INTRO TO SOLDERING

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solder[sod-er]

noun

1. any of various alloys fused and applied to the joint between metal objects to unite them without heating the objects to the melting point.
2. anything that joins or unites: *the solder of their common cause.*

verb (used with object)

1. to join (metal objects) with solder.
2. to join closely and intimately: *two fates inseparably soldered by misfortune.*

Part I

Soldering Irons and tips

IRON TYPES: Soldering gun (good for large wire); soldering pencil (25 watts+); analog variable heat; digital variable heat; rework station with heat gun; butane portable; battery powered portable; de-soldering station; de-soldering vacuum gun. Soldering iron tip temperature should be around *600°F (315°C).* Other temperatures depending on material soldering to, size of work, etc.

TIP TYPES: Conical (various sizes as well as bent); Knife edge; bevel; screwdriver tip; chisel tip.

Pick the largest applicable tip for the job for best heat transfer. Personal preference will be up to your comfort level, budget and material you are working on as well as your own comfort by practicing using different tip types.

TIP CARE: Keeping a clean tip with a brass wire sponge ball and damp sponge will prolong the life of your tips. Add a small amount of solder or tip tinner to your tip after soldering

session to keep your tip from getting oxidized between sessions. Clean with some sand paper or brass wire sponge to remove heavy debris. Solder should easily flow to the tip of the iron. If not, repeat cleaning until tip is shiny and solder flows freely.

PART II

Solder types

Electronics solder generally falls into one of three types, a lead alloy solder, a lead-free solder or a silver alloy solder. Lead-based solder is solder that is made from an alloy of tin and lead, sometimes with other metals as well. The reason that lead is combined with tin is that the resulting alloy has a lower melting temperature, an important property of solder when most electronic components are very heat sensitive! Lead alloy solder is often referenced by its alloy ratio such as 60/40 or 63/37, with the first number being the tin by weight and the second number being the amount of lead by weight. Both of these common alloys are good for common electronics, but 63/37 is a eutectic alloy, which means that it has a sharp transition between liquid and solid states as temperature changes. This property helps reduce cold solder joints that can happen when a part moves as the solder is cooling.

Selecting the Right Solder

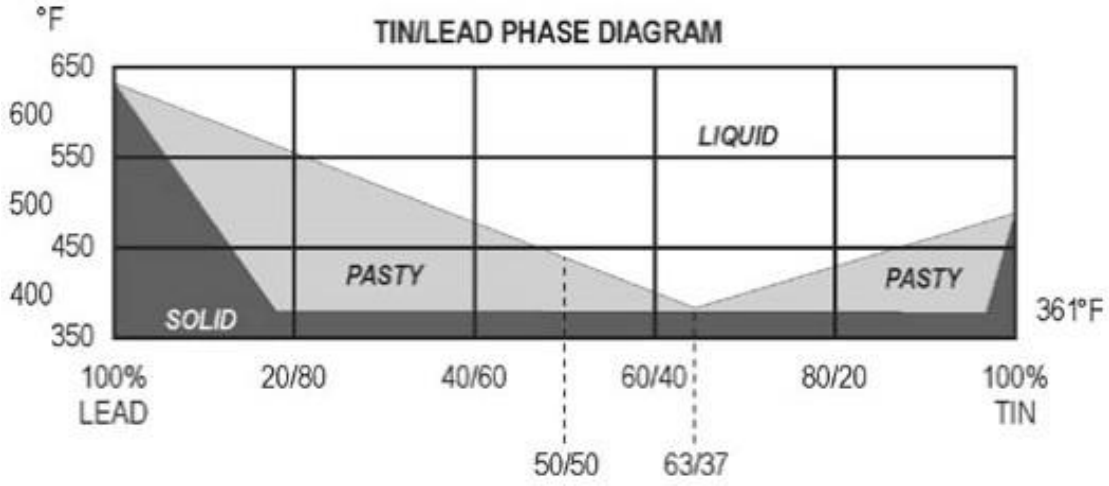
Several different features can make selecting the right solder challenging. The right solder needs to take in to account the material being soldered, the use of flux, the size of the parts being soldered, and the potential health and safety issues of soldering.

