Waltworks Custom Framebuilding Course Syllabus and Outline

Welcome!

Most of what you'll be learning you will learn by **doing it** yourself – but I've compiled some basic information (as well as an outline of the flow of work I use to build a frame) as a reference.

Please remember that the balance of your class fee is due on your first day!

Basic TIG welding necessities:

These are all common items that should be available both locally and online. This is purely a list of consumables and small parts, however – I am assuming you have access to a TIG machine or are renting my 120V Miller Maxstar. If you do not have any welding equipment and need advice on what to purchase, please call me to discuss.

Remember: the more practice you get beforehand, the better the class will go. If you are struggling with the welding, you will struggle with the class. You have plenty of lead time - make it a goal to get in 20-30 hours of practice before you arrive!

If you need some mitered tubing scraps, let me know and I will make you a big box of them.

-1# each of .035", .045", and .065" (might be sold as 1/16") ER70S (might be sold as ER70S2) weldingrod. This stuff is great for joining cromoly to cromoly or to mild steel. Do not use for stainless (we will play with stainless when you are here). Should cost <$5/#.

-Box (usually 8 pieces) of 1/16" ceriated tungsten. **(BRING TO CLASS)** This is your electrode for the torch. It is a little more expensive than thoriated, but thorium is bad for you in dust form, and you'll be grinding the tungsten a lot. Make sure you have the appropriate collets, gas lenses, etc for your torch.

-Leather TIG gloves. **(BRING TO CLASS)** Buy the cheapest ones you can get, sized so that *you can get them off one-handed* (ie, just throw to the floor very quickly). Leather is a great insulator but if it gets hot enough, it will burn the crap out of you - and you need to be able to quickly get the glove off in that situation.

Do not use these for anything but TIG! When you get more experience you may move to something else (or with a tighter fit) but for now this is the safe way to go.

-Welding Helmet. **(BRING TO CLASS)** I prefer these:
https://weldingsupply.com/cgi-bin/einstein.pl?PNUM::1:UNDEF:X:14529
Buy shades 8, 9, 10. If you want to use the helmet for really heavy duty (not bike) stuff, also get 11 and 12. Shades are super cheap ($3 each) and you'll want to swap out and experiment with how much light feels ok to you. There is no safety difference between the shades (they all block 100% of UV), it's just a question of how bright is comfortable without obscuring your view too much.

Jackson is a SUPER common brand and any welding supply probably has this helmet in stock or something very similar. They can easily be modified to fit a respirator if you want to use one in the future, too.

Lots of people prefer auto-darkening helmets. For bike work, these sometimes suck because the sensor can get blocked by part of the frame (when you're reaching around behind something to weld it in, for example) and you'll get flashed - which isn't dangerous, but is very unpleasant.

On the other hand, for MIG/stick welding on bigger jobs, it is awfully nice to not have to flip the helmet up and down all the time to see what you're doing. Auto darkening helmets also double as great protection for grinding or blasting (or anything where lots of crap is flying around). There will be a big selection of auto-dark setups available anywhere. Check to make sure the shade will go down low enough (at least down to 8 shade).

-Argon bottle. You will have to lease this (unless you get a very small one) from welding supply. If you start small they will apply your lease fee to leasing a larger bottle in the future, so I'll leave it up to you to select an appropriate size. The valves (regulator compatibility) are the same regardless of the tank size. Make sure you can easily handle the bottle, they are awkward and can mess you up if you are struggling to get them in/out of your car. Don't have your kids in the car with the tank, it'll destroy things if you get in a wreck (just due to the unsecured weight).

-Small wire brush. Try to only use this for cleaning off areas you want to weld, rather than scrubbing your sink or grease off your bike! They are like $2.

If you will be working in an enclosed space without much ventilation, I'd suggest a respirator as well. The guys at the welding supply can help with this. I like the half-face ones from North, and the "Defender" (basically filters everything you can conceivably filter) cartridges. This is NOT probably something you need unless you are unusually sensitive to vapors/particulates or you plan to do a LOT

of welding on a consistent basis (and even then most people don't bother because they are not very comfortable). For working with dirty metal or anything with stainless or corrosion resistance, you will want to protect your lungs, though. For now, your call. Feel free to let me know if you want to discuss that more. DO NOT WELD ANYTHING GALVANIZED OR ZINC PLATED. This is a quick way to give yourself serious lung problems.

<u>If you have a torch/handle that you are comfortable with, please bring it with you to class.</u>

Building a frame in 52 easy steps (and change)

Please note that this outline does NOT include every step, or discuss in full every technique we will use. It is purely intended as an easy reference to help guide you through the basic process

- Identify driveside of BB shell.
    - Discuss varieties of shells, PF and BB30, T47, English, EBBs, etc.
- Drill vent hole.

