BASIC Basic Welding

Outcomes

1. This workshop will **not** teach you how to weld.

2. It will discuss basic safety practices of the process and equipment. Basic information you need 'before' you start to use the equipment.

We will cover

- **Safety Equipment**
- **Gas Welding**
  - Cylinders, Valves, hoses, torches, filler rod
- **Oxy/Acetylene cutting**
  - Torch, gas pressures, technique
- **Soldering**
  - Temperatures, flux (acid and rosin), solder wire
- **Brazing**
  - Temperatures, flux, filler rod
- **Arc Welding** – MIG GMAW
  - Shielding gas, wire, settings, torches, grounding
  - Spool gun
- **Arc Welding** – Stick SMAW
  - Settings, electrodes, grounding
- **Arc Welding** – TIG GTAW
  - Shielding gas, torch, electrode, settings, grounding, filler rod
- **Plasma cutting**

Notice

Protect your own safety.

You are responsible for verifying all information related to safety and protection measures.

You are responsible for damage to equipment and facilities.

(I believe that I am giving you accurate information but, *don't take my word for it. Independently verify for yourself.)*

Welding

Fusion of 2 (or more) pieces of metal by melting and joining.

(Plastic is also welded – but will not be discussed as part of this Workshop.)

Welding

Uses Heat

Created by:

Combustion (gas welding, forge welding)
Electric resistance arc (arc welding)

Friction
Induction

(and, Electron Beam, Laser, Plasma)

Welding

What is a good weld

A good weld starts with clean well aligned material

Smooth, non porous, as strong as or stronger than the metals being joined.
Full penetration (melted joint is all the way through the material)
Full fusion (materials are melted together, weld is not laying on top of the joined materials)

Safety gear

Protection from heat and radiation.

And, Keep a Fire Extinguisher handy and know where additional extinguishers are located.

Protective Gear

Clothing, cotton (man made fabrics, polyester, rayon, nylon, melt and stick to you)
Gloves (stuff is hot)
Long sleeves
Long pants
Shoes
Goggles / helmet
Head cover or Do Rag

Special welding garments

Fume Extraction

Extract the fumes or provide lots of ventilation.

Fume extractors
Fans
The great outdoors

Welding Space

Flamable objects (wood shavings, rags, fluids) in the welding shop area are subject to having hot metal set them on fire.

Galvanize/Platings

Don’t weld Galvanized or Zinc plated metal. The fumes are very dangerous (Zinc Flu).

Cadmium and other platings are dangerous as well

Pot Metal (is a Zinc alloy) There are some special rods (Muggy Weld) that is more like brazing (not getting up to the temperature where Zinc fumes become hazardous)

Protecting Others

Gas welding – flying sparks
Gas cutting – Lots of flying sparks

Arc welding – UV – flying sparks
TIG – Lots of UV
Stick – UV and flying sparks. Chunks of hot slag
Plasma – Lots of flying sparks, UV

Note: pets (dogs, cats) will watch an arc until they go blind. Get them out of direct sight.

Let people around you know what is going on. Yell 'Welding' before striking an arc. Give them a chance to protect their eyes.

Get Comfortable

Set up the work at a convenient height
Make it easy to move along the weld seam
If possible, be seated
Have a place to brace your arms/hands

Welding uses lots of small moves and fine motor control

Oxy/Acetylene

EYE PROTECTION

APPLICATION	BASE METAL THICKNESS	LENS SHADE
Oxygen/Acetylene Welding	Up to 1/8"	3-4
Oxygen/Acetylene Welding	1/8" to 1/2"	4-5
Oxygen/Acetylene Welding	1/2" and over	5-6
Oxygen/Acetylene Cutting	Up to 1"	4-5
Oxygen/Acetylene Cutting	1" to 6"	5-6
Oxygen/Acetylene Cutting	6" and over	6-8

Combustion

Uses heat of combustion, typically Acetylene and Oxygen. (Can use other gasses, propane, natural gas, hydrogen)

Oxy/Acetylene Flame is 6,396° F

(Butane lighter ~ 3,000° F)

(Propane torch ~3,200° F)

(MAAP (methylacetylene and propadiene) ~3,700° F)

Soldering

Lower temperature, ~ 650°F

Tin Lead or
Tin Antimony

Need a good mechanical connection first
Solder holds the joint after it is made

Needs flux to help clean base material, help solder flow, and keep oxygen out.

