

 CITY OF TUCSON	City of Tucson Central Safety Services Number: S-018 Subject:	Page 1 of 16
		Effective Date: October 10, 2000
	Welding	Reviewed/ Revised: January 1, 2013

1.0 PURPOSE

To help employees involved in welding, cutting and brazing work recognize hazards, prevent accidents, injuries, and illnesses, follow safe work practices and to select and use proper personal protective equipment.

2.0 SCOPE

To outline safe welding practices for employees while working inside facilities, buildings, shops, or performing field work.

3.0 DEFINITIONS

AC or alternating current: Is the kind of electricity which reverses its direction periodically. For 60 cycle current, the current goes in one direction and then in the other direction 60 times in the same second, so that the current changes its direction 120 times in one second.

Arc voltage: The voltage across the welding arc.

Bare electrode: A filler metal electrode consisting of a single metal or alloy that has been produced into a wire, strip, or bar form and that has had no coating or covering applied to it other than that which was incidental to its manufacture or preservation.

Base metal (material): The metal (material) to be welded, brazed, soldered, or cut.

Covered electrode: A composite filler metal electrode consisting of a core of a bare electrode or metal cored electrode to which a covering sufficient to provide a slag layer on the weld metal has been applied. The covering may contain materials providing such functions as shielding from the atmosphere, de-oxidation, and arc stabilization and can serve as a source of metallic additions to the weld.

Crater: In arc welding a depression at the termination of a weld bead or in the molten weld pool.

DC or direct current: Electric current which flows only in one direction. In welding, an arc welding process wherein the power supply at the arc is direct current.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 2 of 16
----------------------------	------------------	-------------------------	-------------------------------------	-----------------

Flux: Material used to prevent, dissolve, or facilitate removal of oxides and other undesirable surface substances.

Gas metal arc welding: (GMAW) An arc welding process that produces coalescence of metals by heating them with an arc between a continuous filler metal (consumable) electrode and the work. Shielding is obtained entirely from an externally supplied gas or gas mixture.

Gas tungsten arc welding: (GTAW) An arc welding process that produces coalescence of metals by heating them with an arc between a tungsten (non-consumable) electrode and the work. Shielding is obtained from a gas or gas mixture. Pressure may or may not be used and filler metal may or may not be used. (This process has sometimes been called TIG welding, a non-preferred term.)

Groove weld: A weld made in the groove between the work pieces.

Heat-affected zone: That portion of the base metal that has not been melted, but whose mechanical properties or microstructure have been altered by the heat or welding, brazing, soldering, or cutting.

Joint penetration: The depth a weld extends from its face into a joint, exclusive of reinforcement.

Lap joint: A joint between two overlapping members in parallel planes.

Manual welding: A welding operation performed and controlled completely by hand.

Melting rate: The weight or length of electrode melted in a unit of time.

Open Circuit Voltage: The voltage between the Output terminals of the welding machine when no current is flowing in the welding circuit.

Overhead position: The position in which welding is performed from the underside of the joint.

Overlap: The protrusion of weld metal beyond the weld toe or weld root.

Porosity: Cavity type discontinuities formed by gas entrapment during solidification.

Radiography: The use of radiant energy in the form of X-rays or gamma rays for the non-destructive examination of metals.

Reverse polarity: A nonstandard term for direct current electrode positive.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 3 of 16
----------------------------	------------------	-------------------------	-------------------------------------	-----------------

Shielded metal arc welding: (SMAW) An arc welding process that produces coalescence of metals by heating them with an arc between a covered metal electrode and the work pieces. Shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

Spatter: The metal particles expelled during fusion welding which do not form a part of the weld.

Straight polarity: A nonstandard term for direct current electrode negative.

Stringer bead: A type of weld bead made without appreciable weaving motion.

Tack weld: A weld made to hold parts of a weldment in proper alignment until the final welds are made.

Underbead crack: A crack in the heat-affected zone generally not extending to the surface of the base metal.

Undercut: A groove melted into the base metal adjacent to the weld toe or weld root and left unfilled by weld metal.

Vertical position: The position of welding in which the weld axis is approximately vertical.

Weave bead: A type of weld bead made with transverse oscillation.

