to the weld pool and surrounding area. A nozzle of a given size will allow only a given amount of gas to flow before the flow becomes turbulent. When this occurs the effectiveness of the shielding is reduced, and nozzle size must then be increased to restore an effective non-turbulent flow of gas.

Coolers and Coolants

Water free-flowing directly out of the tap from well or city water sources is not recommended to continuously cool the torch head. Since cold tap water can be below the dew point and cause moisture build-up inside the torch body, this may lead to weld zone contamination until the torch temperature exceeds the dew point. Continuous flow of tap water is not recommended as a coolant because of its inherent mineral content, which can build up over a period of time and clog the small cooling orifices in the torch head. Conservation also dictates use of less wasteful methods, such as coolant radiator re-circulating systems.

The re-circulating coolant must be of the proper type. Since high frequency is being used it should be de-ionized to prevent the coolant from bleeding off the HF prior to it getting to the arc. If the ambient temperature can drop below freezing it must also be protected, but DO NOT use antifreeze. Antifreeze contains leak preventers or other additives and is electrically conductive. Some method of reducing algae growth is advisable. Consult with the coolant system manufacturer for their recommendation on proper coolant solution. De-ionized water can be used if the prior concerns are addressed. All coolants must be clean. Otherwise, blocked passages may cause overheating and damage the equipment. It is advisable to use a water strainer or filter on the coolant supply source. This prevents scale, rust, and dirt from entering the hose assembly.

The rate of coolant flow through the torch is important. Rates that are too low may decrease cooling efficiency. Rates that are too high damage the torch and service line. The direction the coolant flows through the torch is critical. It should flow from the coolant source directly through the water hose to the torch head. The torch head is the hottest spot in the coolant system and should be cooled first with the coolant at its most efficient thermal transfer temperature. This coolant upon leaving the torch head should cool the electrode power cable on its return to the re-circulating system.

Remote Control

Sometimes a welding application requires the welder to place a weld in a location where access to controls on the power source is not readily available. The welder may need to control the amount of current being used. Extra amperage may be required at the start to establish a weld pool more quickly on cold metal, or when making long welds on materials such as aluminum, where weld current must be gradually reduced because of the arc pre-heating the work.

Most welding machines designed primarily for TIG welding provide remote control capability. The remote control capabilities usually include output and current control. Generally, output and current control are located as separate switches on the machine's front panel and can be operated independently if desired. By using a remote control device, the welder can safely get to a location away from the power source, activate the power source and its systems, (gas flow, arc starter, etc.) and vary the amperage levels as desired.

Remote output gives the welder control of open circuit voltage (OCV) which is present at the output studs of the power source with no load attached. Once a torch is connected to the output, the electrode would be continuously energized if it were not for the output control. The remote outputs primary job then is to interrupt the weld circuit until the welder is prepared to start the arc.

The current control switch on the power source when in the remote position works in conjunction with the main current control. If the main current control is set at 50%, the maximum output current available through the remote device is 50%. To obtain full machine output current through the remote device, the main current control must be set at 100%. Understanding this relationship allows the welder to fine tune the remote control device for the work being done.

The most popular of the remote output and current controls is the foot pedal type seen in Figure 3.26. This type operates much the same as the gas pedal in an automobile: the more it is depressed, the more current flows. Another type which affords greater mobility is the finger-tip control seen in Figure 3.27. The finger-tip control mounts on the torch.

Figure 3.26 TIG foot control. A foot-operated remote output and current control.

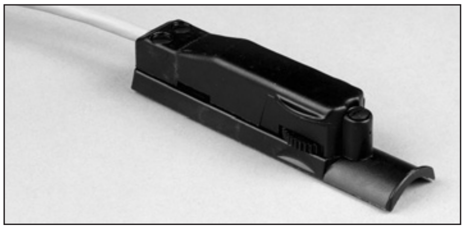


Figure 3.27 Finger-tip control. A finger-tip torch mounted output and current control.

Running Gear and Cylinder Racks

In order for the GTAW process to work most effectively, it is necessary to keep the TIG torch to a fairly short length, generally never over about 50 feet. To allow the power source to be moved within easy reach of the work, having it mounted on a running gear is very advantageous. It not only allows for ease in mobility but aides in keeping the workshop clean. Having the power source mounted a few additional inches off the floor also keeps the internal components in the machine cleaner.

Cylinders are considered high-pressure vessels and must be protected from damage. If the cylinder cap is not in place and the cylinder is not secured, a serious accident can occur. Never leave one of these high-pressure cylinders in an unsecured manner. Figure 3.28 shows a combination running gear and cylinder rack.