Electronics – user rosin core solder

Copper pipe – use acid solder and lead free solder if drinking water pipes.

(Similar to Brazing)

Brazing

Low temperature, Not Welding, ~ 840°F

Metal filler rod flows around the joint 'sticking' the pieces together.

Can be very strong and less brittle that a weld.

Need flux

Can use flux coated filler rod

(Similar to Soldering)

Flux

Chemical that helps keep oxygen out of the joint and helps clean the metal
Helps the metal ‘flow’

Borax

Acid and Rosin

Liquid and paste

Cylinders

Keep upright

Cylinder cap when not in use

Oxygen and Acetylene Cylinders

O2 2,400 psi
Acetylene 250 psi

Secure tanks with chain.

Regulators

O2, no oil or grease (instant fire)
Guage reads tank pressure
Reg reads pressure to hose
Use 8-20 for welding
20-30 for cutting
Use two hands to open valve to avoid shocking gauge
Open a few turns

Acetylene
Open ¼ turn
Use 5 lbs regulator pressure
Never use 15 or more – acetylene explosive
Wait, didn't you just tell me the cylinder is at 250 psi?
Yes, but, the cylinder is full of acetone and acetylene is dissolved in that
That's why only ¼ turn – helps to keep acetone from being drawn out of the bottle.

Gas Pressures

Oxygen & Acetylene Gas Pressures

WELDING

METAL THICKNESS	ROD DIAMETER	TIP (Drill Size)	PRESSURES (PSI)	
			OXYGEN	ACETYLENE
1/16"	1/16-3/32"	56	8 - 20	5
1/8"	3/32-1/8"	53	11 - 25	5
1/4"	5/32-3/16"	48	12 - 23	5

CUTTING

METAL THICKNESS	ORIFICE (Drill Size)		PRESSURE (PSI)	
	PREHEAT	CUTTING	OXYGEN	ACETYLENE
1/8 - 3/8"	70	67	20 - 30	3
3/8 - 3/4"	62	58	30 - 40	5
3/4 - 1"	57	54	40 - 45	5
1 1/2 - 2"	54	51	45 - 50	5

Torch Body

Red is Acetylene

Green is Oxygen

Torch tips

Finger tight only
Bigger tip – bigger fire, more heat

Metal Thickness --Tip Size
1/4 - 1/2 ---------- 5
3/16 - 1/4 ---------- 4
1/8 - 3/16 ---------- 3
1/16 - 1/8 ---------- 2
5/64 - 3/32 ---------- 1
3/64 - 5/64 ---------- 0 (The zero tip is called an “aught")
1/32 - 3/64 ---------- 00 ("double aught")
1/64 - 1/32 ---------- 000 ("triple aught")

Striking Torch

Always use a striker (flint on steel)

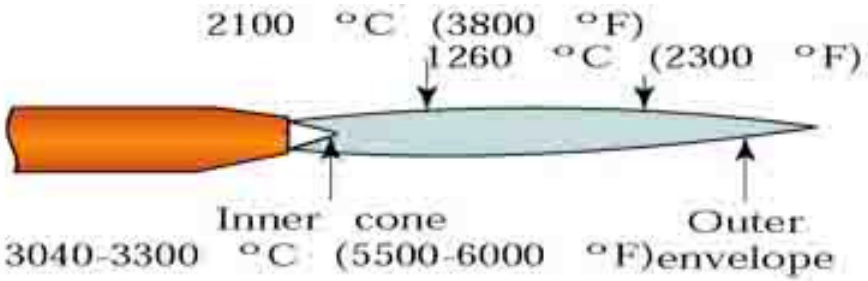
ONE at a time

Acetylene first
-1/8 turn of torch valve
- Use Striker
- will be smoky
- rooted, or attached to end of torch
- adjust for about 1 inch of straight flame

O2
- crack valve slowly
- bring down to neutral flame (blue cone – neutral flame)

-Carburizing/reducing flame, dual cone for some brazing, less oxygen
-Oxidizing flame, more oxygen, hiss or roar, lots of sparks, rarely used