    -3/16" is sufficient. Very large vent holes will cause increased distortion of the BB shell post-weld.

    -Vent holes are useful to let water drain, let rustproofing compounds in, and they make welding easier on thin wall tubes. You can also backpurge (mandatory on titanium).

    -Larger holes for Di2 bikes.

3. Install BB shell in fixture (using appropriate spacers) and clean with nylon abrasive wheel.

    -These are superior to wire wheels and inexpensive, but cannot remove deep rust/scale.

    -Chemical cleaning usually not needed with steel, except in cases of excessive oil/mill scale. Denatured alcohol recommended.

4. Find butt (or butts) on seat tube and choose where to miter.

    -Butts are often not to spec! Always measure!

    -Seat tubes can be configured many ways – lug/external sleeve, external butted, internally butted, fusion welded plug, etc.

5. Miter seat tube to BB shell.

    -This miter can be offset to help make it easier to miter/weld chainstays, to increase tire/seat tube clearance, or both. Can cause problems with front derailleurs in some cases, however.

6. Deburr and clean seat tube.

    -Generally a mechanical cleaning is sufficient. For very oily/greasy tubes a bottle

brush and dish soap works great.

7. Center seat tube on shell, tighten seat tube cone, and test for fit (wiggle test). If further mitering is necessary, miter by hand to finish fit.
    -Half round files are made to match SAE sized tubing. It's a good idea to have a set of 8"-16" files for mitering.
    -Centering can be easily accomplished by using a parallel or calipers.
8. Tack seat tube to BB shell at 1:30/4:30/7:30/10:30 in fixture.
    -Check alignment after tacking – if alignment is problematic, you can still break the tacks and correct.
9. Weld seat tube to BB shell.
    -Typical sequence is front/nondrive quarter, front/drive quarter, rear/nondrive quarter, rear/drive quarter.
10. Check seat tube alignment and adjust as needed.
    -For smaller diameter tubes, cold setting can work.
    -For larger diameter tubes, re-running a section of weld bead (no added rod) is usually the most practical solution.
    -Alignment is mostly determined by good miters and weld sequence.
11: Drill relief hole in seat tube and slot using double hacksaw blade.
    -Typically 3/16" relief hole, but larger is fine too.
    -I prefer to slot the front of the seat tube.
    -Discuss brazed-on binders vs. collars.
12. Cut head tube to length, install spacers/heat sinks if required, and install in fixture.
    -Basic chop saw cut is suffient, no need to face head tube before welding.
    -Discuss head tube/headset standards.
13. Set fixture to match BikeCAD drawing.
14. Locate butts on downtube and toptube, decide where to miter.
15. Miter downtube as per BikeCAD angles/lengths.
16. Fit downtube into fixture to locate head tube.
17. Miter toptube.
18. Install water bottle bosses (if required). Test fit bottles to double check locations.
    -Ceeway in the UK is a great source for these.
    -6mm or ¼" drill bit works great.
    -Remember that bottle cages are not standardized.
19. Clean brazing flux from bottle bosses with hot water and abrasive wheel.
20. Clean tubes and drill vent holes in BB shell and head tube.
21. Tack downtube in at BB shell bottom to pull downtube down/into frame. Then tack at head tube and remaining points on downtube.
    -Tack at 1:30/4:30/7:30/10:30 (approximately). Avoid the points of the DT/ST compound miter when tacking.
22. Do a very brief alignment check to make sure there isn't a problem with the miters or tacking (pull top head tube cone up slightly to check for gaps).
23. Weld in the top of the downtube/head tube joint – easy access while the toptube is not in yet.
24. Tack the toptube in, using a sequence that holds it into the frame.
25. Perform another very quick alignment check.
26. Weld (in fixture if possible) bottom 2/3 of DT/BB joint, top and bottom of seat tube/toptube, toptube/head tube, and downtube/head tube.

-Don't weld the sides of the joints in the fixture as the back sides are very hard to reach – and we want to be alternating sides of the joints when finish welding.

