MIG Welding

Outcomes

1. Learn the basics of MIG Welding
    1. Hoses
    2. Regulators
    3. Cylinder storage
    4. Setting the flow regulator
    5. Selecting Amperage and Wire Feed Speeds
    6. Butt Joint
    7. Outside Corner Joint
    8. Tee Joint

We will cover

- **Safety Equipment**
- **MIG Welding**
- **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

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)
No 'inclusions' – non-metalic stuff, carbon, slag, bubbles, or other foreign materials in the weld.

Rusty metal makes lots of sparks and poor welds – rust gets combined in the weld. Rust is not strong.

Welding

Getting material clean.

Mill Scale – impurities that come to the surface when the metal is made.

Remove, rust, impurities, mill scale, oil, paint, platings, coatings.
(Be aware removing paint – may contain lead.)

When using silicon carbide – wear a dust mask !

Protective Gear

Clothing, cotton (Man made fabrics. Polyester, rayon, nylon, melt and stick to you)
Gloves (stuff is hot) Typically lighter than gas welding gloves
Long sleeves
Long pants
Shoes
Goggles / helmet
Head cover or Do Rag

Special welding garments

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) Pot metal is not MIG weldable.

Welding Space

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

Typically your vision may be somewhat blocked by goggles or a hood, you may not be aware of a fire.

Protecting Others

MIG welding – bright arc light, flying sparks
Plasma cutting – Lots of flying sparks

Let people around you know what is going on. Let folks know you are striking an arc. Give them a chance to move to a safe area and shield their eyes. (Tell them to move if they don't take the hint.)

Pets. A cat or dog will stare at the arc until they go blind. Protect their vision. Move them out of sight of the welding operation.

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.

For MIG welding, use a welding hood (full face coverage).

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**

MIG GMAW

How it works

Feeds filler wire that also carries welding current through a gas shield

Wire comes from a roll inside the machine

2 controls – Power and wire feed speed

Make sure you have a good ground
Don’t step on the cables
No sharp bends or kinks in the welding cable
Liners

MIG Pliers – special

Point and shoot

MIG GMAW

How it works

Short Circuit – wire carrying current touches material, gets very hot and melts both base material and wire.

Globular deposition – molten glob forms on end of wire and is moved to the base metal. Heat of glob melts material together.

Spray Transfer – Arc vaporizes wire before it gets to the base metal forming a spray of very hot liquid metal. Melts the base material. Needs special gun. Heavy material. More stick out. Flat and horizontal.

MIG Arc Temperature

Air is not a good conductor of electricity.

Arc jumps between electrode and the material to be welded in ionized gas. Arc is started by the current from the welder, through the wire, short circuiting and melting (vaporizing) the wire.

Temperature between 3,000° and 20,000° C
(5,400° F to 36,000° F)

Fume Extraction

Extract the fumes or provide lots of ventilation.

Fume extractors
Fans
The great outdoors

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 and pure Argon (For Aluminum).

Al, Ti – use pure argon

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

Flow of gas shields the weld through the 'gas lens' of the welding gun nozzle. Use about 20 CFH (cubic feet per hour) of gas flow