Weld: A localized coalescence of metals or non-metals produced either by heating the materials to welding temperature, with or without the application of pressure, or by the application of pressure alone, and with or without the use of filler material.

Weld face: The exposed surface of a weld on the side from which welding was done.

Weld metal: That portion of a weld which has been melted during welding.

Weld pass: A single progression of welding or surfacing along a joint or substrate. The result of a pass is a weld bead, layer, or spray deposit.

Weld pool: The localized volume of molten metal in a weld prior to its solidification as weld metal.

Weld root: The points, as shown in cross section, at which the back of the weld intersects the base metal surfaces.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 4 of 16
----------------------------	------------------	-------------------------	-------------------------------------	-----------------

Weld toe: The junction of the weld face and the base metal.

Welding procedure: The detailed methods and practices involved in the production of a weldment.

Welding rod: A form of welding filler metal, normally packaged in straight lengths, that does not conduct electrical current.

4.0 RESPONSIBILITIES

A. Supervisors

1. Management shall recognize its responsibility for the safe usage of cutting and welding equipment on its property and based on potential for fire within or near the welding area, establish dedicated work areas for cutting and welding, and establish procedures for cutting and welding, in field locations which shall require a Hot Work Permit (Reference OSHM S-010).
2. Supervisors shall designate an individual responsible for authorizing cutting and welding operations in areas not specifically designed for such processes and ensure that cutters or welders and their supervisors are suitably trained in the safe operation of their equipment and the safe use of the process.
3. Supervisors shall also advise all contractors about flammable materials or hazardous conditions.

B. Employees

1. Welders and Trades Helpers shall be responsible for the safe handling and use of the cutting or welding equipment and process and shall keep a copy of the Operations and Maintenance Manual for each piece of equipment used (their own or on City equipment). Manual must be read, used, and followed by the welder as to operations and maintenance of that equipment.
2. Welders shall determine the combustible materials and hazardous areas present or likely to be present in the work location and shall protect combustibles from ignition by the following:
 - a. Have the work moved to a location free from dangerous combustibles;
 - b. If the work cannot be moved, have the combustibles moved at least 35 feet from the work or have the combustibles properly shielded against ignition;
 - c. See that cutting and welding are so scheduled that plant operations that might expose combustibles to ignition are not started during cutting or welding.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 5 of 16
----------------------------	------------------	-------------------------	-------------------------------------	-----------------

3. Welders shall secure authorization in the form of a Hot Work Permit for the cutting or welding operations from the designated management representative and shall determine that conditions are made safe prior to welding, cutting or brazing. Welders shall ensure a fire extinguisher is carried on the welding vehicle and determine that fire protection and extinguishing equipment are properly located at the site and where fire watches are required welders shall see that they are initiated at the work site.

5.0 TRAINING AND EDUCATION

- A. Departments shall ensure that all welders and Trades Helps are trained in the safe operation of welding, soldering and cutting equipment.
- B. Central Safety Services shall assist departments by providing employee training in safe welding procedures, hot work, and personal protective equipment.

6.0 GENERAL

A. Hot Work

1. Except in designated welding areas, welding, cutting and brazing work is required to have a hot work permit. (Refer to Occupational Safety and Health Manual, S-010, Hot Work).

B. Containers

1. No welding, cutting or other hot work may be performed on used drums, barrels, tanks or other enclosed containers until they have been purged so thoroughly as to make absolutely certain that no flammable materials are present, nor are there any substances such as greases, tars, acids or other materials which, when subjected to heat, might produce flammable or toxic vapors. Any pipelines or connections to the drum or vessel must be disconnected or blanked.

C. Confined Space

1. Refer to Occupational Safety and Health Manual; S-005, Confined Space Program for instructions on confined space entry. Continuous air monitoring is required when welding due to the introduction of gases into the Confined Space atmosphere that may displace oxygen or interact with the atmosphere and combust.
2. When welding or cutting is being performed in any confined space, the gas cylinders and welding machines shall be left on the outside where feasible. Generators supplying power to welding machines must be kept outside the confined space. Before operations are started, heavy portable equipment mounted on wheels shall be securely blocked to prevent accidental movement.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 6 of 16
----------------------------	------------------	-------------------------	-------------------------------------	-----------------