Solder is available with none, one or several rosin (flux) cores running through the center of the solder wire. This embedded rosin flux helps the solder flow and bond to the parts being soldered, however, sometimes the rosin flux that is embedded in the solder is undesirable for a number of reasons, such as the cleaning method that must be used following the soldering or the presence of a strong acid flux (such as acid-flux solder used in plumbing which should never be used on electronics) and a separate flux is desirable. The three types of rosin-core solder are non-activated (R), mildly activated (RMA), and activated (RA), the latter being the most acidic of the three.

Solder is also available in a number of diameters, with 0.02", 0.032”, 0.063" and 0.04" being common solder diameters. Larger diameter solders are great for large solder jobs, tinning larger gauge or multistrand wires but make fine work such as surface mount soldering much more difficult. This is where the 0.02" and 0.04" solder become quite useful. Overall, most work can be done with just the 0.04" diameter solder, especially when combined with a little experience and adequate flux.

.032” 63/37 with RMA flux (44 rosin core) is easiest size and type for most uses.

.020” is better for through hole soldering.



Leaded Solder Alloys with Melting points

Product	**Alloy**	**Melting Temperature**
Low Melt	52%Sn / 32% Pb / 18 Cd	293°F.(145°C)
60/40	60%Sn / 40% Pb	361-374°F.(183-190°C)
63/37	63%Sn / 37%Pb	361°F (183°C)
50/50	50%Sn /50%Pb	361-421°F.(183-216°C)

AVOID ORGANIC CORE SOLDER UNLESS OTHERWISE INSTRUCTED BY MANUFACTURER – It's only used for industrial, but will eat away at the tin over time without proper uses.

PART III

Proper Technique

This is as close as I can figure to NASA standards. List is taken from YouTube NASA Certified instructor Mike Bunting teaching soldering techniques. This is far beyond what steps most hobbyists or even professionals take, but it's worthwhile to know the full proper technique and reason to go through such an intricate process to get the proper solder connection.

1. Strip wire(s)
2. Roll to keep wires together (you will be introducing oils to the wires from your fingers)
3. Clean wires with alcohol to remove oils
4. Apply flux to wire
5. Cut length of solder
6. Clean solder with alcohol to remove oxidation
7. Remove alcohol residue with Chem-wipe
8. Clean iron with dry Chem-wipe
9. Lightly tin soldering iron tip
10. Tin wire entire length stopping just short of insulation
11. Clean tinned wire with alcohol
12. ***PLACE HEATSHRINK OVER WIRES!!!***
13. Make splice or connection
14. Clean connection with alcohol
15. Apply flux to wires
16. Cut length of solder
17. Clean solder with alcohol to remove oxidation
18. Remove alcohol with Chem-wipe
19. Clean iron with dry Chem-wipe
20. Lightly tin soldering iron tip
21. Solder wires or connection
22. Clean solder connection with alcohol
23. Inspect solder connection (You should be able to see strands of wire)
24. Re-apply solder if bare areas or remove large drops of solder
25. Re-clean as needed
26. Slide heat-shrink over connection and shrink

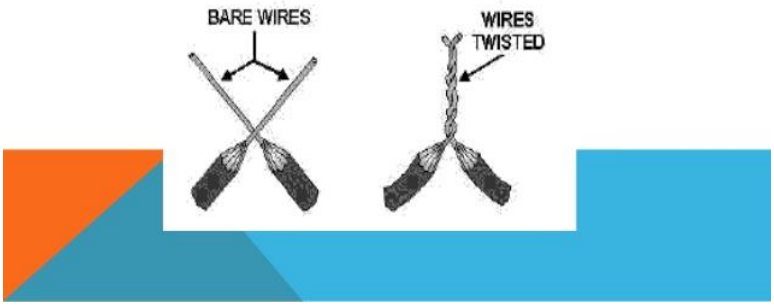
PART IV

Splices

- Rat tail (non-solder)
- Fixture Joint (non-solder; similar to rat tail, but different diameter wire)
- Western Union
- Staggered
- Knotted tap joint