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 Welder

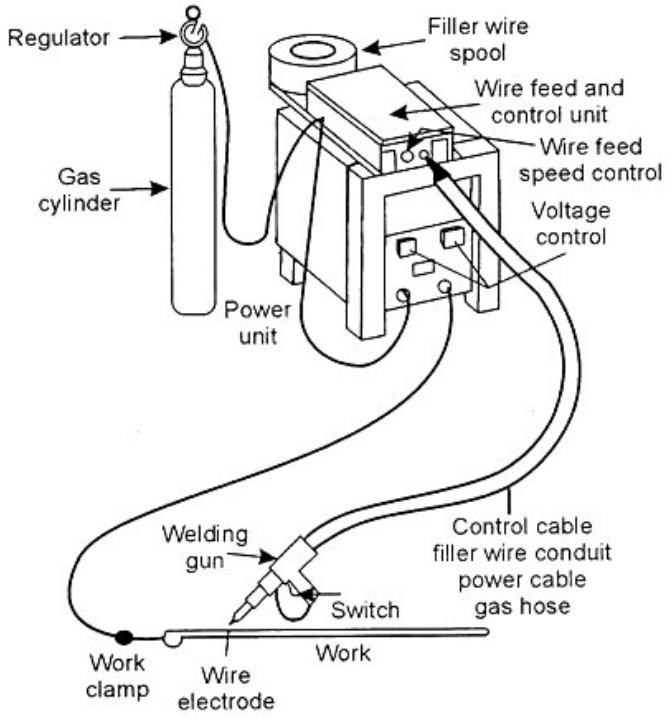


Fig. 27.1 Components of Gas Shielded Metal Arc Welding Process

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 – assumes your item has a metal to metal connection to the table (i.e. cannot be laying on an insulating surface – like a fire brick)

Includes Plasma cutting

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 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

Polarity is DC (Direct Current)
May require reversing for flux coated or core wire

DCEP Direct Current Electrode Positive – most common
DCEN Direct Current Electrode Negative

AC (Alternating Current – not recommended)

