TIG Welding

My experience and thoughts about TIG welding.

Contents

Recommended Reference Material for Beginners

TIG Welding Tips for Beginner and Intermediate Welders | MillerWelds

How to Solve 10 Common TIG Welding Problems [Guide] | MillerWelds

TIG Welding Mistakes - When To Troubleshoot - Welders Manual

Argon Tank Sizes for MIG or TIG Welding (welditmyself.com)

Arc Welding Fundamentals (lincolnelectric.com)

Everything You Need to Know about TIG Filler Rod! Eastwood - Bing video

TIG Welding Aluminum: The #1 GUIDE For Beginner [2021] (vietmfg.com)

How to TIG Weld Aluminum part 1 - Bing video

AC Frequency Settings for TIG Welding Aluminum - "How to Tig Weld Aluminum" part 3 - Bing video

Aluminum Tig Welding: Setting AC Balance - Bing video

IMPORTANT – not all material on the web is correct – when in doubt trust your welder manual.

Recommendations from Experience

1. Wearing some sort of mask is NOT optional. No mask causes your visor to fog up.
2. Clamp both sides of material when cutting with a miter/chop saw for safety.
3. Clean the electrode tip early and often.
4. Don't breathe the electrode tip grinding dust.
5. Use a tungsten stick-out gauge – don't eyeball it.
6. Use AC welder setting for aluminum.
7. Consult your welder manual and use the lowest recommended cleaning setting.
8. Check your gas lines for leaks after replacing the gas cylinder.
9. Use the Miller Electric TIG calculator tool to determine all the correct settings.
10. Or, if you don't have the calculator then:
    a. Use the correct electrode diameter & cup size based on your material thickness.
    b. Use the correct argon flow rate for your electrode & cup size.
    c. Use the correct filler rod for your material.
    d. Use the weld type chart amperages – don't guess.
11. Only press the pedal partially until cleaning is done, then fully press it down to start the weld.
12. Don't go overboard buying fancy fixtures, a basic table works for most welds.
13. Practice, practice, practice.

Las Vegas Recommended Welding Supplier

After calling around several suppliers I found that these guys were the most responsive and reasonable for DIY welders. This was not an extensive search so there may be better places, but this one is at least friendly, knowledgeable and reasonable prices.

Linde Welding Gas & Equipment Center

4260 W Tompkins Ave
Las Vegas, NV 89103

(702) 252-7877

Las Vegas Welding Gas Supply & Industrial Equipment | Linde 70206 (lindedirect.com)

Store hours: 7am-4pm M-F

Pricing: 80cf argon tank $413 to purchase tank (12/28/2022) - $389 on Amazon

$61+tax to refill an 80cf argon tank.

Recommended Material Supplier

Use **Online Metals** – Great Selection and Web Site

Most everything at Online Metals is cheaper than Lowes (even when you add in their shipping charge) and they have an awesome web site that is a joy to use.

A 6' ¾" carbon steel angle A36 hot rolled bracket is $9.02 at Online Metals, and the "same?" hot rolled steel at Lowes is $18.98 (but Lowes doesn't specify the alloy.) Even when I tracked down the Hillman manufacturer's web site for this angle bracket, it still didn't specify the alloy! This is another example of Lowes crappy web site.

Aluminum ¾" angle bracket 1/16" thickness – slightly cheaper at Lowes

For some bizarre reason Lowes is cheaper – BUT ONLY for 6' ¾" angle bracket: $11.38/piece (vs. $12.21 + shipping/piece at Online Metals) and Lowes has free shipping on orders over $45 as long as you don't order anything over 6' in length (then there is a $79 shipping charge.)

So **for this specific bracket** you can save money at Lowes – but it is barely worth it as their web site is hard to use and their packaging is absurdly oversized – you end up with more cardboard box than metal!

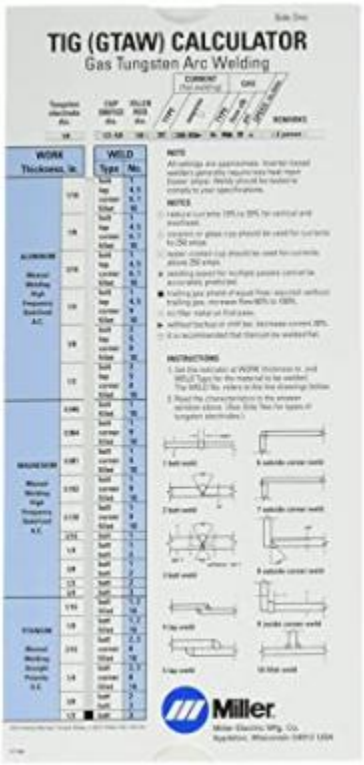
When you are dealing with a professional metal supplier, you will need to know a little about how the different types of metal are designated in order to make an informed purchase. This website gives you the basic information needed: Aluminium alloy - Wikipedia.

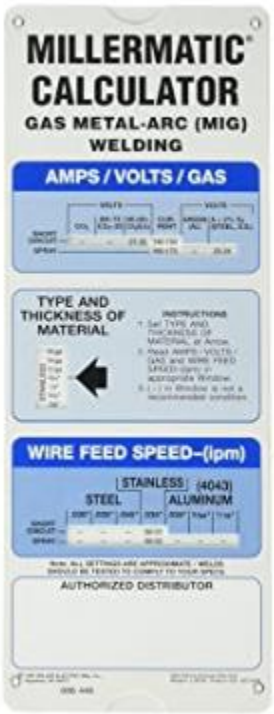
Useful Charts and Tables

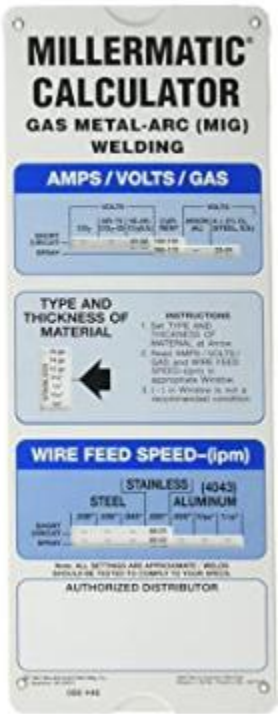
Handy Calculator Tool

The tables below are very useful, but the best thing (I didn't find it at first) is to get the Miller Electric TIG/Stick calculators. These cover basically everything in all of the tables below and are much easier to use. You just slide the card to your material type, thickness, and joint type and it gives you all of the correct setup parameters.