Neutral Flame



Reducing Flame

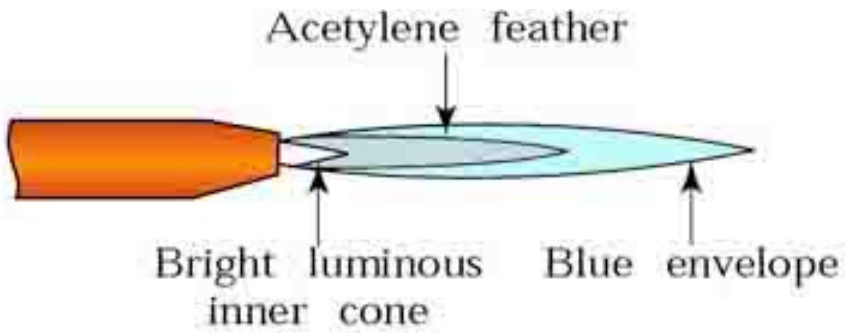


Figure 2: Carburizing Flame

Oxidizing Flame

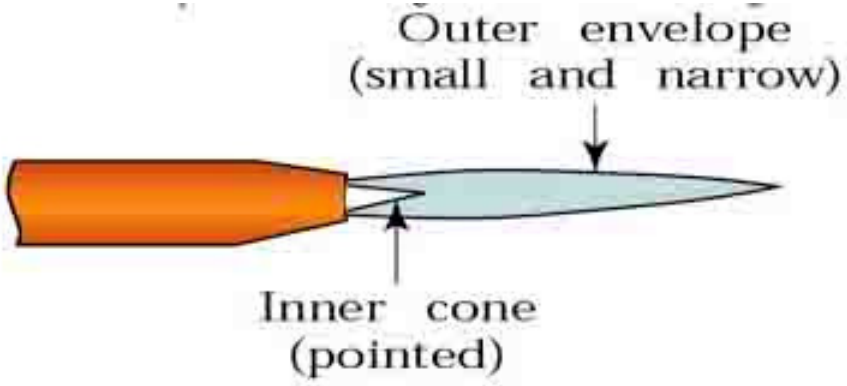


Figure3: Oxidizing Flame

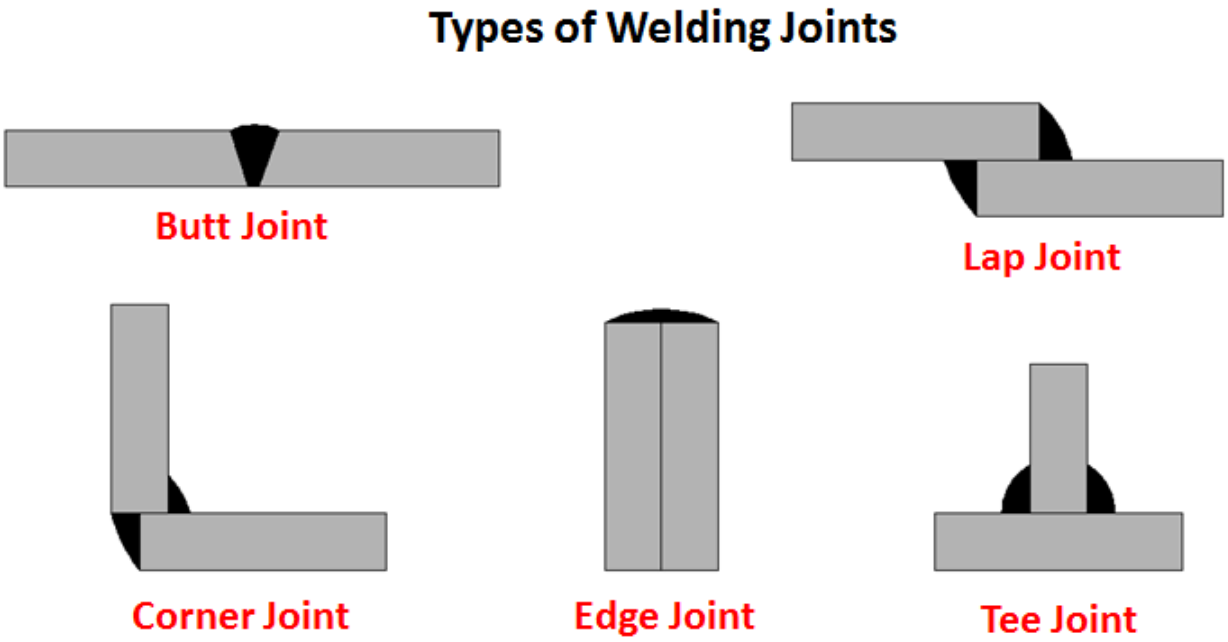