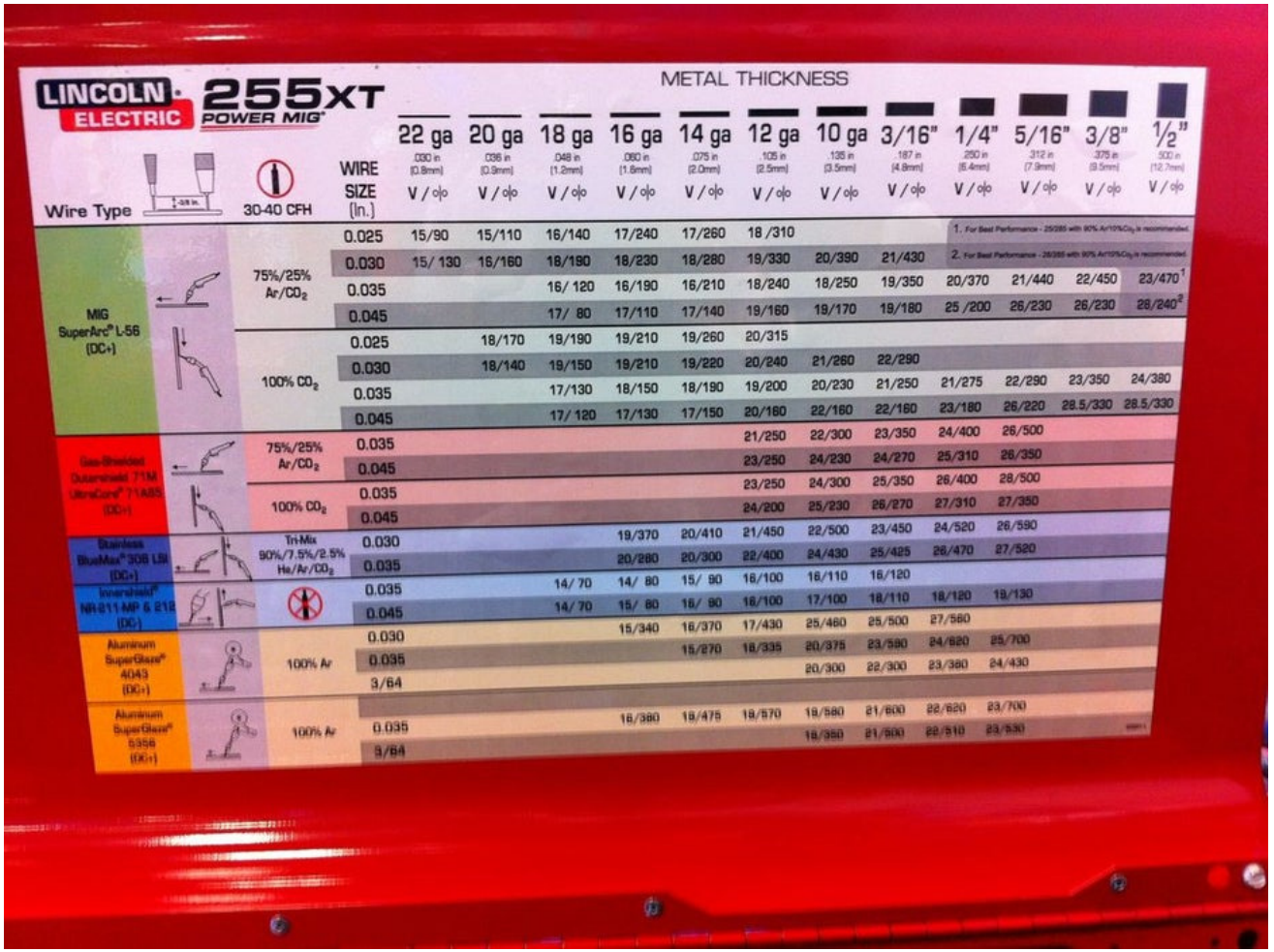
MIG GMAW Wire

Wire comes in various diameters. Larger wires, larger welds. 0.025” 0.030” 0.035” 0.040”
Use drive wheels and tips that match the wire size

Fast
Easy (maybe too easy)

Spatter
Clogs nozzle and messes up shielding gas flow
(Nozzle dip or spray helps to prevent sticking)

MIG GMAW Wire



MIG GMAW Wire

LINCOLN ELECTRIC 255XT POWER MIG

Wire Type		30-40 CFH	WIRE SIZE (In.)	22 ga .030 in (0.8mm) V / o/o	20 ga .036 in (0.9mm) V / o/o	18 ga .048 in (1.2mm) V / o/o	16 ga .060 in (1.6mm) V / o/o
MIG SuperArc® L-56 (DC+)		75%/25% Ar/CO_2	0.025	15/90	15/110	16/140	17/240
			0.030	15/ 130	16/160	18/190	18/230
			0.035			16/ 120	16/190
			0.045			17/ 80	17/110
		100% CO_2	0.025		18/170	19/190	19/210
			0.030		18/140	19/150	19/210
			0.035			17/130	18/150
			0.045			17/ 120	17/130

Stick Out

How much wire between the nozzle and the work.

Should be 3/8 to 1/2 inch.

Use MIG pliers to trim to length before starting the weld

The MIG Weld

Tends to be more ‘proud’ than gas or TIG welding due to the constant feed of wire into the weld puddle.

Inspection

Check the equipment for problems before you start.
General inspection
Valves work, connections tight
Hoses, no cracks, general condition
Gas cylinders, damage, upright, constrained
Regulators, connections tight
Hood lenses clean and in good shape, and adjusted for your head

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. Elbows in.

Welding uses lots of small moves and fine motor control

Arrange the hose so it is not pulling on the gun or uncomfortable.

Place welding on a suitable surface. Fire bricks are good. A welding table (avoid welding to the table).
Concrete is not a good welding surface (H2O expands).
Confirm good ground.

Make a dry run – move the MIG gun along the weld path to be sure nothing binds up and that you have good access to the joint.

Cylinders

Keep upright (If laid down allow 30 minutes upright before using)

Cylinder cap when not in use

Argon CO2 (25% CO2, 75% Argon) 1,500 psi

Argon 2,640 psi

Secure tanks with chain.

Regulators

Remove protective cap
Visually Inspect
Look for any contamination on or in the gas outlets of both the bottle and regulator
Gauges should be up at slight angle.
Be sure regulator flow control valve is all the way open
Don’t stand in front of regulators when opening valve.

Flow rate is in CFH (Cubic Feet per Hour)