[Amazon.com : Miller Electric - 043125 Package Calculator : Welding Wire : Office Products]







Tungsten Electrode & Filler Rod Selection

Tungsten Electrodes for GTAW - Selection Guide

Base Alloy	Thickness	Current	Electrode
Aluminum	All Thick Thin	ac dcen dcep	Pure, Zirconium Thoriated Thoriated, EWZr
Copper and Copper Alloys	All Thin	dcen ac	Thoriated Pure, Zirconium
Magnesium Alloys	All Thin	ac dcep	Pure, EWZr, Thoriated
Nickel and Nickel Alloys	All	dcen	Thoriated
Plain Carbon and Low-Alloy Steel	All Thin	dcen ac	Thoriated Pure, EWZr
Stainless Steel	All Thin	dcen ac	Thoriated Pure, EWZr
Titanium	All	dcen	Thoriated

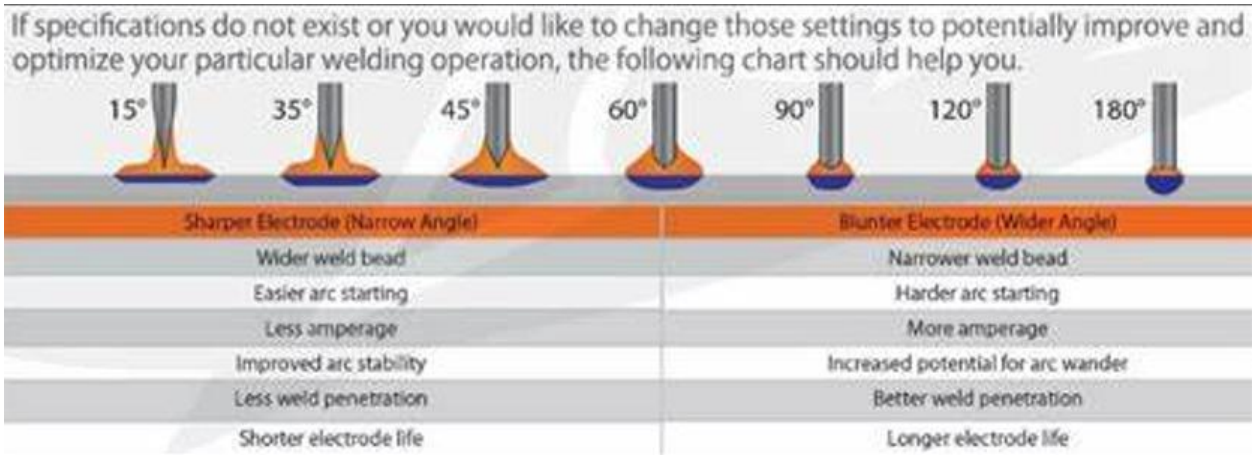
Filler Alloys for Welding of Wrought Aluminum Alloys

Base Alloy, Type	6070	6061 6030, 6101 6201, 6151 6351, 6951	5456	5454	5154 5254	5086	5083	5052 5652	5005 5050	3004 Alc. 3004	2219 2519	2014 2036	1100 3003 Alc.3003	1060 1070, 1080 1350
1060, 1070 1080, 1350	4043	4043	5356	4043	4043	5356	5356	4043	1100	4043	4145	4145	1100	1188
1100, 3003, Alcaid 3003	4043	4043	5356	4043	4043	5356	5356	4043	1100	4043	4145	4145	1100	
2014, 2036	4145	4145									4145			
2219, 2519	4043	4043	4043	4043	4043	4043	4043	4043	4043	4043	2319			
3004 Alcaid 3004	4043	4043	5356	5654	5654	5356	5356	4043	4043	4043				
5005, 5050	4043	4043	5356	5654	5654	5356	5356	4043	4043					
5052, 5652	5356	5356	5356	5654	5654	5356	5356							
5083	5356	5356	5183	5356	5356	5356	5183							
5086	5356	5356	5356	5356	5356	5356								
5154, 5254	5356	5356	5356											
5454	5356	5356	5356											
5456	5356	5356	5356											
6061, 6063, 6351, 6101,6201, 6151, 6951	4043	4043												
6070	4043													

Argon Flow Rates

Electrode Diameter in inches (mm)	Cup Size	ARGON FLOW - FERROUS METALS		ARGON FLOW - ALUMINUM	
		Standard Body CFH (L/MN)	Gas Lens Body CFH (L/MN)	Standard Body CFH (L/MN)	Gas Lens Body CFH (L/MN)
020 (0.50)	3, 4 or 5	5-8 (3-4)	5-8 (3-4)	5-8 (3-4)	5-8 (3-4)
040 (1.00)	4 or 5	5-10 (3-5)	5-8 (3-4)	5-12 (3-6)	5-10 (3-5)
1/16 (1.60)	4, 5 or 6	7-12 (4-6)	5-10 (3-5)	8-15 (4-7)	7-12 (4-6)
3/32 (2.40)	6, 7 or 8	10-15 (5-7)	8-10 (4-5)	10-20 (5-10)	10-15 (5-7)
1/8 (3.20)	7, 8 or 10	10-18 (5-9)	8-12 (4-6)	12-25 (6-12)	10-20 (5-10)
5/32 (4.00)	8 or 10	15-25 (7-12)	10-15 (5-7)	15-30 (7-14)	12-25 (6-12)
3/16 (4.80)	8 or 10	20-35 (10-17)	12-25 (6-12)	25-40 (12-19)	15-30 (7-14)
1/4 (6.40)	10	25-50 (12-24)	20-35 (10-17)	30-55 (14-26)	25-45 (12-21)

Electrode Grind Angles



Weld Currents based on Electrode, Weld Type and Material Thickness

TUNGSTEN ELECTRODE CURRENT RANGES

Tungsten Diameter in inches (mm)	Gas Cup (Inside Diameter)	TYPICAL CURRENT RANGE				
		Direct Current, DC	Alternating Current, AC			
		DCEN	70% Penetration		(50/50) Balanced Wave, AC	
		Ceriated, Thoriated, Lanthanated, LaYZr™	Zirconiated	Ceriated, Thoriated, Lanthanated, LaYZr™	Zirconiated, Pure, LaYZr™	Ceriated, Thoriated, Lanthanated, LaYZr™
.040" (1.0mm)	#6 (3/8")	15–80 amps	20–60 amps	15–80 amps	10–30 amps	20–60 amps
1/16" (1.6mm)	#6 (3/8")	70–150 amps	50–100 amps	70–150 amps	30–80 amps	60–120 amps
3/32" (2.3mm)	#8 (1/2")	150–250 amps	100–160 amps	140–235 amps	60–130 amps	100–180 amps
1/8" (3.2mm)	#8 (1/2")	250–400 amps	150–200 amps	225–325 amps	100–180 amps	160–250 amps

All values are based on the use of Argon as a shielding gas. Other current values may be employed depending on the shielding gas, type of equipment, and application. DCEN = Direct Current Electrode Negative (Straight Polarity)

Steel Thickness (mm)	Filler Rod (mm)	Tungsten (mm)	Practice beads / Closed root butt joint	Fillet joint	Open root butt joint (gap is half of material thicknesss) / Lap joint / Outside corner joint
			Amps	Amps	Amps
0.8	1.0	1.0 or 1.6 [1]	25	30	20
1.0	1.0	1.0 or 1.6 [1]	30	35	25
1.2	1.0	1.6	35	45	30
1.5	1.0	1.6	45	55	40
2.0	1.0 or 1.6 [2]	1.6	60	75	55
3.0	1.6	1.6	90	110	80

Note: 16 gauge Aluminum (0.0508") = 1.29mm, 1/8" = 3.17mm

Note: these numbers are for steel (not aluminum)

Aluminum Gauge & Tolerances (16 gauge & 1/8" highlighted)