Figure 3.28 Cylinder is securely chained in a safe operating condition with a running gear to allow ease of moving the power source and related equipment.

Automated TIG Welding

With increasing needs for high productivity and quality, automated welding is becoming more popular. This can be as simple as a fixed torch head (arc) with the workpiece (joint) being moved by it. Or a fixed workpiece (joint) with the torch (arc) being moved along it. Figure 3.29 shows an example of this type of automation.

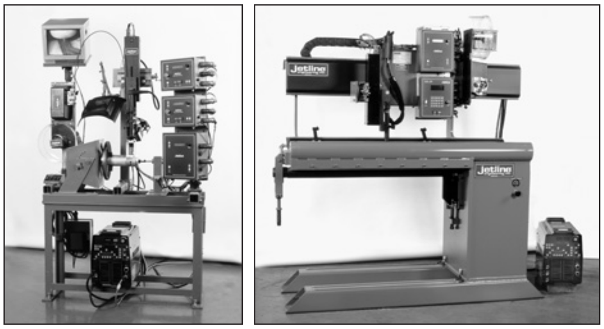


Figure 3.29 Examples of “Hard” Automation. Note the stationary workpiece in one case while the arc is stationary in the other.

One of the most common forms of automation with the GTAW process is its use in orbital welding. The orbital welding equipment clamps onto the workpiece and is used to make tube to tube and tube to sheet type welds. Continued refinement in the computer controls and the inverter power sources systems have made them extremely reliable for precise repeatability. Figure 3.30 shows an orbital welding head and related equipment.

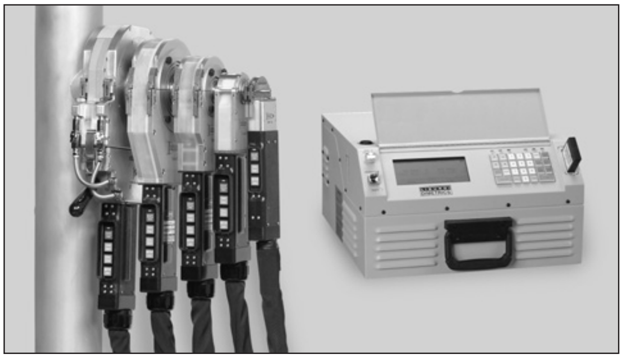


Figure 3.30 An orbital welding head and related equipment.

Whichever method is used, additional control is required over the welding sequence for automation.

A weld sequence is what happens when a signal is given to start the welding operation and also what happens when the welding operation is shutdown. Figure 3.31 is an example of a weld sequence.

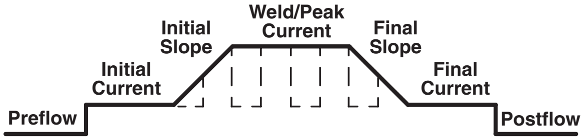


Figure 3.31 The various functions controlled by the weld sequence controller.

These sequence controllers can be built directly into the power source (see Figure 3.32) or be housed in a separate control box (see Figure 3.33).

Figure 3.32 An inverter type power source with built-in weld sequencer primarily used for automated welding.

Figure 3.33 A precision TIG controller with built-in weld sequencer, HF, timers for gas flow, metering and relay control for fixturing.

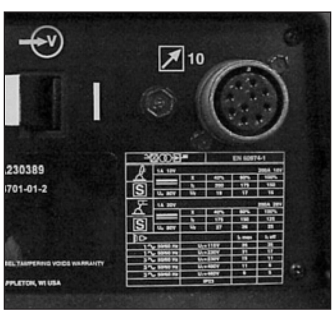


Figure 3.34 The 10-pin connector on an inverter power source capable of being connected for automation operation.

Microprocessors

The ability to control the weld sequence is brought about by the use of microprocessors. These powerful controllers are almost always used in automated welding systems where repeatability is of great importance.

Microprocessor controllers usually have the ability to store numerous weld programs in memory assuring repeatability as well as reducing set-up time.

Those functions controlled by microprocessors might include:

- Arc starting
- Initial current, initial time and initial slope
- Weld current, and weld time
- Final slope, final current and final time
- Pulse peak and background current
- Pulse frequency
- Percent of on time (pulse)
- Post-flow

Connection for Automation Applications

In order to interface the automatic welding power source with the peripheral equipment some means of connection must be provided. This peripheral equipment can be the fixture holding the part, to initiate part clamping or positioning for welding. It can also be for starting the arc movement along the seam or the part moving under the fixed arc. This is a timing function and can best be handled by the weld controller. Figure 3.34 is a 10-pin connection port for connecting this power source to peripheral equipment. It provides indications of the output at specific points in time.