27. Remove frame from fixture and weld in sequence the remaining joints.
    -My personal sequence is downtube driveside, downtube nondrive, seat tube drive, seat tube nondrive, toptube drive, toptube nondrive, downtube drive, downtube nondrive.
    -Everyone is a little different with weld sequence and you can experiment and see what works for you.
28. Frame back into fixture.
    -No further alignment checks until chainstays are welded in – BB shell distortion will prevent accuracy.
29. Determine where chainstays, chainring, tire, cranks, and disc rotor/heels will need to clear and pick an appropriate chainstay.
    -Discuss varieties of chainstay assembly – wishbone, yoke, prebent, asymmetric.
30. Dimple chainstays if required.
    -Stays can be dimpled for tire, chainring, or both.
    -Dimpling has hard limits, and always weakens the stay.
    -Dimpling tools mostly consist of shaped wood or aluminum blocks, cradles, and some form of press.
31. Miter dropouts to chainstays (there are a variety of ways to do this) and tack in place.
    -3 tacks is generally sufficient. You can partially weld the dropouts in if desired.
32. Load stays into chainstay fixture and miter to BB shell
    -Miter offcenter if needed to maximize clearance for welding around seat tube area.
33. Check that stays are same length/aligned.
    -This will sometimes require hand filing a bit.
    -For modern/through axle bikes it is important to get the stays very even! On older QR dropouts, dropout slots can be filed (to some extent) in the event of an alignment problem.
    -In some cases the stays can be pushed slightly inboard, then released – if they come to center, you're good!
34. Set fixture to ~1/2 degree more drop than needed, stays will tend to pull down.
35. Tack stays to BB shell in 3 places on each side (top, bottom, center/inside)
36. Weld chainstays in sequence.
    -I prefer inside/nondrive, inside/drive, outside/drive, outside/nondrive.
37. Face shell.
38. Reinstall frame in fixture and check front end alignment. Fix as needed.
    -With oversize tubes, best way to do this is by reheating/rerunning bead to pull frame.
39. Check chainstay alignment. These can mostly be coercing into position by hand, but you can use more heat if you have to as well.
40. Bend seatstays.
    -There are a variety of ways to do this. Discuss/demonstrate.
    -Prebent stays can work in some cases, but not as often as for chainstays.

-Avoid very thin walls/heat treated tubes.

41. Miter seatstays to seat tube.
    -We will build a fastback style stay frame, but we will discuss other methods (wishbone, brazed/capped, etc).
42. Miter seatstays to dropouts (variety of ways to do this).
43. Tack seatstays, check alignment again. This is your last chance to fix a problem!
44. Weld in seatstays.
    -Leave a gap/vent hole somewhere at the dropout end. You can seal this after finishing other welds.
    -Sequence is relatively unimportant here, but it's still good to alternate sides.
    -Generally most difficult welding on the frame.
    -Remember that you can extend your tungsten WAY out in the tight spots!
    -If it's just too tight, you can fill tight spots with silver rather than a full TIG joint.
45. Construct seatstay/chainstay bridges, if needed.
    -Demonstrate how to make bridges (straight) on the mill.
    -Curved bridges require hand mitering (which we will do just to get a taste of how it works).
    -Bridges are relatively unimportant structurally but important for fender/brake/kickstand mounting, and for aesthetics.
46. Weld or braze in bridges.
    -Totally safe to silver braze or fillet braze if TIG is too difficult to do – bridges can be a real pain.
    -You can use plate, old disc rotors, etc – no need to use tubing if you don't want to.
47. Weld or braze on cable guides/stops (and pump pegs, derailleur mounts, etc).
    -Discuss how to locate, plusses/minuses of various configurations, types of guide/stop.
48. Cap/finish stay/dropout joints
49. Ream seat tube to size.
50. Remove heat sinks.
51. Check and adjust rear axle spacing.
52. Prep for powdercoat (check for flux/pinholes/other potential issues and correct as needed).
    -Reaming/chasing/facing of the frame is best done after powdercoat to avoid contaminating the frame with cutting fluids and making things hard for the powdercoater.

Boom. You're done!

Tools and other useful links

Commonly requested sources for some of the small tools and information we used in class:

SRAM tech docs/frame fit specs: https://www.servicearchive.sram.com/service

RattleCAD: https://sourceforge.net/projects/rattlecad/

BikeCAD: https://www.bikecad.ca/

Linkage (full suspension): https://bikechecker.com/

ISU Westlake Insurance: https://www.isuwestlake.com/

Tubing magnets: https://www.amazon.com/Strong-Tools-MVDF44-Adjustable-Magnetic/dp/B00JXDSVA6/ref=pd_bxgy_469_2/144-4294448-1524100?_encoding=UTF8&pd_rd_i=B00JXDSVA6&pd_rd_r=03f58c5f-6772-44ff-9d7e-eb2a1df364a2&pd_rd_w=bNzka&pd_rd_wg=5VyVf&pf_rd_p=a2006322-0bc0-4db9-a08e-d168c18ce6f0&pf_rd_r=XZ7VKFVV95SGBFCAPBQ4&psc=1&refRID=XZ7VKFVV95SGBFCAPBQ4

Seat tube reamer: https://www.mscdirect.com/product/details/02239093

Nyalox cleaning wheel: https://www.amazon.com/Dico-7200048-Medium-Nyalox-Wheel/dp/B002YDJU98/ref=asc_df_B002YDJU98/?tag=hyprod-20&linkCode=df0&hvadid=330525688788&hvpos=1o3&hvnetw=g&hvrand=14794755052659219179&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9029752&hvtargid=pla-665437793196&psc=1&tag=&ref=&adgrpid=65172136286&hvpone=&hvptwo=&hvadid=330525688788&hvpos=1o3&hvnetw=g&hvrand=14794755052659219179&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9029752&hvtargid=pla-665437793196

Stainless Cable guides: https://framebuildersupply.com/collections/guides/products/stainless-hydro-guide-10-pack

Master List of Framebuilding Suppliers

Note that this list is not comprehensive – but it does include most of the extant sources for framebuilding supplies and tubing.