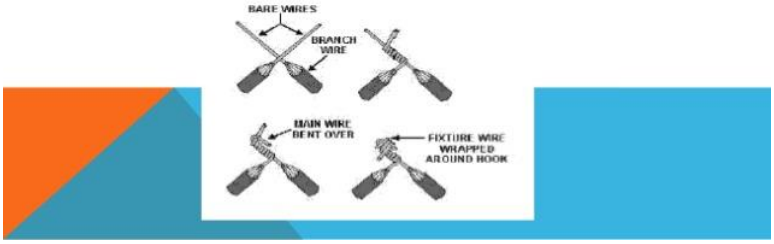
RATTAIL JOINT TYPES OF SPLICES

A splice that is used in a junction box and for connecting branch circuits is the rattail joint (the figure below).



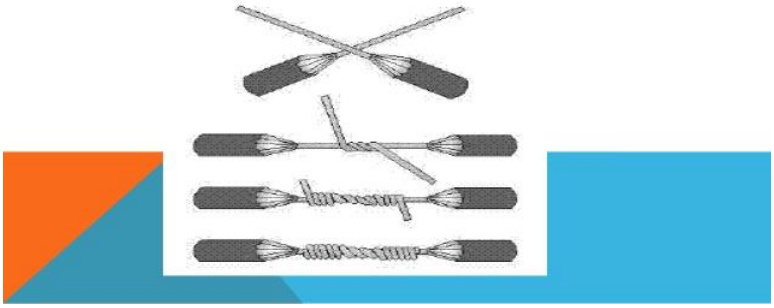
FIXTURE JOINT TYPES OF SPLICES

The fixture joint is used to connect a small-diameter wire, such as in a lighting fixture, to a larger diameter wire used in a branch circuit. Like the rattail joint, the fixture joint will not stand much strain.



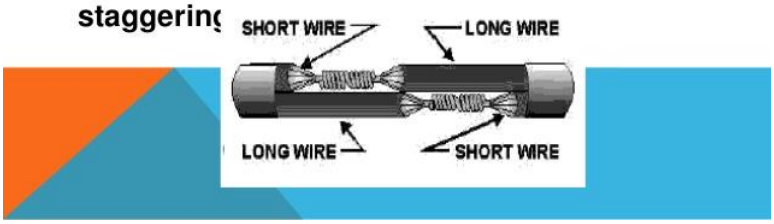
WESTERN-UNION-SPLICE.

The Western Union splice joins small, solid conductors. The Figure below shows the steps in making a Western Union splice.



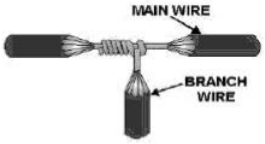
STAGGERING TYPES OF SPLICES

Joining small multiconductor cables often presents a problem. Each conductor must be spliced and taped. If the splices are directly opposite each other, the overall size of the joint becomes large and bulky. A smoother and less bulky joint can be made by staggering



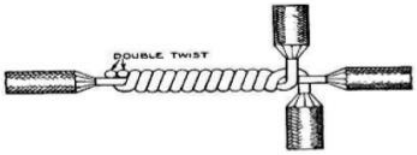
KNOTTED TAP JOINT TYPES OF SPLICES

All the splices discussed up to this point are known as butted splices. Each was made by joining the free ends of the conductors together. Sometimes, however, it is necessary to join a branch conductor to a continuous wire called the main wire. Such a junctio[illegible] is called a tap joint