Sheet Metal Gauge Guide				
Gauge	Steel (mm)	Galvanized (mm)	Stainless (mm)	Aluminum (mm)
3	0.2391 (6.07)	--	--	--
4	0.2242 (5.69)	--	--	--
5	0.2092 (5.31)	--	--	--
6	0.1943 (4.94)	--	--	0.162 (4.1)
7	0.1793 (4.55)	--	0.1875 (4.76)	0.1443 (3.67)
8	0.1644 (4.18)	0.1681 (4.27)	0.1719 (4.37)	0.1285 (3.26)
9	0.1495 (3.80)	0.1532 (3.89)	0.1563 (3.97)	0.1144 (2.91)
10	0.1345 (3.42)	0.1382 (3.51)	0.1406 (3.57)	0.1019 (2.59)
11	0.1196 (3.04)	0.1233 (3.13)	0.1250 (3.18)	0.0907 (2.30)
12	0.1046 (2.66)	0.1084 (2.75)	0.1094 (2.78)	0.0808 (2.05)
13	0.0897 (2.28)	0.0934 (2.37)	0.0940 (2.40)	0.0720 (1.80)
14	0.0747 (1.90)	0.0785 (1.99)	0.0781 (1.98)	0.0641 (1.63)
15	0.0673 (1.71)	0.0710 (1.80)	0.0700 (1.80)	0.0570 (1.40)
16	0.0598 (1.52)	0.0635 (1.61)	0.0625 (1.59)	0.0508 (1.29)
17	0.0538 (1.37)	0.0575 (1.46)	0.0560 (1.40)	0.0450 (1.10)
18	0.0478 (1.21)	0.0516 (1.31)	0.0500 (1.27)	0.0403 (1.02)
19	0.0418 (1.06)	0.0456 (1.16)	0.0440 (1.10)	0.0360 (0.91)
20	0.0359 (0.91)	0.0396 (1.01)	0.0375 (0.95)	0.0320 (0.81)
21	0.0329 (0.84)	0.0366 (0.93)	0.0340 (0.86)	0.0280 (0.71)
22	0.0299 (0.76)	0.0336 (0.85)	0.0310 (0.79)	0.0250 (0.64)
23	0.0269 (0.68)	0.0306 (0.78)	0.0280 (0.71)	0.0230 (0.58)
24	0.0239 (0.61)	0.0276 (0.70)	0.0250 (0.64)	0.0200 (0.51)
25	0.0209 (0.53)	0.0247 (0.63)	0.0220 (0.56)	0.0180 (0.46)
26	0.0179 (0.45)	0.0217 (0.55)	0.0190 (0.48)	0.0170 (0.43)
28	0.0149 (0.38)	0.0187 (0.47)	0.0160 (0.41)	0.0126 (0.32)

TOLERANCES FOR 6061 ALUMINUM SHEET / PLATE (inches +/-)						
Plate Size	Thickness +/-	Length Flatness	Width Flatness	Width X Length Size Tolerance		
				Mill Size	Standard Pre-Cut	Custom Cut
.032	.003	1/4" in 6ft	1/2" in 4ft	+ 1/2" / - 0"	+/- 1/4"	+/- 1/16"
.040 - .063	.0035					
.063 - .079	.004					
.080 - .090	.0045					
.100 - .125	.006					
.190 - .250	.011	3/16" in 6ft	3/8" in 4ft			+ 1/8" / -0"
.313 - .375	.017					
.500 - .625	.023					
.750 - .875	.031		5/16" in 4ft			
1.00 - 1.50	.039					
1.625 - 2.25	.055		3/16" in 4ft			
2.50 - 3.00	.075					
3.25 - 3.50	.100	1/8" in 6ft	1/8" in 4ft			+1/4" / -0"
3.75 - 6.00	.130					
6.00 - 8.00	.160					
Tolerance values are in inches and provided herein by Metals Depot for informational purposes only and not guaranteed.						

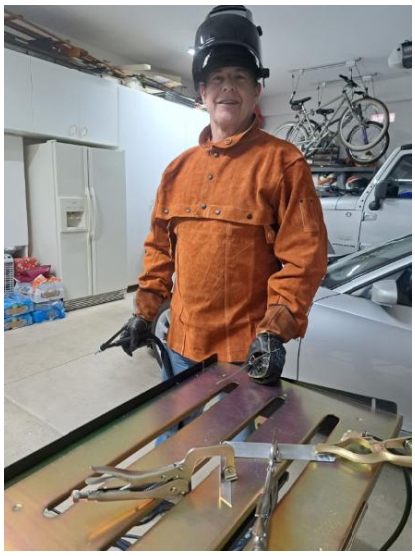
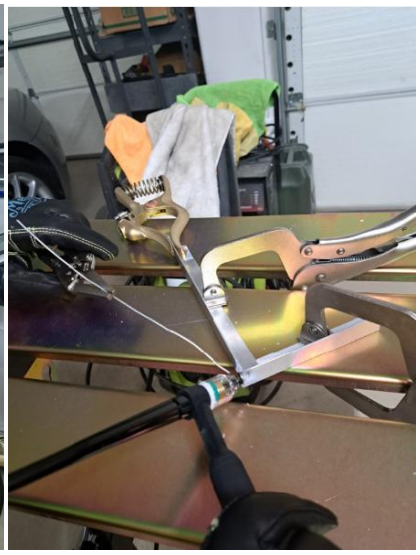
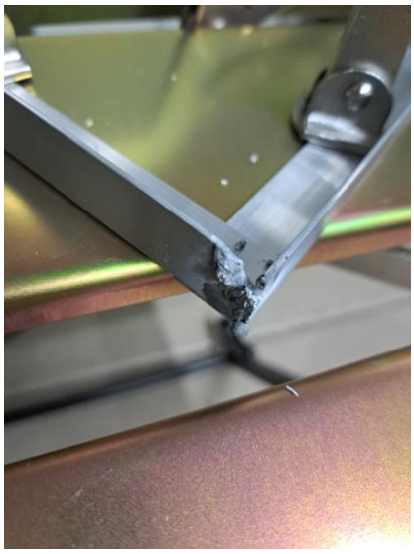
Skill Progress

I ordered a bunch of TIG welder equipment (see Equipment List) in late December 2022 and early January 2023 and received and assembled the bulk of it the week of January 7-10.

For those of you not interested in all the mistakes I made along the way, you can skip directly to Sixth Weld – 1/31/2023 to see everything working.

First Weld – 1/15/2023

After a few days of setting up and getting familiar with the equipment I attempted my first weld (30A, 1/16” tip, #5 cup, 6cfm, 16 gauge material.)

It’s hard to imagine a crappier weld, but I was pretty excited that I had got anything to work at all without catching myself on fire and blowing up the house.

Needless to say, I spent some time online researching what I had done wrong.

Major issues were:

- I had no idea what I was doing
- I had mistakenly set the argon cfm to 6 when it should have been around 12-15.
- I had failed to inspect the welder gas lines for leaks – there was one between the cylinder and the regulator.
- I had mistakenly thought the tungsten tip should be slightly inside the cup, but it should be about 1/8” outside the cup.
- I had failed to make the setup easy to move the torch – ergonomics. I later turned the table, draped the torch cable over my shoulders and made the hand movements towards my face.

Second Weld – 1/24/2023

I spent some time finding what I'd done wrong (and gotten distracted on another electronic project) and a few days later attempted my second set of welds (40-50A, 1/16" tip, #5 cup, 12cfm, 16 gauge material.)

On this pass things started out bleak (pieces to the left) and progressed to better looking welds (pieces on the right.)