Turning off

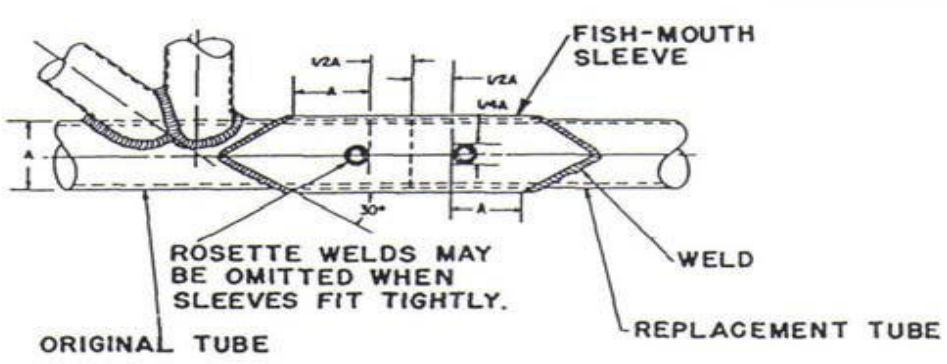
Torch
O2 First
Then Acetylene

Close cylinder valves

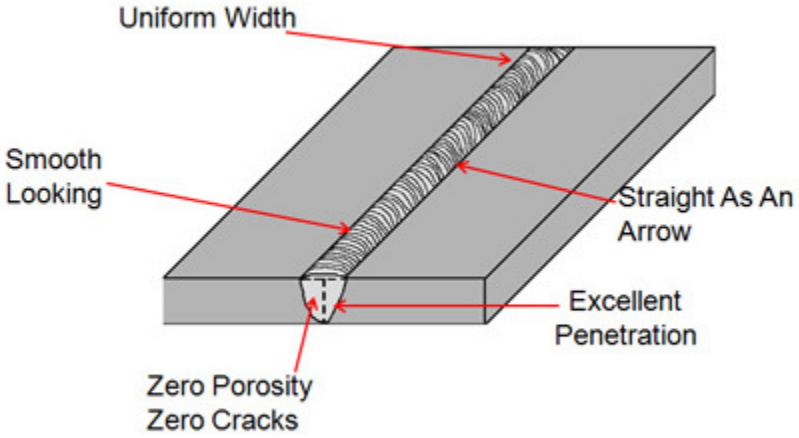
Bleed pressure from lines *One at a time*
Open regulators (valves counter-clockwise)