3. Where a welder must enter a confined space greater than five (5) foot vertical entry through a manhole or other opening, a rescue tripod shall be on-site for emergency retrieval. When retrieval lines and life lines are used for this purpose, they will be attached to the full body harness to the manufacturer's specified attachment point.
4. An attendant with a preplanned rescue procedure will be stationed outside to observe and communicate with the welder at all times and be capable of putting rescue operations into effect. There shall be only one welder/rescue worker per safety belt and life line. Rescue worker shall maintain a continuous line of sight and/or be in communication with the worker in the confined space. When more than one weld/rescue worker is in the confined space at the same time, precautions must be taken so that life lines do not cross.
5. When welding is suspended for over 30 minutes, such as during lunch or overnight:
 - a. All electrodes shall be removed from the holders with the holders carefully located so that accidental contact cannot occur;
 - b. The welding equipment should be shut off;
 - c. The gas and oxygen supply valves will be closed, the regulators released, and the valves on the torch shut;
 - d. Where practical, the torch and hose will also be removed from the confined space.

D. Personal Protective Equipment

1. All employees shall be protected from falling when working 4 feet or more above a lower level. (OSHM Manual S-004, Fall Protection Program). Welding cables and other equipment must be placed so that it is clear of passageways, ladders and stairways, entangled to eliminate the trip hazard. On any portable welding equipment, the grounding lug provided must be utilized and attached to an earth ground when available.
2. Employees shall wear long-sleeved shirts or jackets and long trousers made from a close-weave material that is unlikely to ignite. Leather aprons, jackets, chaps and gloves provide are acceptable protection. Pants should be without cuffs. No synthetic fabrics shall be worn.
3. Eye protection of the proper type, for the specific task to be done, shall be worn by those performing, observing or supervising the hot work or any grinding or similar related work which accompanies the process.
4. Oxyacetylene welding produces low level ultraviolet light, so it cannot cause flash burns. The lens shade density used for gas welding can,

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 7 of 16
----------------------------	------------------	-------------------------	-------------------------------------	-----------------

therefore, be much lighter, providing a better view of the work and its surroundings.

5. For arc welding, helmets and goggles shall be equipped with the proper density (shade) lens. Lens density must be dark enough to prevent eye injury while still permitting the employee to view the work as much as possible. (See Appendix A).

Note: Gold or silver plated lenses are prohibited.

6. Physical protection from sparks and grinding/chipping debris requires that all helmet lenses, goggles, eyeglasses or face shields employed during these activities meet the ANSI guidelines for impact resistance. One piece welding goggles shall be worn over prescription eyeglasses or special corrective lenses for welding hoods are available from welding supply stores at city expense.
7. Shields shall be erected so as to protect passers-by from the flash of arc welding.
8. Hearing protection shall be provided and worn where required and may be worn at any time to reduce ambient noise. Safety footwear shall conform to AD 2.03-3.
9. Respiratory protection shall be selected appropriate to the reasonably anticipated or known hazards associated with welding. Respiratory protection shall be selected according to the procedures outlined in OSHM IH-001 – Respiratory Protection. Portable exhaust systems shall be utilized when required when welding stainless material and all metals when available.

E. Signage

1. Warning signs shall be provided and posted to warn other workers who may not normally work near the welding. The warning signs shall state the PPE requirements regarding eye protection, hearing protectors, or a respirator and shall limit or deny entry to employees attempting to enter an area without personal protective equipment.

F. Ventilation

1. Welding shall be performed in areas of open ventilation, whenever possible. Exhaust units shall be utilized in indoor and/or enclosed areas. Air shall be continuously monitored while welding, cutting, and/or brazing is performed in any confined space.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 8 of 16
----------------------------	------------------	-------------------------	-------------------------------------	-----------------

G. Sanitation

1. Preparation, storage, or consumption of food shall not be permitted in/near welding areas. Hand washing facilities or sanitary wipes or waterless hand cleaner shall be made readily available to employees. Any City provided tools or protective clothing shall be cleaned as needed. Work areas shall be cleaned at end of each shift or more frequently as needed. Work areas shall be kept free of flammable debris. Flammable work materials (rags, solvents, etc.) shall be disposed in approved containers and emptied daily.