Typical is 20- 25 CFH

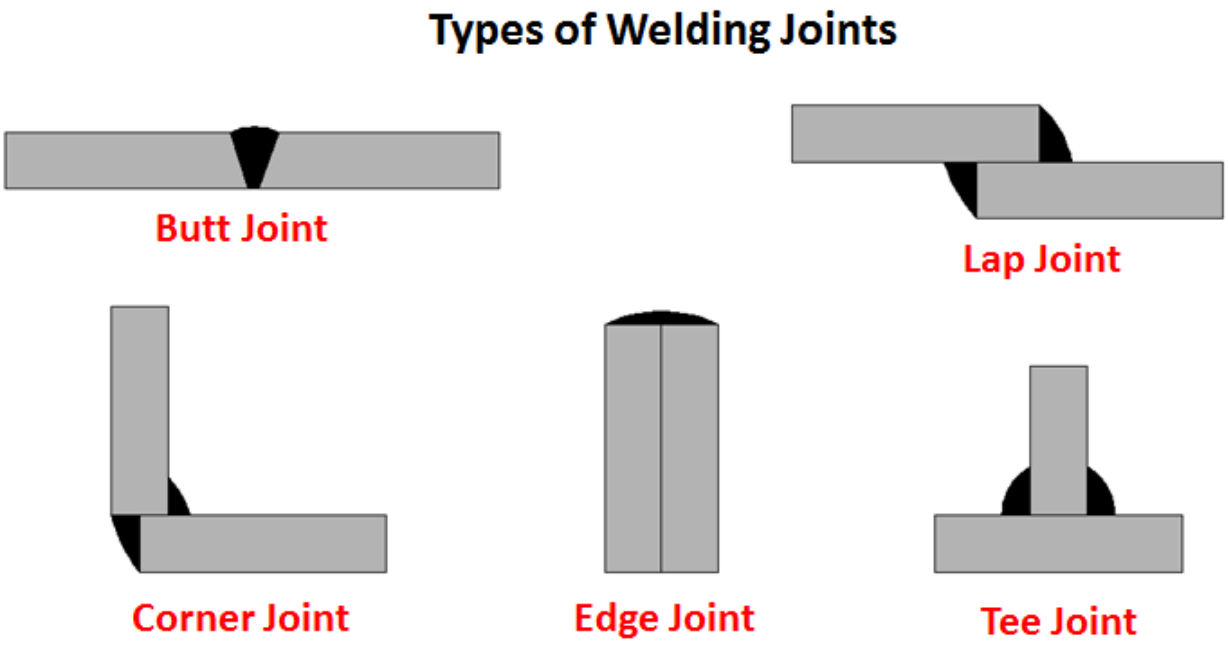
Too low a flow results in a porous contaminated weld.
Too high a flow wastes gas.

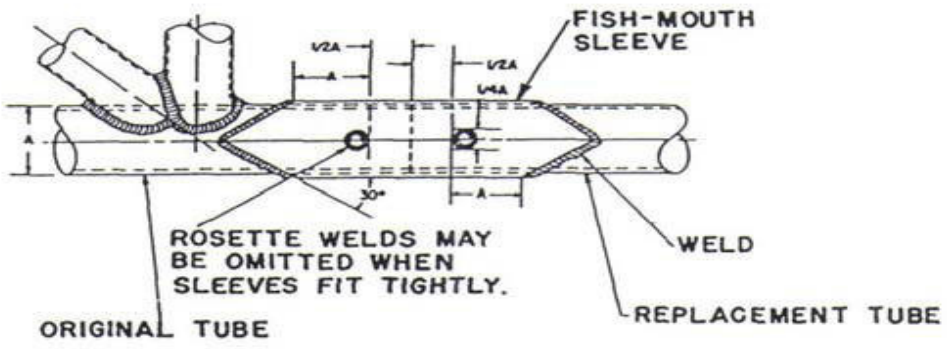
These are all dry connections. (No oil, grease, pipe dope, Teflon tape, etc.)

Regulators

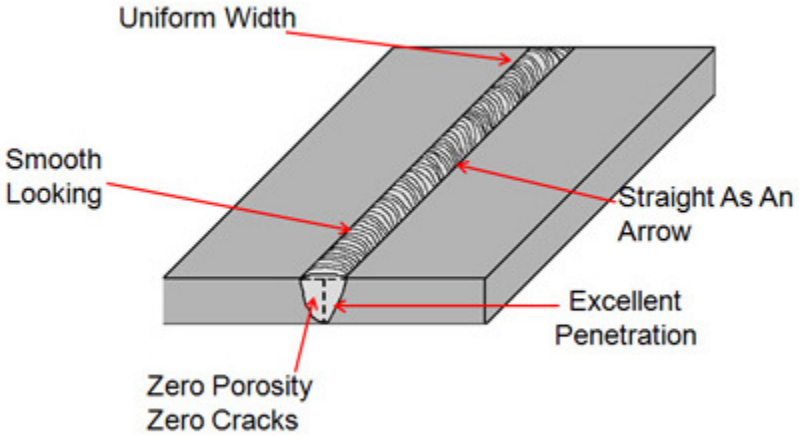
MIG Gun Nozzle Size Inside Diameter	Minimum Suggested Flow	Typical Flow Setting	Maximum Suggested Flow
3/8 inch (For Access on Small Welders)	15 CFH	18-22 CFH	~ 30 CFH
1/2 inch (Typical on Small Welders)	18 CFH	22-27 CFH	~ 40 CFH
5/8 inch (Most Industrial Welders)	22 CFH	30-35 CFH	~ 55 CFH
3/4 inch (For Large Size Cored Wire)	30 CFH	30-40 CFH	~ 65 CFH