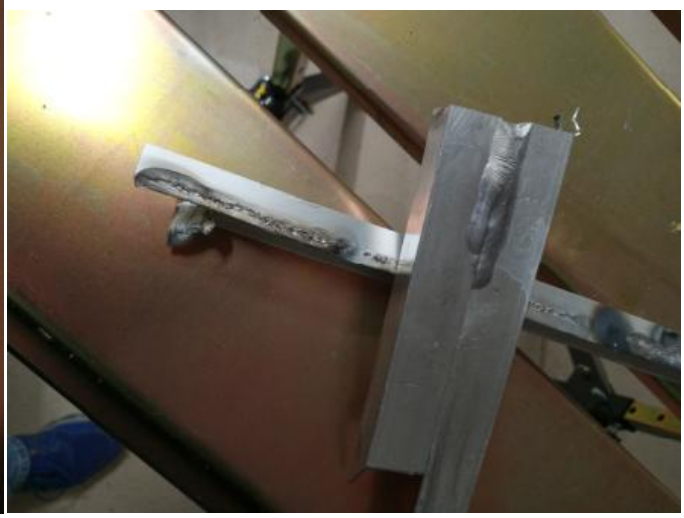
The grey splotchy welds are where I was using aluminum filler rod – the other ones were just the torch moving a bead along the material (with no filler rod.) The welds on the right have the nice purplish color you expect from TIG which shows that my skill on getting the gas cone to protect the weld were improving.

I also got bolder and moved up the 40-50A range which made things go a lot smoother. I was able to see the molten pool below the tip and move the torch at a rate where the metal melted but without cutting a hole in the material (even though this was 16 gauge aluminum.)

I spent some time afterwards trying to see why the welds with filler material looked so horrible. What I found is that you have to use very specific filler rod for different materials. I had been using some old aluminum gas torch brazing rods that I had lying around! This was a very bad idea. I researched it and ordered some ER4043 1/16" TIG filler rod.

Third Weld – 1/30/2023

After my filler rod arrived, I gave it another shot (40-50A, 1/16" tip, #5 cup, 12cfm, ER4043 1/16" TIG filler rod, 16 gauge material.)



My second attempts had used up all of my 16 gauge flat material so I switched to 16 gauge angle bracket.

As can be seen above, the welds look dramatically cleaner than the previous ones done with brazing filler rod. Gone is the horrible grey and black mess left by the brazing rod, leaving instead a clean weld.

However, as can be seen, the welds are "bare" i.e. there is not enough filler material to fill up the joint and provide a proper joint.

The weld holding the two pieces together is solid (i.e. they don't fall apart even when mild pressure is applied) and look relatively good and clean. This is major progress from my initial welds so I am pretty happy.

I was wondering if I could eliminate the ‘droop’ on the bottom of the welds by welding above the solid table (versus above the hole in the table.)


As can be seen above, this did eliminate the ‘droop’ but has two serious drawbacks:

1. It burns the table.
2. The weld takes much longer to heat the metal and does not flow as nicely.

A quick look on the internet shows that the weld pieces should be elevated above the table and held in place with various fixtures. I’ll have to do more work in this area.

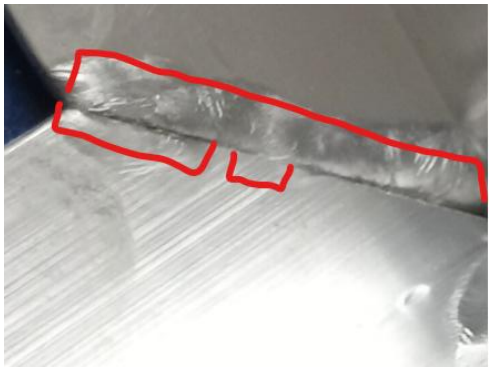
Fourth Weld – 1/31/2023

I ordered an assortment of magnetic welding fixture to assist in holding the pieces above the welding table. They should arrive in a few days. In the mean time I tried out the angle fixture I had been using with my gas brazing (30A, 1/16" tip, #5 cup, 12cfm, ER4043 1/16" TIG filler rod, 16 gauge material.)



While this is another crappy weld, I was able to learn several things:

1. Putting the metal in above the clamp jaws better exposes the joint and reduces the amount of heat lost to the clamp. This was part of the reason I gave up on using the clamp with gas brazing.
2. I reduced the current to 30A (from the previous welds 50A) and there is almost no "drooping" on the bottom of the weld now.
3. If you look closely at the joint below, you can see that the top piece has melted the entire length of the weld, but the bottom piece has only melted in two spots. This is undoubtedly due to the fact that I am moving the torch in a straight line catching only one of the two pieces. I need to start moving the torch from side to side to catch both pieces.



Fifth Weld – 1/31/2023

I did some more research and realized that I had made a **HUGE** mistake with all the previous welds – I had set the machine to use DC current. Aluminum should (almost) ALWAYS use AC current to properly burn off the oxide layer.

Additionally I got my tungsten stick-out gauge today and was able to see that I did not have the electrode sticking far enough out of the cup. I had it about 1/8" and it should be about 5/16" for the #5 cup.

I used the following settings: AC, 100Hz, 10% cleaning

(30A, 1/16" tip, #5 cup, 12cfm, ER4043 1/16" TIG filler rod, 16 gauge material.)

The above pictures show the before (left) and after (right – which is rotated 180 degrees – the black and silvery area is the AC weld.) The first attempt (on the left) to join two pieces was pretty bad. The second attempt to simply put a bead on a piece of metal turned out stunningly well – and there is no "drooping" on the backside like I was having with the DC settings.

Note that these welds were done with ZERO cleaning or preparation of the metal. All of the cleaning was performed by the torch itself!

Sixth Weld – 1/31/2023

I bumped the amperage up to 40A and made another attempt to join two pieces. This went really well as you can see below. I think I'm now able to do basic aluminum TIG welding!

(AC, 100Hz, 10% cleaning, 40A, 1/16" tip, #5 cup, 12cfm, ER4043 1/16" TIG filler rod, 16 gauge material.)

Fixturing Issues

Magnets

I received my fixturing magnets (see Fixturing) and tried them out. I knew beforehand that magnets are not attracted to aluminum but I was thinking that by placing the aluminum between the magnet and the welding table, the magnet would hold it in place. I was sadly mistaken.

Then I tried holding the aluminum together between two magnets as shown below. This sort of worked – as in they did hold the material but it was very unstable and slid around the welding table easily.