H. Cylinder Storage and Restraint

1. Employees shall refer to OSHM S-014 Compressed Gas Cylinders for policy regarding the handling, storage and restraint of all gas cylinders

I. Use of Oxygen

1. Oxygen shall not be used as a substitute for compressed air or utilized to power pneumatic tools. Oxygen shall not be utilized to blow out pipelines, test radiators, purge tanks or containers, or to "dust" clothing or work. Oxygen shall always be utilized with a regulator on oxygen cylinders to reduce the cylinder pressure to an acceptable working pressure. Employees shall not interchange oxygen regulators, hoses, or other apparatus with similar equipment intended for other gases.

J. Hoses

1. Employees shall always use a flash-back arrestor or similar back flow protection at the regulator. Manufacturers recommended testing and maintenance must be followed.
2. Hoses shall not come in contact with oil or grease. Employees shall protect hoses from being walked on or run over and employees shall not work with hoses over the shoulder, around the legs, or tied to the waist. Protect hoses from hot slag, flying sparks, and open flames. Connections shall be compatible. Do not use white lead (pipe dope), oil, grease, or other pipe fitting compounds for connections on hose, torch, or other equipment. Hoses shall not be crimped to shut off gases.
3. Hoses should be inspected, before and after each use, for burns, worn places, or leaks at the connections. Leaks shall be repaired promptly. Repair leaks by cutting hose and inserting a brass splice. Do not use tape for mending. Replace hoses if necessary.
4. Make sure that hoses are securely attached to torches and regulators before using. Do not use new or stored hose lengths without first blowing them out with compressed air to eliminate debris. Only approved gas hoses for flame cutting or welding should be used with oxy-fuel gas equipment.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 9 of 16
----------------------------	------------------	-------------------------	-------------------------------------	-----------------

K. Machine Welding

1. Locate welding machines where they have adequate ventilation and ventilation ports are not obstructed. Check the welding equipment to make sure the electrode connections and the insulation on holders and cables are in good condition. All checking should be done with the machine off or unplugged. All energy supply deficiencies should be investigated by a trained electrician.
2. Do not operate the polarity switch while the machine is operating under welding current load. Do not operate the rotary switch for current settings while the machine is operating under welding current load. Operate the rotary switch while the machine is idling.
3. Turn off the welding machines from the power supply when they are left unattended. The welding electrode holders must be connected to machines with flexible cables for welding application. Use only insulated electrode. There can be no splices in the electrode cable within 10 feet of the electrode holder. Splices, if used in work or electrode leads, must be insulated.
4. Partially used electrodes should be removed from the holders when not in use. A place should be provided to hang up or lay down the holder where it will not come in contact with persons or conducting objects.
5. When electric generators powered by internal combustion engines are used inside buildings or in confined areas, the engine exhaust must be conducted to the outside atmosphere, or adequate general ventilation provided as required by the City's Industrial Hygienist.

L. Plasma Arc Welding & Cutting

1. Adequate ventilation is required during the plasma arc welding process. The bright arc rays also cause fumes from the hydro-chlorinated cleaning materials or decreasing agents to break down and form phosgene gas. Cleaning operations using these materials should be shielded from the arc rays of the plasma arc.
2. At current levels over 15A, a standard welder's helmet with proper shade of filter plate for the current used is required.
3. At current levels below 15A, a full plastic face shield with additional eye protection with a No. 6 filter lens is required.
4. When welding any metals high in copper, lead, zinc, or beryllium special ventilation requirements must be designated by City of Tucson's Industrial Hygienist.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 10 of 16
----------------------------	------------------	-------------------------	-------------------------------------	------------------

5. When a pilot arc is operated continuously, normal precautions should be used for protection against arc flash and heat burns. Suitable clothing must be worn to protect exposed skin from arc radiation.