Aero Metals
Aerospace & Commercial Metals UK. Aluminium UK. Stainless Steel UK . Alloy UK.

Hi-Temp UK . Low Cost Aluminium
UK source of plain gauge 4130 and T45. Very helpful, willing to sell by the foot rather than full lengths, huge stock and reasonably priced.

Aircraft Spruce
Pilot Supplies, Avionics, and Homebuilt Aircraft Parts from Aircraft Spruce and Specialty Co.
4130 cromoly (non-butted) in lots of shapes and sizes.

Alex Mead
Alex Meade Bikeworks
Fixtures, dummy axles, other framebuilding tools.

Anvil – now out of business!
Anvil Bikeworks: Professional tools for the professional bike builder
The nicest fixtures on earth. Be the envy of your framebuilding friends!

Bringheli
BRINGHELI
Tubing, tools, lugs, etc.

Bike Fab Supply
www.bikefabsupply.com
Small parts, lugs, tubes

Bikelugs.com
BikeLugs.com
Kirk Pacenti's beautiful lugs and small parts

Ceeway
Framebuilding Bicycles. Tubing, Parts, and Tools
Tubing, brazeons and small parts, tapping/reaming/facing tools. Located in the UK.

Composite Resources
Composite Product Design and Manufacturing | Composite Resources
Composite frame tubing for the carbon fiber set!

Design Engineering
Call 319-367-2282 - website no longer exists, but they're still making stuff.
Brazeons/small parts only. Very inexpensive and American made!

The Dillsburg Aeroplane Works
Sadly, now out of business.

Edge Composites

http://edgecomponents.com/BuyOnline.aspx?catid=1&page=1
Manufacturer of carbon frame tubing, also forks/rims/bars/etc.

Fairing
Fairing Industrial Inc.-frame builder,aluminum tubes,cr-mo tubes,bicycle tubing,bottom bracket,cable stops,rahmenbauern,Aluminiumrohre,cr-mo rohre,Fahrrad-rohre,Innenlager Kabel-Stationen,framebouwers,aluminium buizen,cr-mo-buizen,fiets buizen,trapas
Steel frame tubing and a distributor for Reynolds in the US.

Framebuilder Supply:
https://framebuildersupply.com/

Henry James
Henry James investment cast steel lugs
Tubing, small parts, tools, jigs/fixtures, consumables.

KVA
KVA STAINLESS: MS3 Stainless Steel Custom Bicycle Tubing
Supplier of stainless bicycle tubing, made in the USA!

MSC
MSC Industrial Supply Co. | Find Power Tools, Hand Tools, Machine Tools & More
A huge range of industrial supplies. Framebuilders can find cutters of all kinds, machine tools and parts, shop supplies, and more.

Nova Cycles
Cycle Frame Tubing :: Nova Cycles Supply Inc. :: The Framebuilder's Source" is the dominant supplier of cycle frame building materials in North America
Tubing, brazeons and small parts, consumables, some fixturing equipment and tools

Paragon Machine Works
Home
Dropouts, brazeons, some tools (purge equipment, arbors, etc)

Simple bikes
simplebikes.com
Suppliers of the ARCTOS frame building system

Solid bikes
Solid Bikes
Suppliers of Integrated head-tubes and BB shells for BMX.

Sputnik
Sputnik Tool

Tooling for framebuilding

Strawberry Bicycle
Strawberry Cyclesport Inc.
Cutters and framebuilding tools

Titanium Joe
Custom Titanium Tubing North America - Titanium Joe
Titanium tubing (not bike specific, if you don't know exactly what you need, this isn't the best place to get tubing)

Titanium sports
TiLite
Suppliers of titanium tubes in both round and custom shaped forms

True Temper
No longer in business.

UBI
United Bicycle Institute
Steel and ti frame tubing and parts

Vari-Wall – possibly now out of business?
The current sole supplier of domestically made frame tubing.
https://shop.vari-wall.com/

Ventana USA
Welcome to Ventana Mountain Bikes USA
Suppliers of pre made single pivot suspension systems and kits for builders.

Wicks Aircraft
Wicks Aircraft Supply
4130 steel (non-butted) tubing in an amazing variety of sizes and thicknesses.