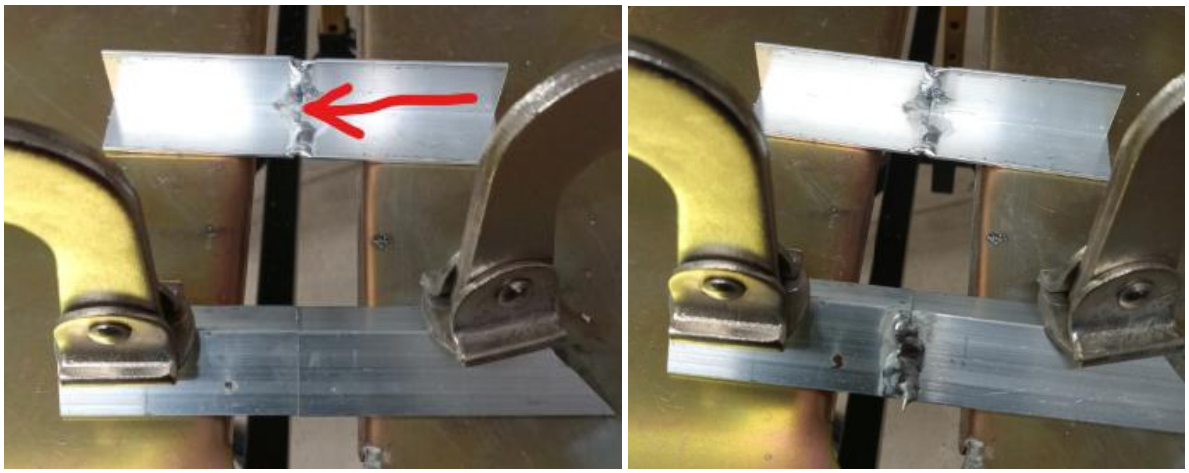
The weld was crappy because the magnet bodies acted as heat sinks and prevented the material from heating quickly.

Another issue that I hadn't thought about was the warning on the magnets not to get them hot. High heat causes a magnet to lose its magnetism so a TIG arc ¼" away from the magnet is just going to destroy the magnets.

I'm sure these magnets would be awesome when welding iron based alloys but they are not very useful for aluminum.

Interior Angle Welds

All of my interior angle welds have failed to properly extend the weld all the way to the corner of the angle. So I figured I could simply weld it from the other side as shown below.

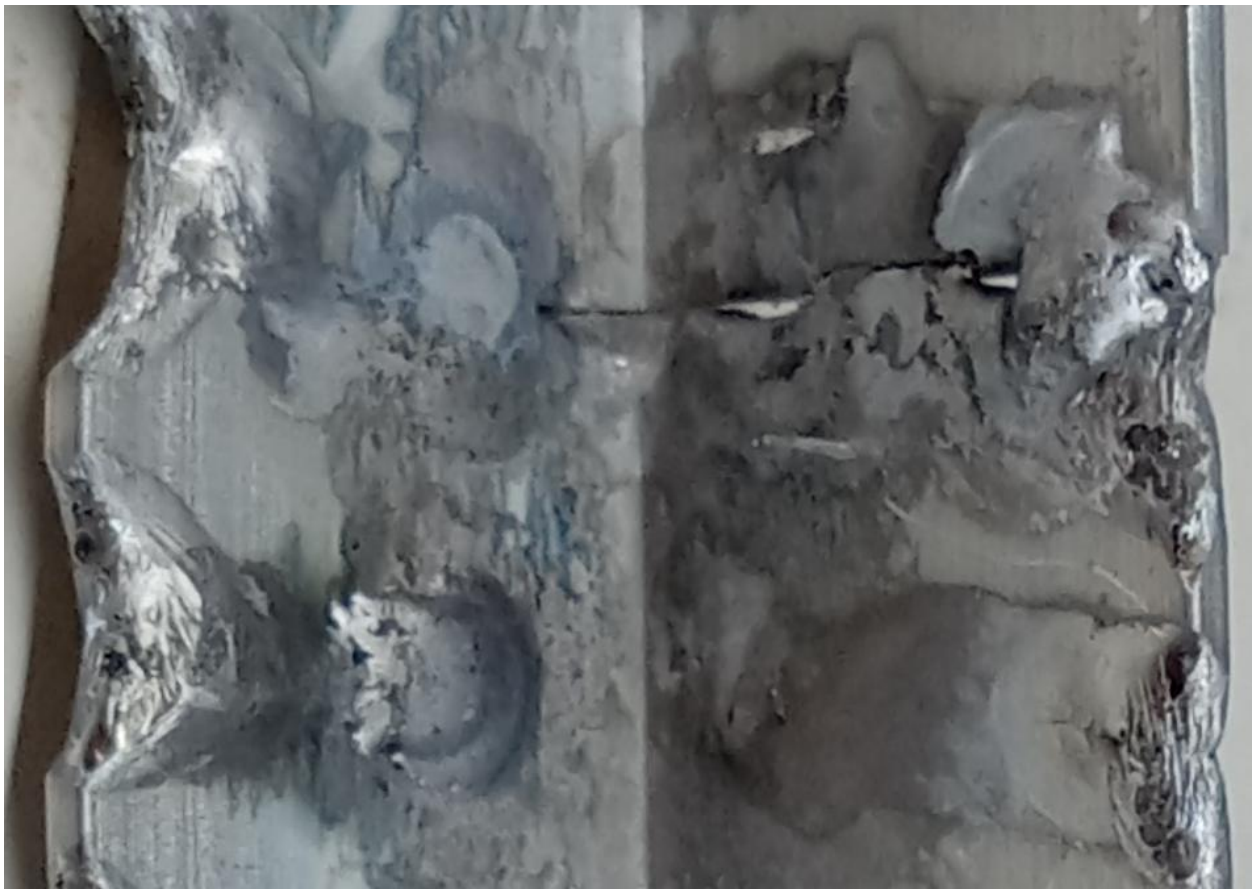


While this does work, the fixturing is not as solid because the clamps are on the crest of the metal, and more importantly create an uneven surface on the outside of the material which makes it difficult later position it flatly on the table without grinding the filler material off.

Surface vs. Joint Welding

I did a bunch of test welds on the surface of three pieces of angle bracket below. These all turned out very nicely. Then I attempted to weld the three pieces together and was surprised to find that these welds did NOT come out as nicely as the surface welds.

Here is a close up of the differences (rotated 90 degrees.)



You can see the filler rod flowed on the upper left side of the joint, but barely at all on the lower side – and the right side of the joint is a real mess. Whereas the surface weld looks very even.

Since all of these welds were done with the same conditions it must be something specific about the joint. Clearly one side was getting more heat than the other.

Attempt to Reduce Heat Sink Effect of Welding Table

My first thought was that the welding table was creating an uneven heat sink effect on the two pieces, thus causing one to heat before the other. To try this out I welded some pieces attached to a fire brick as shown below.


The first attempt, on the bottom, came out nicely, but the top was a disaster (I think I balled the electrode by mistake.) The second weld (after cleaning the tip) also was not very good.

My second attempt was to use the welding table but without the C-clamps. My thinking was that the C-clamps increased the heat flow from the material into the table. So instead I held the piece with a weak magnet. The results were equally disappointing as seen below.

How do the Pros do it?

I then did some research into a better welding table and fixtures and found the following: FixturePoint™ Convertible Welding Table

This seems like a really nice setup and it holds the metal away from the welding table – thus reducing the heat sink effect of the table. The drawback is that it costs $496 and would take up another six square feet of my limited garage space – vs. my current table that folds up.

Interestingly Klutch makes almost the same product for half the price here: Klutch Steel Welding Table with Tool Kit — 36in.L x 24in.W x 33 1/4in.H | Northern Tool

An additional issue is that this table is not helpful in making things larger than 2'x3' and my reason for welding is to make solar panel brackets that are much larger. Larger tables run into the $5000-$10,000 range and can only be justified if you are doing this for a living.