M. Air Carbon Arc Welding & Cutting

1. The air carbon arc can be used for cutting or gouging most of the common metals. **The process is not recommended for weld preparation for stainless steel, titanium, zirconium, and other similar metals without subsequent cleaning. This cleaning, usually grinding, must remove all of the surface carbonized material adjacent to the cut.**
2. When using a constant voltage (CV) power source, precautions must be taken to operate it within its rated output of current and duty cycle.
3. Alternating current power sources having conventional drooping characteristics can also be used for special applications. AC type carbon electrodes must be used.
4. The air pressure must range from 80 to 100 psi. The volume of compressed air required ranges from as low as 5.0 cu ft/min (2.5 liter/min.) up to 50 cu ft/min. (24 liter/min.) for the largest-size carbon electrodes.
5. The air blast of air carbon arc welding will cause the molten metal to travel a very long distance. Metal deflection plates should be placed in front of the gouging operation, and all combustible materials should be moved away from the work area. At high-current levels, the mass of molten metal removed is quite large and will become a fire hazard if not properly contained.
6. A high noise level is associated with air carbon arc welding. At high currents with high air pressure a very loud noise occurs. Ear protection, ear muffs or earplugs must be worn by the arc cutter.

N. Gas Shielded Arc Welding Hazards

1. Gas shielded arc welding processes have certain dangers associated with them. These hazards, which are either peculiar to or increased by gas shielded arc welding, include arc gases, radiant energy, and metal fumes.
2. Metal Fumes
 - A. The physiological response from exposure to metal fumes varies depending upon the metal being welded. Ventilation and personal protective equipment requirements are specific for the metal being welded and requirements must be determined by the City Industrial Hygienist. If any unfamiliar metal is to be welded, contact Central Safety Services before initiating the work process.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 11 of 16
----------------------------	------------------	-------------------------	-------------------------------------	------------------

O. Screens

1. When workers or other persons may be exposed to the hot work operations involving arc welding, they must be protected by non-combustible or flame-proof screens or shields or must be required to wear appropriate personal protective equipment (goggles).

7.0 ADVICE AND COUNSEL

Central Safety Services will administer and review this policy as necessary.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 12 of 16
----------------------------	------------------	-------------------------	-------------------------------------	------------------

APPENDIX A

Oxygen-Fuel Gas Welding - General Requirements

- Keep your head out of the welding plume.
- When the gas cylinders are in use, a regulator is attached, and the cylinder shall be secured to prevent falling by means of chains or clamps.
- Cylinders should be handled with respect.
 - They should not be dropped or struck.
 - They should never be used as rollers.
 - Hammers or wrenches should not be used to open cylinder valves that are fitted with hand wheels.
 - They should never be moved by electromagnetic cranes.
 - They should never be in an electric circuit so that the welding current could pass through them.
 - An arc strike on a cylinder will damage the cylinder causing possible fracture, requiring the cylinder to be condemned and discarded from service.
 - Care must be taken to protect the valve from damage or deterioration.
 - Escaping fuel gas can also be a fire or explosion hazard.
- Any cylinders, not in use, must have their caps on, and cylinders, either filled or empty, should have the valve closed, and marked "filled" or "empty".
- When working in confined spaces, provide adequate ventilation for the dissipation of explosive gases that may be generated.
- Keep a clear space between the cylinder and the work so the cylinder valves can be reached easily and quickly.
- Use cylinders in the order received. Store full and empty cylinders separately and mark the empty ones appropriately.
- Always wear protective clothing suitable for welding or flame cutting. Keep work area clean and free from hazardous materials. When flame cutting, sparks can travel 30 to 40 feet. Do not allow flare cut sparks to hit hoses, regulators, or cylinders.
- Fire on the cylinder:

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 13 of 16
----------------------------	------------------	-------------------------	-------------------------------------	------------------

- If the fire on a cylinder is a small flame around the hose connection, the valve stem, or the fuse plug, try to put it out as quickly as possible.
- A wet glove, wet heavy cloth, or mud slapped on the flame will frequently extinguish it.
- Thoroughly wetting the gloves and clothing will help protect the person approaching the cylinder.
- Avoid getting in line with the fuse plug, which might melt at any time.
- Torches/Regulators
 - Do not experiment with torches or regulators in any way.
 - Do not use oxygen regulators with acetylene cylinders.
 - Do not use any lubricants on regulators or tanks.
 - Always use the proper tip or nozzle, and always operate it at the proper pressure for the particular work involved. This information should be taken from work sheets or tables supplied with the equipment.
 - When not in use, make sure the torch is not burning. Also, release the regulators, bleed the hoses, and tightly close the valves. Do not hang the torch with its hose on the regulator or cylinder valves.
 - Do not light a torch with a match or hot metal, or in a confined space. Use friction lighters or stationary pilot flames.
 - Use oxygen and acetylene or other fuel gases with the appropriate torches and only for the purpose intended.
 - Treat regulators with respect. Do not turn valve handle using force.
- Lighting Torch