Arc Length Control System

Since arc length is critical on some applications, devices like Figure 3.35 are available to maintain it consistently to plus or minus 0.1 volts. Arc length and arc voltage mean the same thing. Monitoring the voltage and using this data to control the arc length will provide for consistent weld appearance, profile and penetration.

Figure 3.35 An arc length control and head mechanism.

Figure 3.36 Control and magnetic head for arc manipulation.

Figure 3.37 A cold wire TIG set up.

Figure 3.38 A seam tracker for maintaining the arc and joint alignment.

Magnetic Arc Control

This control uses magnetic fields to deflect the arc in advantageous directions. It is useful for high speed automatic welding to even out the weld pool, prevent undercut, and promote uniform penetration. The oscillation and positioning effects of these magnetic fields on the arc improve weld appearance and weld bead profiles. See Figure 3.36.

Cold Wire Feed System

GTAW is generally considered a low-deposition process. However, by automating it and adding the filler wire in an automatic fashion its deposition rate can be increased. Increased weld deposition means higher travel speeds and more parts out the door at the end of the day. Figure 3.37 represents a Cold Wire Feed System. Improved penetration and weld profiles can be had by feeding the filler wire into the back edge of the weld pool versus the front half of the weld pool, which is typically done with manual welding. Some systems can be set up where the filler wire is preheated electrically. These systems are referred to as Hot Wire TIG.

Seam Tracking

In order to keep the welding arc on track when following a constantly varying weld seam, systems like Figure 3.38 have been developed. This type control allows the equipment to constantly monitor the weld joint location both horizontally and vertically over the joint. In order to have consistency at high travel speeds, devices like this can control the position of the welding arc within plus and minus 0.005 inch or 0.13 mm.

IV. Electrodes and Consumables

Tungsten Electrodes for GTAW

Electrodes made of tungsten and tungsten alloys are secured within a GTAW torch to carry current to the welding arc. Tungsten is preferred for this process because it has the highest melting point of all metals.

The tungsten electrode establishes and maintains the arc. It is said to be a "nonconsumable" in that the electrode is not melted and included in the weld pool. In fact, great care must be taken so that the tungsten does not contact the weld pool in any way, thereby causing a contaminated, faulty weld. This is generally referred to as a "tungsten inclusion".

Tungsten electrodes for GTAW come in a variety of sizes and lengths. They may be composed of pure tungsten, or a combination of tungsten and other elements and oxides. Electrodes are manufactured to specifications and standards developed by the American Welding Society and the American Society For Testing And Materials. Electrodes come in standard diameters from .010" through 1/4", as seen in Figure 4.1. The diameter of tungsten electrode needed is often determined by the thickness of base metal being welded and the required amperage to make the weld.

Lengths of tungstens needed are often determined by the type of torch used for a particular application. Standard lengths are shown in Figure 4.2. Of these, the 7" length is the most commonly used. For special applications some suppliers provide them in cut lengths to your specifications. For example, .200" – .500", .501" – 3.000" and 3.001" – 7.000".

Standard Tungsten Sizes

U.S. Customary		SI Units	
Diameter in	Tolerance ± in. [b, c]	Diameter in	Tolerance ± mm [b, c]
0.010[a]	0.001	0.300	0.025
0.020	0.002	0.50	0.05
0.040	0.002	1.00	0.05
0.060	0.002	1.60	0.05
0.093	0.003	2.00	0.05
0.125 (1/8)	0.003	2.40	0.08
0.156 (5/32)	0.003	2.50	0.08
0.187 (3/16)	0.003	3.00	0.08
0.250 (1/4)	0.003	3.20	0.08
		4.00	0.08
		4.80	0.08
		5.00	0.08
		6.40	0.08
		8.00	0.08

Notes:
a. 0.010 in. (0.30 mm) electrodes are also available in coils.
b. Tolerances, other than those listed, may be supplied as agreed upon between supplier and user.
c. Tolerances shall apply to electrodes in both the clean finish and ground finish conditions.

Figure 4.1 Diameters of standard tungsten electrodes (Courtesy AWS).

3" (76 mm)	12" (305 mm)
6" (152 mm)	18" (457 mm)
7" 178 mm)	24" (610 mm)

Figure 4.2 Standard tungsten lengths.