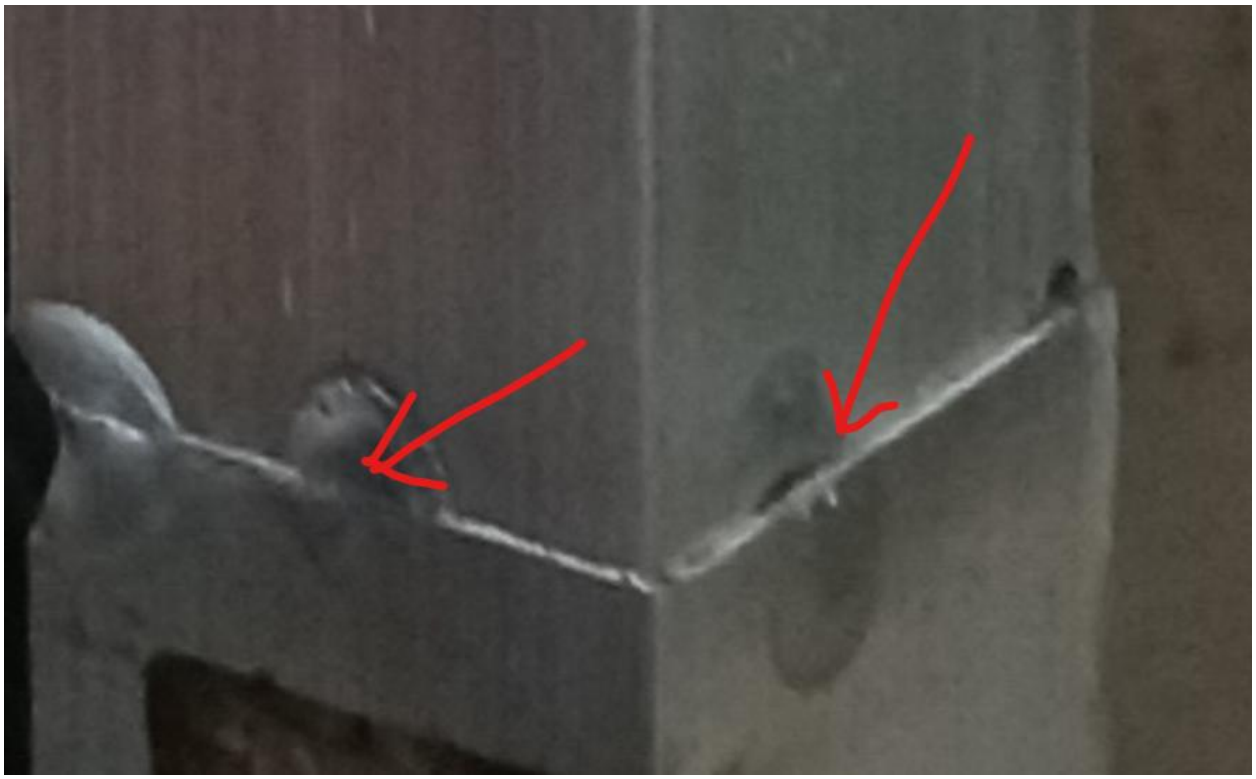
So I resigned myself to the fact that I really need more practice.

I later found this video which very clearly demonstrates torch movement on a proper welding table: Tig Brazing vs Tig Welding - Bing video. This is an additional argument to get a professional welding table.

Attempts to Properly Center Material

My first try was to keep the joint centered in the middle of the welding table slot. I did 7 welds like this without much more success. Additionally, when I applied pressure to the welded piece it broke on two welds.

Although this didn't solve anything, I happened to notice the back of the joints all exhibited a similar 'hot spot' issue at the start of the weld as seen below:

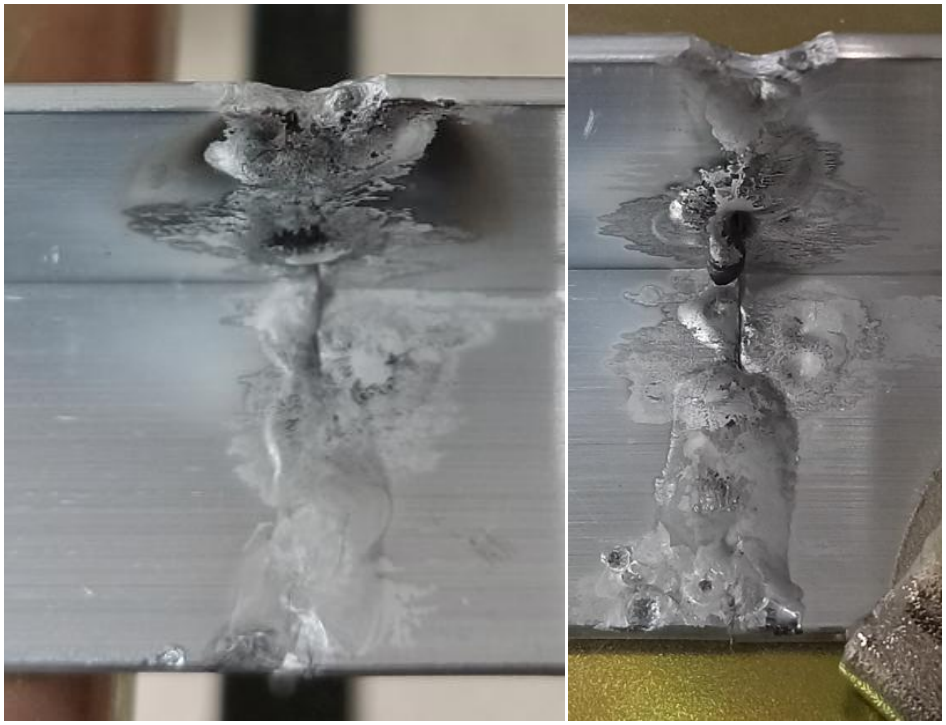


This got me thinking. First of all I realized that I been trying various different amperages (most of the recent welds had been at 40 amps.) So my first thought was to RTFM and actually use the recommended 35 amps for this type of weld.

Additionally I realized that I was not completely pressing down on the foot pedal when making welds which resulted in actual amperage somewhere between zero and the 40 amp setting. This is undoubtedly why I was having trouble getting the weld bead started in a timely manner.

So I set the welder to 35 amps and started fully pressing the foot pedal.