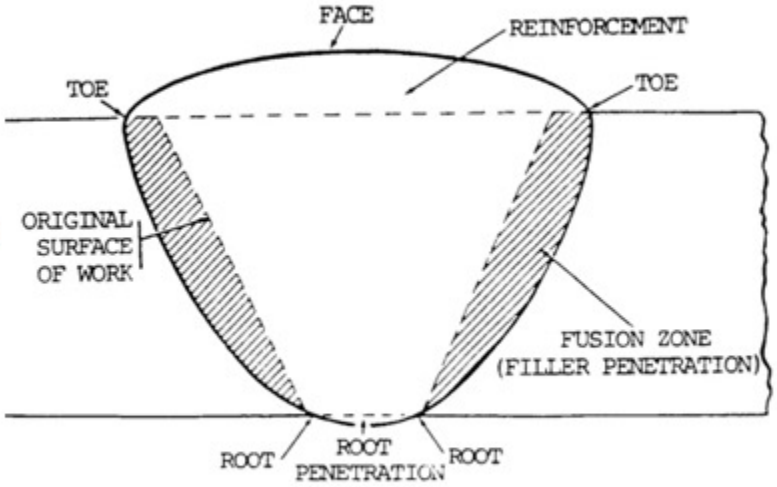
Types of Joints



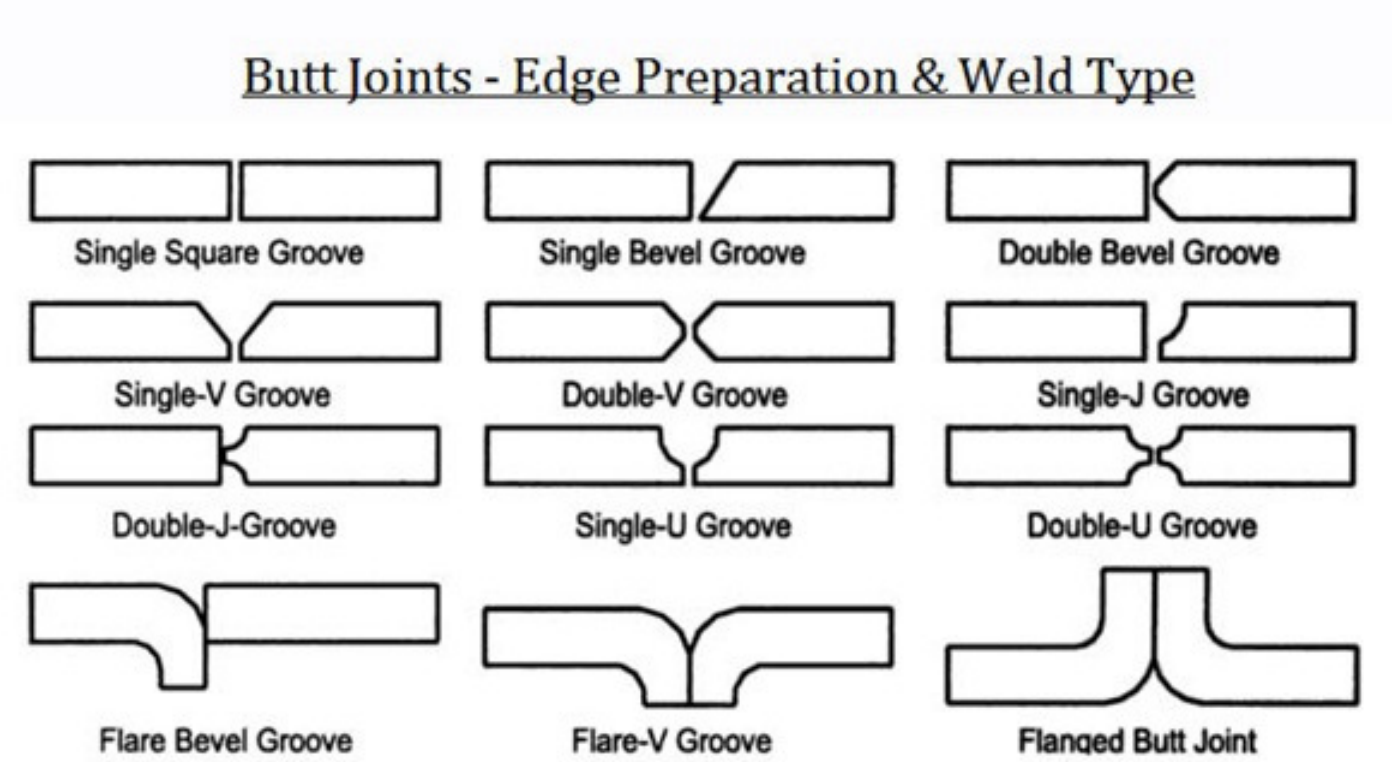


Good Welds

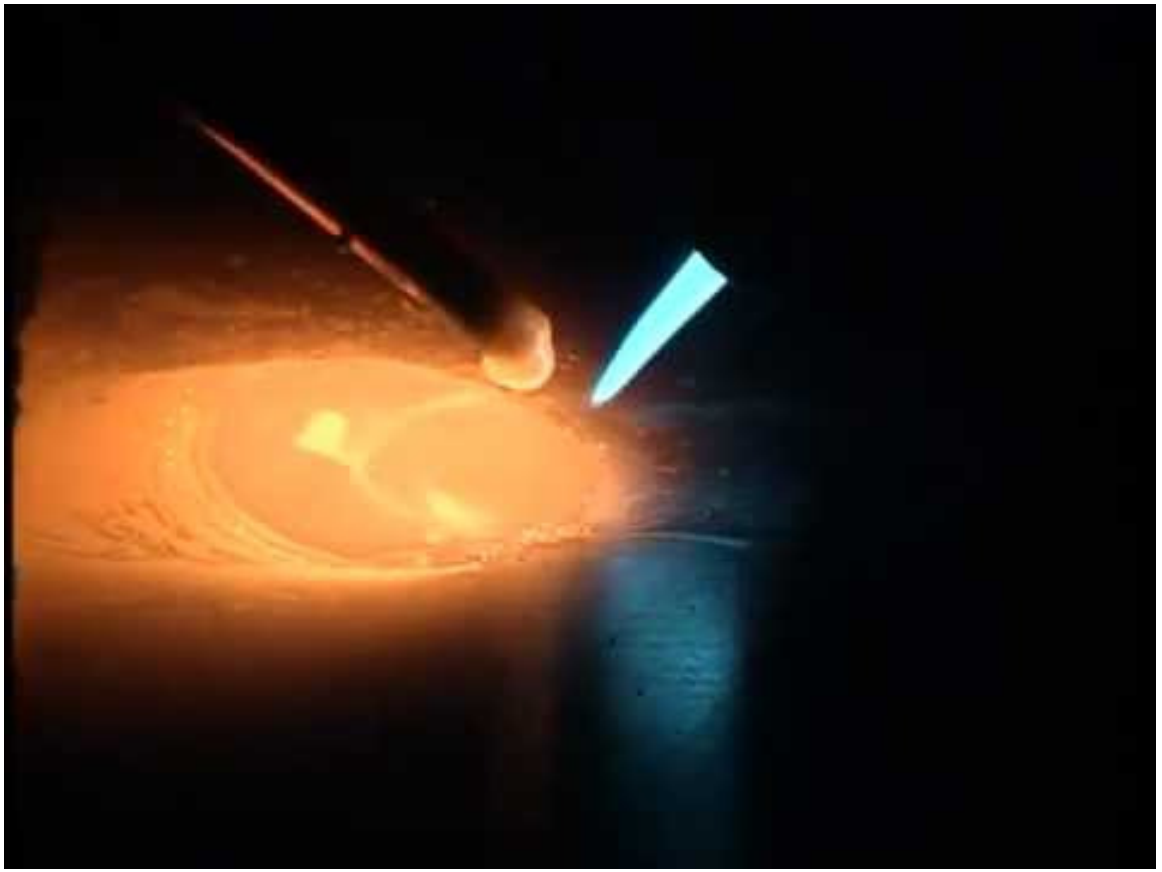

Uniform Width
Smooth Looking
Straight As An Arrow
Excellent Penetration
Zero Porosity
Zero Cracks


FACE
REINFORCEMENT
TOE
TOE
ORIGINAL SURFACE OF WORK
FUSION ZONE (FILLER PENETRATION)
ROOT
ROOT PENETRATION
ROOT

Weld Preparation



The Puddle



Filler Rod

Types (Match to material being welded)

Names similar to Mig Wire

ER70S-2 (**ER**=cut length, **70**,000 psi, **S**olid, **-2** has titanium, zirconium and aluminum)

ER308 and ER308L - One of the most common welding rods, it's the choice for welding 304 stainless steel, which is widely used in manufacturing, as well as 200-series and other 300-series steels.

ER309 and ER309L - Used for welding dissimilar metals. Can handle higher heat than has good corrosion resistance.

ER316 and ER316L - Commonly used for pressure vessels, valves, chemical equipment and marine applications.

Filler Rod

Carbon steel welding rods have a copper coating to prevent rusting and oxide build-up. The AWS classification for these products is pretty straightforward. Most welders use RG-45 or RG-60 rods. Here's what the designation means:

RG - Rod Gas

45 - tensile strength times 10,000 = 45,000 PSI

RG-65 is a less commonly used, low-alloy rod designed for high speed fusion welding of pressure vessels, tanks and piping.

Cutting Torch

Used to cut metal (not for thin sheet metal)

Uses an oxygen jet to oxidize (burn off) metal
Heat of the burning metal keeps the cut going

Makes lots of molten metal slag

Red is Acetylene
Green is Oxygen
3rd knob on torch is for O2 heater flame adjustment.
Lever turns on O2 jet

Use the heater flame to get a thinner part of the metal hot and then start the cut

Rosebud

Used for heating metal

Usually as preheat for welding

Or

To get metal hot in advance of bending, forming, forging.