Always use the following sequence and technique for lighting a torch:

1. Open acetylene cylinder valve.
2. Open acetylene torch valve $\frac{1}{4}$ turn.
3. Screw in acetylene regulator adjusting valve handle to working pressure.
4. Turn off the acetylene torch valve (this will purge the acetylene line).
5. Slowly open oxygen cylinder valve all the way.

Subject: Welding	Number: S-018	Rev. January 1, 2013	Effective Date: October 10, 2000	Page 14 of 16
----------------------------	------------------	-------------------------	-------------------------------------	------------------

6. Open Oxygen torch valve $\frac{1}{4}$ turn.
7. Screw in oxygen regulator screw to working pressure.
8. Turn off oxygen torch valve (this will purge the oxygen line).
9. Open acetylene torch valve $\frac{1}{4}$ turn and light with lighter.

Use only friction type lighter or specially provided lighting device.

10. Open Oxygen torch valve $\frac{1}{4}$ turn.
11. Adjust to neutral flame.

- Shutting Off Torch

Always use the following sequence and technique for shutting off a torch:

1. Close acetylene torch valve first, then the oxygen valve.
 2. Close acetylene cylinder valve, then oxygen cylinder valve.
 3. Open torch acetylene and oxygen valves to release pressure in the regulator and hose.
 4. Back off regulator adjusting valve handle until no spring tension is left.
 5. Close torch valves.
- Use mechanical exhaust at the point of welding when welding or cutting lead, cadmium, chromium, manganese, brass, bronze, zinc, or galvanized steel.
 - Do not weld or flame cut on containers that have held combustibles without taking special precautions.
 - Do not weld or flame cut into sealed container or compartment without providing vents and taking special precautions.

APPENDIX B
Recommended Welding Lenses

Application	Base Metal Thickness (inches)	Recommended Shade Number
Arc Welding with 1/16", 3/32", 5/32" electrodes	1/8 to ¼	10
3/16", 7/32", ¼ " electrodes	¼ to 1	12
5/16", 3/8" electrodes	Over 1 inch	14
TIG* welding with non-ferrous 1/16", 3/32", 1/8", 5/32" electrodes	Up to ¼ inch	11
TIG * welding with ferrous 1/16", 3/32", 1/8", 5/32" electrodes	Up to ¼ inch	12
Soldering	All	2
Brazing	Up to ¼	3 or 4
Light Cutting	Up to 1 inch	3 or 4
Medium Cutting	1 to 6 inches	4 or 5
Heaving Cutting	Over 6 inches	5 or 6
Gas Welding (light)	Up to 1/8 inch	4 or 5
Gas Welding (medium)	1/8 to ½ inch	5 or 6
Gas Welding (heavy)	Over ½ inch	6 or 8

- for MIG welding decrease shade by one

APPENDIX C

FILTER SHADES FOR WELDING AND CUTTING				
Operations	Electrode diameter, in.	Arc current, A	Minimum protective shade number	Recommended shade number
Shielded-metal- arc welding	< 3/32	< 60	7	-
	3/32-5/32	60-160	8	10
	5/32-1/4	160-250	10	12
	> 1/4	250-550	11	14
Gas-metal-arc and flux-cored-arc welding		< 60	7	-
		60-160	10	11
		160-250	10	12
		250-500	10	14
Gas-tungsten-arc welding		< 50	8	10
		50-150	8	12
		150-500	10	14
Air-carbon-arc welding	Light	< 500	10	12
	Heavy	500-1000	11	14
Plasma-arc welding		< 20	6	6-8
		20-100	8	10
		100-400	10	12
		400-800	11	14
Plasma-arc cutting	Light *	< 300	8	9
	Medium *	300-400	9	12
	Heavy *	400-800	10	14
Torch brazing		-	3	3-4
Torch Soldering		-	2	2
Carbon arc welding		-	14	14