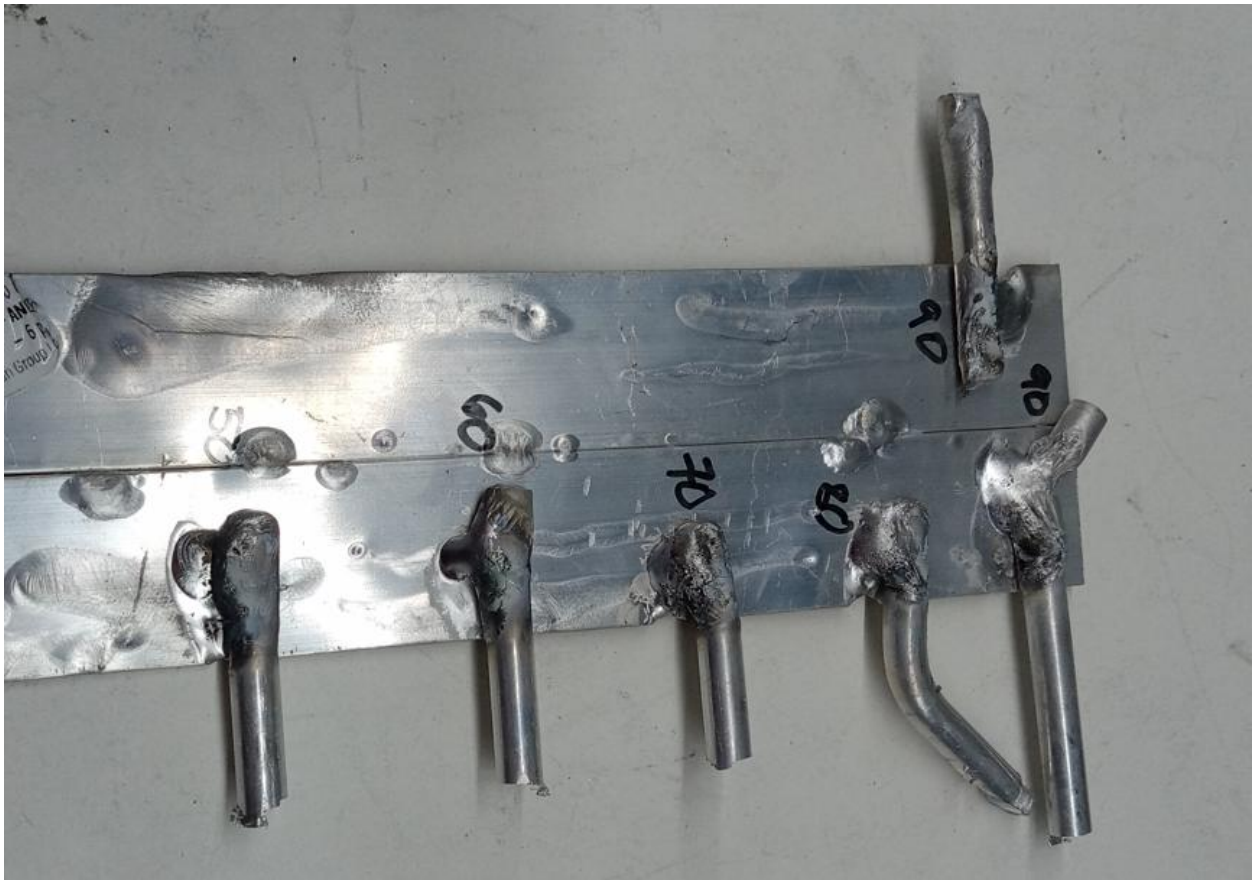
The welds were much easier and cleaner (well for a beginner anyway) as can be seen below:



And the “hot spots” were gone from the back of the material:

Uneven Metal Thickness

It's common sense in retrospect, but I failed to recognize it the first time I tried to weld ¼" rod to 1/16" plate using 35 amps and caused a weak joint that later failed. I later cranked up the amps and did some test runs as can be seen below.



The problem, of course, is that the thin metal will melt with 35 amps, but the thicker rod takes forever to melt at 35 amps. So the trick is to crank up the amps appropriate for the thicker material and focus the arc mostly on the thicker material until it starts to melt and then briefly heat the thinner metal.

As you can see the flow on the higher amperage welds above looks much cleaner and rugged than the lower amperage welds and it welds much faster.

Important: although not shown, both the base sheet metal AND the rod were both clamped down to the welding table for these welds.

Starting the Weld

After watching more videos, I realized another thing I was doing wrong was that I thought the whole weld should be done at a single current setting. This was causing the edge of the metal to burn off at the start of the weld as shown in the picture below on the weld pointed to with the rod.

To resolve this, a simple change is necessary.

Start the weld by only pressing the foot pedal part way – just enough to get the arc going and allow the cleaning action to begin, but not enough to melt the metal. When you see the area under the electrode go from dull grey to bright silver, you know that the cleaning is complete.

The great thing about this is that you have all the time in the world when cleaning, it's not until you start the welding that you need to move the weld puddle along before the material melts.

Now, once the area under the electrode is clean, you can fully depress the foot pedal, bumping up the current to a level high enough to melt the metal and start your weld.

I also bumped the cleaning ratio from 10 to 30 percent, and then back down to 20 percent during these tests. I'm not sure this really helped and it leaves a bigger cleaning mark around the weld which doesn't look as good. I'll probably go back to 10 percent with this welder (since it touts that it works well down to 5 percent cleaning) now that I found the pedal trick.

This very simple change makes all the difference in the world! Now every weld is easy and I don't have "rush" and hope it works before I burn a hole in the metal.

Uneven Metal Thickness with Proper Startup and Grounding

When I did the prior section (Uneven Metal Thickness) I forgot to note that the rod material was clamped down to the table. So when I tried doing a few more rods using the new proper startup process, I was surprised to find that the welds were crappy and it was difficult to get the arc to clean the rod material as it kept trying to jump back to the base sheet plate.

The issue was that (on the three highlighted welds on the left image below) I simply laid the rod on top of the sheet plate and attempted to weld it. Again common sense tells us that the arc will take the path of least resistance – which is through the base plate – because the rod does not have a solid ground connection.

The two images to the right show the same setup – but with a clamp properly grounding the rod to the table. You can see the image on the right, with the clamp removed, is a vast improvement over all the previous rod-to-sheet welds as there is minimal distortion of the rod and a good clean weld

Now I understand why you need the following tool!

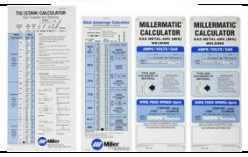
Here is an actual setup for the solar panel bracket.

And here is a comparison of the (crappy) weld I had previously made before learning the techniques shown in this section.

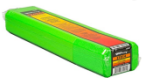
As can be seen, the weld is dramatically cleaner. The only error on the new weld can be seen on the bottom where the left side of the flat metal was over heated and showing a burn mark on the surface. This was the first side that I did and had to heat it several times before getting it right. The other side then went much smoother.

Equipment List

Basic Requirements

2022 Everlast PowerTIG 210EXT 210amp Ac Dc Tig Stick Advance Pulse Welder 110/220 Volt Inverter-based IGBT Technology - - Amazon.com		1625.00
4 Drawer Cabinet Welding Cart Heavy Duty Rolling Welder Carts with Drawers Cable Hook Tank Storage Safety Chain for Tig Mig Welder and Plasma Cutter Tank (4 drawer cabinet welding cart) - - Amazon.com		169.99
Strong Hand Tools Nomad Welding Table with MagSpring Clamp and Mini Magnet Twin Pack, Model Number TS3020FK - Arc Welding Equipment - Amazon.com		158.00
Amazon.com: Rolling Stool with Wheels Heavy Duty Hydraulic for Shop Guitar Lab Tattoo Workbench Medical,Adjustable Swivel Stool Chair (Black) : Beauty & Personal Care		96.00
3mirrors Tungsten Electrode Sharpener Grinder Head 24 Guides, Healthy TIG Welding Tool with Dust Housing 5X 35mm Double Diamond Wheels, 2X Connecting Rod - - Amazon.com		85.99
Dremel Lite 7760 N/10 4V Li-Ion Cordless Rotary Tool Variable Speed Multi-Purpose Rotary Tool Kit, USB Charging, Easy Accessory Changes - Perfect For Light-Duty DIY & Crafting - - Amazon.com		61.40
KEILEOHO 6 Pack 11 Inches C Clamp Locking Pliers with Swivel Pads, Heavy-Duty Locking Pliers, Woodworking Clamps Set, Adjustable Nickel Plated C Pliers - - Amazon.com		39.99
[Wire Brush Set for Cleaning 4-Pack Multi Purpose Beechwood Handle Medium & Small, Brass & Stainless Steel Wire Scratch Brush for Rust, Paint, Welding, Heavy & Light Household Cleaning: Amazon.com: Industrial & Scientific		13.50
Amazon.com: Pro HD"Purple" Concentrated Cleaner & Degreaser - Heavy Duty, Professional, Automotive, Restaurant, Grills, Ovens (32 oz Spray @Heavy Strength and 1 Gal Concentrate Refill) : Industrial & Scientific		29.99
Amazon.com : Miller Electric - 043125 Package Calculator : Welding Wire : Office Products		10.65
TOTAL		**2290.51**