Arc

Operation	Electrode	Current	Minimum
Shielded metal arc welding SMAW or Stick	Less than 3	Less than 60	7
	3 - 5	60-160	8
	5 - 8	160-250	**10**
	More than 8	250-550	11
Gas metal arc welding and flux cored arc welding GMAW or MIG		Less than 60	7
		60-160	10
		160-250	**10**
		250-500	10
Gas tungsten arc welding GTAW or TIG		Less than 50	8
		50-150	8
		150-500	**10**
Plasma arc cutting	(Light)**	Less than 300	8
	(Medium)**	300-400	**9**
	(Heavy)**	400-800	10
Torch brazing			**3**
Torch soldering			**2**

UV

Arc welding produces a lot of UV (Ultra-Violet Rays)
Same ones that give you sunburn

Except

It will be the worst sunburn you ever had and it will happen very quickly (single digit minutes)

Sunburned eyes are no fun at all and can cause blindness.

Ground

This is critical for ALL Arc welding.

It is the return path for the electrical current.
Usually connected to the work or the metal table upon which the work is located

Shiny surfaces make good grounds

You do not want to become the ground path.
Can be deadly.

(Oh, and stay out of the insides of the welders. Voltages and currents inside the box are absolutely deadly.)

Any ARC Welding

Importance of Ground

Ground to the item if possible
Ground to metal table is next best – expect sticking.

Includes Plasma cutting

Eye Protection

Operation	Electrode	Current	Minimum
Shielded metal arc welding = Stick = SMAW	Less than 3	Less than 60	7
	3 - 5	60-160	8
	5 - 8	160-250	**10**
	More than 8	250-550	11
Gas metal arc welding and flux cored arc welding = GMAW - MIG		Less than 60	7
		60-160	10
		160-250	**10**
		250-500	10
Gas tungsten arc welding = GTAW = TIG		Less than 50	8
		50-150	8
		150-500	**10**
Plasma arc cutting	(Light)**	Less than 300	8
	(Medium)**	300-400	**9**
	(Heavy)**	400-800	10
Torch brazing			**3**
Torch soldering			**2**

Stick Welding SMAW

Buzz box or Tombstone Welder
Uses a coated electrode

You will need a chipping hammer (not pounding) to chip of the slag (remains of the electrode coating) between weld passes.

MIG GMAW

How it works
Don’t step on the cable
Liners
Wire sizes
Gas shielded
Automatic filler rod

Nozzle dip
MIG Pliers – special
Stick out

Point and shoot

Shielding Gasses

Protect the weld from oxidizing (and nitrogen and hydrogen – embrittlement)

Argon (great general choice)
Helium (expensive, hot arc, higher flow rate, high current applications)
CO_2 (runs hot, inexpensive, less stable arc)

Mixtures – We have Argon/CO_2

Al, Ti – use pure argon

Sometimes a fixture is used to supply shielding gas to the back side of a weld.

MIG GMAW Wire

Types - e.g. ER70S-6

ER - Electric Rod
70 - This two or three-digit number represents the minimum tensile strength of the weld metal, measured in pounds per square inch (PSI) multiplied by 1,000.
S - Solid wire.
6 - This number (with sometimes a letter added) indicates chemical additives used in the wire which may effect the polarity setting on the machine.
The 6 in this case indicates more deoxidizers have been added to the wire, which is helpful when welding on dirty or rusty steel. The other general purpose carbon steel wire type is ER70S-3. This one doesn't have the added chemicals, so is used primarily on new or clean steel.

The most commonly used aluminum MIG wires are ER5056, a soft wire with good ductility, and ER5356, which is harder and has a high tensile strength.

Stainless steel MIG wire includes designations like ER308, ER316 and ER308-L. The L stands for low carbon, which provides extra corrosion resistance.