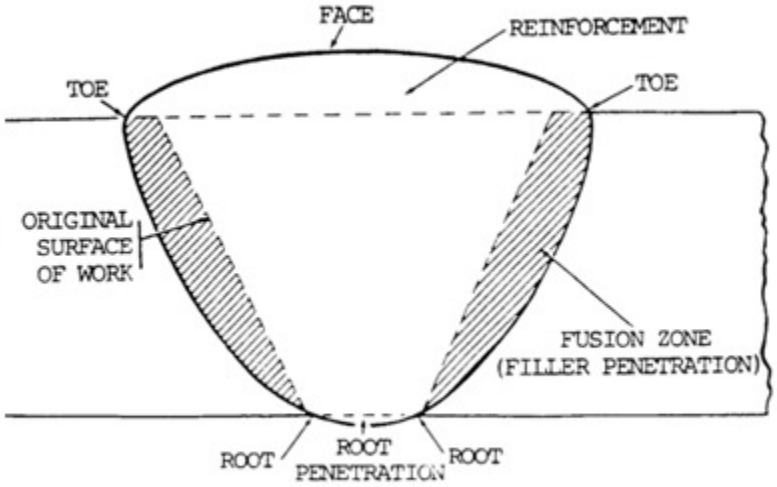
Types of Joints



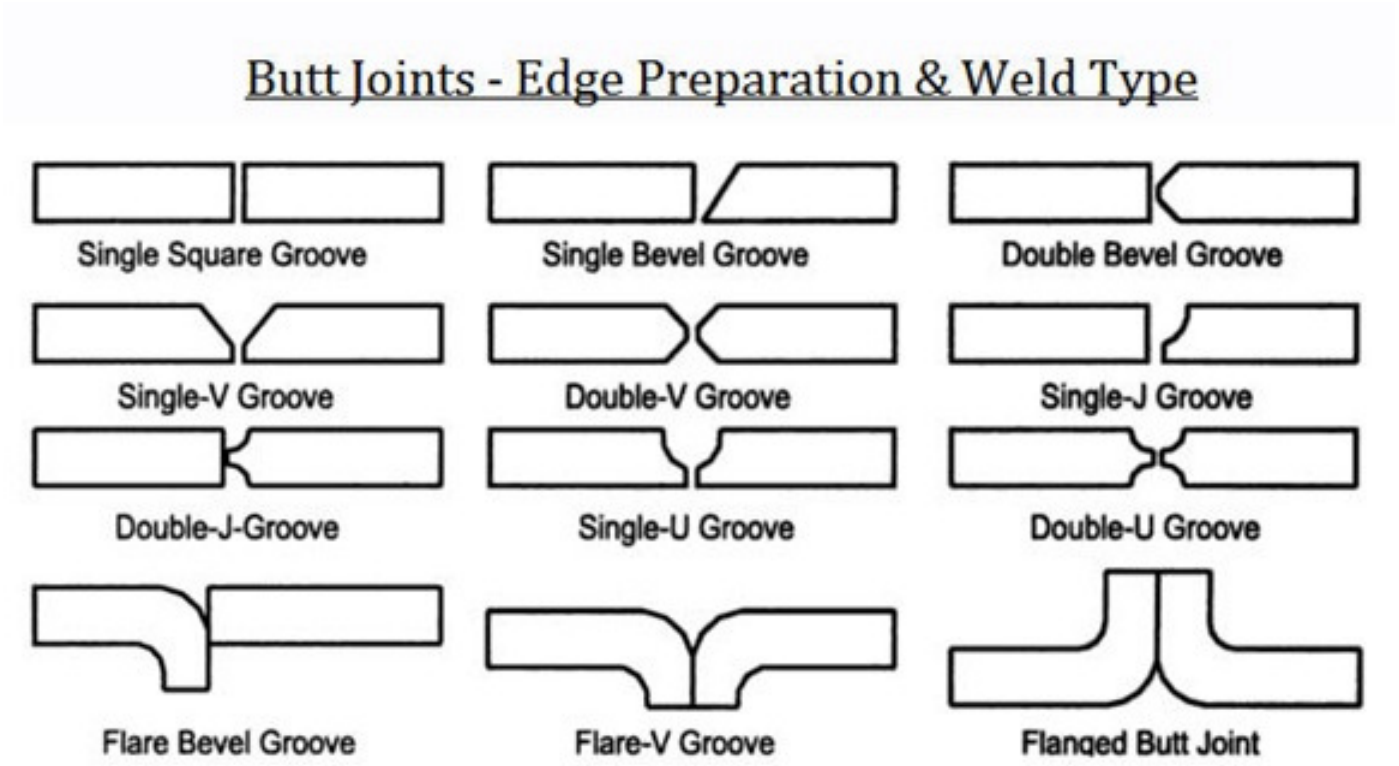


Good Welds


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

Pull vs. Push

Pull – narrower weld

Push – wider weld

Whichever – be sure you can see the puddle

See the puddle melting into the material

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 –

(vid Weld 1)

Tacking

Tacking is making small welds around the piece to hold the pieces in position while the welding is done.

You are using lots of heat and metal expands quite a bit when heated.

The ‘tack’ welds hold everything in alignment and helps prevent warping.

Spatter

Particles of molten metal that are thrown out of the weld seam

Tends to build up inside the gun gas shield and can disturb the shielding gas lens (flow)

Excessive spatter – are you running out of shielding gas?

Nozzle spray or Dip helps to prevent and makes spatter easy to remove (For the gun only – don't put on material to be welded)

Spatter

Spatter

Aluminum

A spool gun is used for Aluminum

Spool of wire is located at the gun end instead of inside the machine

Must use pure Argon gas

Suitable for heavier aluminum (1/8 inch or more)

Coupons

We will make 3 welding ‘coupons’ (these are just sample test welds). Butt joint, outside/inside angle, and a tee joint.

Cutting your material

Cut 6 5-6 inch (or so) pieces using a plasma torch

Running your first bead

2 pieces of flat side by side.

Look for consistent width and height

Try to go in a straight line

Wait for the puddle to form

Just get used to the equipment

Adjust your welding position as needed

Your next Joint

Use 2 pieces of metal and a couple of magnets to make a piece of angle

2 pieces together, one slightly overlapping the other