Consumables

80 cu/ft 100% Argon Cylinder Tank Welding Gas CGA 580 - FULL - - Amazon.com		315.99
YESWELDER Aluminum TIG Welding Rod ER4043 1/16"x16" 5LB - - Amazon.com		49.59
YESWELDER Aluminum TIG Welding Rod ER4043 1/8"x16" 5LB - - Amazon.com		47.59
ER316L - TIG Stainless Steel Welding Rod - 36" x 3/32" (2 Lb) - - Amazon.com		45.99
Weldcote Metals ER70S-2 3/32" X 36" Tig Welding Rod 1 Lb. - Mig Welding Equipment - Amazon.com		22.95
Forney 32005 E7014 Welding Rod, 3/32-Inch, 5-Pound - Arc Welding Rods - Amazon.com		28.59
Blue Demon E347-16 x 3/32" x 12" x 5LB Pack Stainless Steel Arc Welding Electrode - - Amazon.com		55.56
40pcs TIG Gas Lens Collet Body & #4 ~ #12 Pyrex Cup Kit DB SR WP 9 20 25 TIG Welding Torch - - Amazon.com		28.50
YESWELDER 22Pcs TIG Welding Torch Stubby Gas Lens #10 Pyrex Glass Cup Kit For WP-17/18/26 - - Amazon.com		18.99
Tig Tungsten Welding Tungsten Electrodes 2% Thoriated Tungsten 1/16” x 7” (Red,Ewth-2) 10-Pack TOOLIOM - - Amazon.com		12.99
Tig Tungsten Welding Tungsten Electrodes 2% Thoriated Tungsten 3/32” x 7” (Red,Ewth-2) 10-Pack TOOLIOM - - Amazon.com		21.99
TOTAL		**648.73**

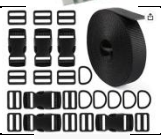
Protective Equipment

YESWELDER True Color Solar Powered Auto Darkening Welding Helmet, Wide Shade 4/9-13 for TIG MIG ARC Weld Hood Helmet - - Amazon.com		39.88
Amazon.com: LeaSeek Leather Welding Jacket - Heavy Duty Welding Apron with Sleeve (Large) : Tools & Home Improvement		69.99
YESWELDER Leather Welding Work Shop Apron with Too Pockets Heat Flame Resistant Cowhide Welder Apron Heavy Duty Blacksmith Aprons 41"		32.50
Defiant Metal TIG Welding Gloves - Premium Black Goatskin Leather (Large): Amazon.com: Tools & Home Improvement		25.89
3M Rugged Comfort Quick Latch Half Facepiece Reusable Respirator 6502QL, Gases, Vapors, Dust, Medium: Amazon.com: Industrial & Scientific		22.04
TOTAL		**190.30**

Fixturing (Magnets don't work for Aluminum)

Arrow Welding Magnets Set Arc Tig Mig Welding Magnetic Arrow Holder Multi-angle Metal Working Tools and Equipment Welding Accessories For Soldering Welding Assembly Installation (6PCS-25/50/75LB) - - Amazon.com		32.85
Arrow Welding Magnets Set Arc Tig Mig Welding Magnetic Arrow Holder Multi-angle Metal Working Tools and Equipment Welding Accessories For Soldering Welding Assembly Installation (4PCS 50LBS) - - Amazon.com		22.85
Amazon.com: Strong Hand Tools, Magnetic V-Pads Kit, Magnets On Both Pad Face & Bottom, 4 Piece Kit (XDV4: 2 pcs. 2", Pull Force 12 lbs) (XFV4: 2 pcs. 2.2", Pull Force 18 lbs), MVDF44 : Everything Else		23.56
Magnetic Corner Squares, (Twin Pack), 12°, 90° & 60° Angle Setting, Max Pull Force: 30 lbs, Low Profile, 3-1/4 x 3-3/4 x 5/8", MST327, Strong Hand Tools: Amazon.com: Industrial & Scientific		25.22
ATPEAM Butt Welding Clamps | Pack of 16 Small Welding Magnets and Clamps Auto Body Panel Clamps for Edge to Edge Magnetic Ground Clamp Welding Door Alignment Tool - - Amazon.com		18.95
Grasshopper Magnetic Welding Finger, Pull Force: 35 lbs, AGH230, Strong Hand Tools - - Amazon.com		32.74
Amazon.com: JointMaster, 90 Degree, Angle Clamping Tool, Throat Depth: 3", Max Capacity: 1-1/4", OAL: 8-1/2", Single Hand T-Joint Clamp Tool, PL634, Strong Hand Tools : Everything Else		28.98
TOTAL		**185.15**

Miscellaneous

Amazon.com: Vidifor 2 Pack Plastic Storage Organizer Box, Storage Container, Jewelry Organizer, Parts Storage Box with Dividers for Crafts, Beads, Buttons, Ornaments, Metal Parts(9 Grids 2 Pack)		16.99
Amazon.com: Buckles Strap 1 Inch: Nylon Webbing Straps 6 Yards, Quick Side Release Plastic Buckle Dual Adjustable 6 Pack, Tri-Glide Slide Clip 12 PCS, Metal D Rings 6 PCS, Heavy Duty, Black		11.99
Highly Accurate Tungsten Stick-out Gauge for TIG Welding, Wrapped in Kawasaki Green Powder Paint. Made in USA - - Amazon.com		18.95
VASTOOLS TIG Holder for Welding Torch/Magnetic Torch Holder/Weld Torch Metal Stand with Strong Magnetic Base/For Mig or Plasma torch - - Amazon.com		13.99
Tungsten Electrode Dispenser/Tungsten Electrode Holder/Magnetic Tungsten Hanging holder/Electrode/Welding Accessory - - Amazon.com		19.95
Amazon.com: 2 Pcs Welders Pencil with 48 PCS Round Refills Mechanical Pencils Metal Welding Marker for Tube Pipe Fitter Welder Steel Construction Woodworking (Silver) : Tools & Home Improvement		12.45
TOTAL		**94.32**

Aluminum Welding Material

I got my initial material from Lowe's. I didn't pay attention to the material that I picked up in the store, but I ordered the following (which is 16 gauge **6063-T5** alloy) on their website for $18.98 each:

Steelworks 1-1/2-in W x 1-1/2-in H x 6-ft L Mill Finished Aluminum Solid Angle in the Angles department at Lowes.com