Fluxed

Aluminum – Uses spool gun

MIG GMAW Gasses

Typical Welding Parameters of Mild & Low Alloy TIG, MIG					
Process	Diameter of Wire		Voltage (V)	Amperage (A)	Shielding Gas
	Inches	Millimeters			
TIG (GTAW)	.035	0.9	10 – 12	50 – 70	100% Argon
	.045	1.14	10 – 12	70 – 100	
	1/16	1.6	12 – 15	100 – 125	
	3/32	2.4	15 – 20	125 – 175	
	1/8	3.2	15 – 20	175 – 250	
MIG (GMAW) Spray Transfer	.035	0.9	28 – 32	165 – 200	98% Argon + 2% Oxygen or 75% Argon + 25% CO^2
	.045	1.14	30 – 34	180 – 220	
	1/16	1.6	30 – 34	230 – 260	
MIG (GMAW) Short Circuiting Transfer	.035	0.9	22 – 25	100 – 140	100% CO^2
	.045	1.14	23 – 26	120 – 150	75% Argon + 25% CO^2

MIG FCAW Wire

Flux-Cored Wire

Using "cored" wire allows a MIG welder to skip the tank of CO2 or argon and weld without the gas. That's because the wire core contains ingredients that do the job of shielding the weld pool. This is particularly helpful when welding out of doors, since a stiff breeze is enough to disperse a compressed gas. The process is formally known as Flux-Cored Arc Welding (FCAW).

Designations get complex. I.e. E71T-1C JH8

(Electrode 70,000 tensile, all position, tubular, rutile slag, CO2 gas, less than 8ml of H2 per 100g)

MIG GMAW Wire

Polarity is DC
May require reversing for flux coated or core wire

DCEP Direct Current Electrode Positive
DCEN Direct Current Electrode Negative

MIG GMAW Wire

Fast
Easy (maybe too easy)

Spatter
Clogs nozzle and messes up shielding gas flow

GTAW TIG

Uses a tungsten electrode in a holder that supplies a gas lens (shielding gas).

Draws an electric arc

Arc is controllable with a foot pedal

Much like torch welding except using an arc as the heat source.

Usually need a filler rod

Tungsten Electrodes

GTAW – TIG welding

Pure tungsten does not work really well
Doped with rare earth elements to help
Many are radio-active
Thorium is very popular
Emits Alpha particles (helium nucleus)
Generally not a problem outside the body
But, Dust from grinding could be deadly if it gets in your lungs. Wear a mask, ventilate.

Consider Zirconated, Lanthanated, Ceriated alternatives

Tungsten Electrodes

Tungsten Electrode Selection Chart

Tig Mode	Tungsten Type	Colour
AC	Pure	Green
DC or AC/DC	Ceriated 2%	Grey
DC or AC/DC	Lanthanated 1%	Black
DC or AC/DC	Lanthanated 1.5%	Gold
DC or AC/DC	Lanthanated 2%	Blue
DC	Thoriated 1%	Yellow
DC	Thoriated 2%	Red
AC	Zirconiated 1%	White

GTAW Steel vs Aluminum

Steel
DC polarity

Aluminum
AC polarity
Argon shielding gas

Plasma Cutting

So much nicer than Oxy/Acetylene
Is an ARC process
Uses 'DRY' air and and electric arc to make a VERY hot plasma stream. **45,000°F**

Has a very thin 'kerf'
Very little slag and easily removed
Typically start cuts at an edge, but can pierce (there's a technique)

Still makes lots of sparks.

Ground is very important -

Please ask Questions

If you are not sure – Ask

Stewards are here to help you make better welds (but not to do the welding for you)

There are special techniques and materials for special circumstances.

Steel vs Aluminum

Steel
As it gets hot it changes color and forms a visible puddle (small spot of molten metal) – a visual clue to how hot it is.

Aluminum
As it gets hot it does not change color and the puddle is more difficult to see – just 'all of a sudden' melts.

Biggest problems

Gas welding – not enough / too much heat
    Incorrectly adjusted flame

MIG Welding – torch too far from work
    Weld just 'laying on top of the metal' (poor penetration)

TIG – dipping the electrode – sharpen a handful

Running out of shielding gas

Welding your work to the welding table

Picking up *hot* parts

Be Safe

Be Safe.

Be Careful.

Equipment

Lincoln Electric has kindly donated a wonderful set of modern quality equipment to our welding shop.

If your are considering purchase of an arc welder or plasma cutter, I can recommend Lincoln as a world class solution.