'Tack' (weld it together a little at each end – this will hold the pieces together as you weld)

Remove the magnets

Weld the joint by moving the puddle along the joint

Flip over and weld the inside joint

(vid weld 1)

Third Coupon

A Tee Joint (a little more challenging)

Position material, tack, and weld

Weld both sides

(vid weld 2)

Tips

Puddle too hot

Metal drips through – holes form

Too cold

Weld material just laying on top, no fusion.

When welding a thick piece to a thin piece, concentrate the heat more on the thick piece.

To fill a hole, work from the edge in, jump around, don't try to fill the hole all at once from one side.

Listen to the sound (referred to as ripping fabric or frying bacon)

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.

There’s a lot more to learn.

Biggest problems

Machine not set up correctly.

Not enough / too much heat (amperage)

Wire feed too fast or too slow

Too far from material (too much Stick Out)

Dirty materials

Poor penetration (weld just laying on top of material)

Welding your work to the welding table

Running out of shielding gas

Picking up ***hot*** parts

Be Safe

Be Safe.

Be Careful.

How do I get independent access to the Welding Shop?

At a future date you must find one of the welding shop stewards and prove Proficiency

You must show that you know the safety guidelines and equipment, how to turn on the shielding gas, adjust the flow, turn on the machine, set it for a particular material, perform a short test weld, and shut down the machine

You must also know where the fire extinguisher is (this is a pass/fail question)

Videos

https://www.youtube.com/watch?v=7_T2VVCnVl8

https://www.youtube.com/watch?v=Xod-ByrxHg4

Equipment

Lincoln Electric has kindly donated a wonderful set of modern superb 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.