Duplex cross joint

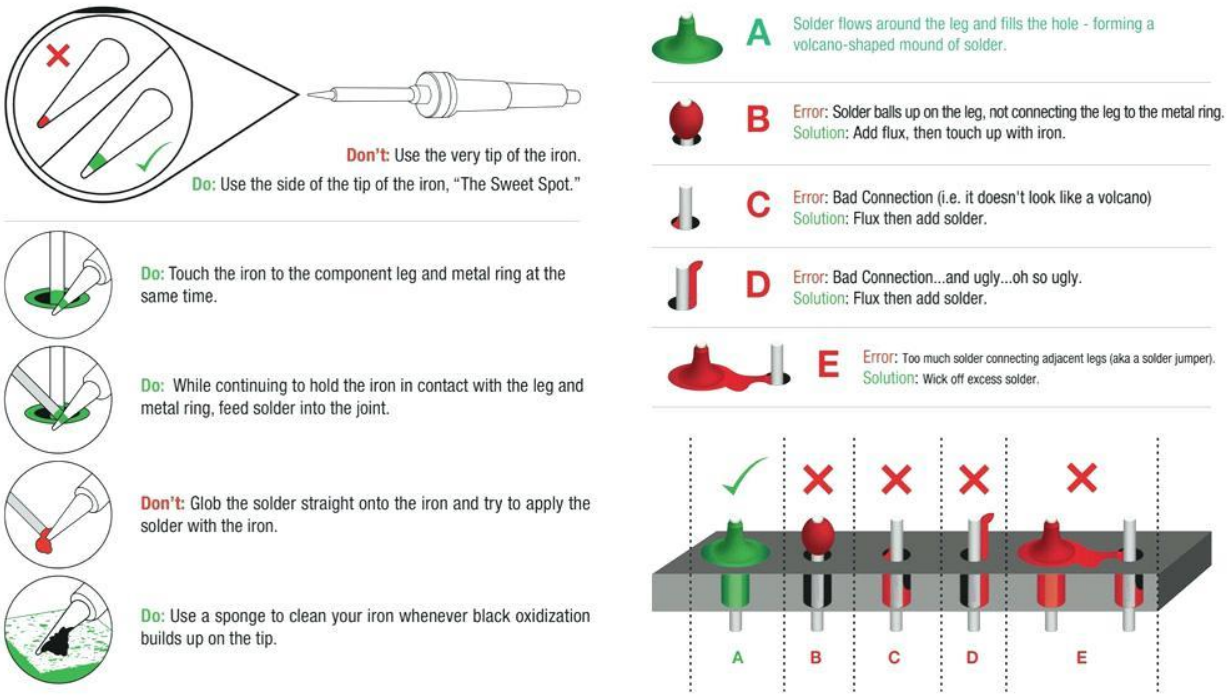
- **This is a two-tap** wire turned simultaneously and is used where the two tap wire is under heavy tensile stress

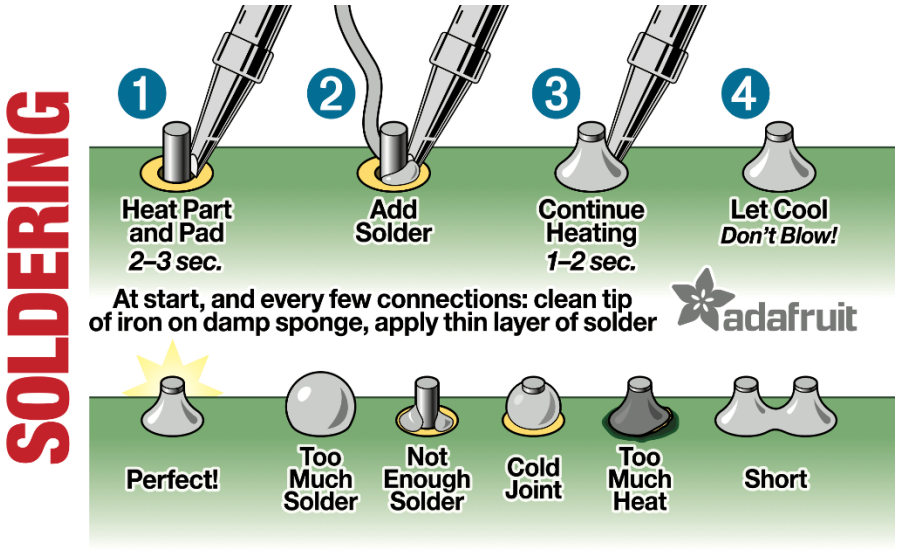


PART V

Through hole

This soldering method is common for circuit boards.





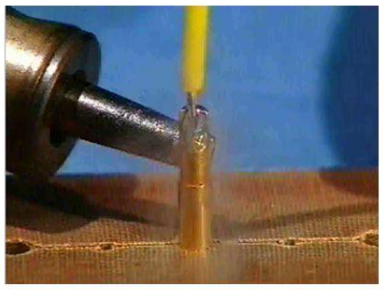
PART VI

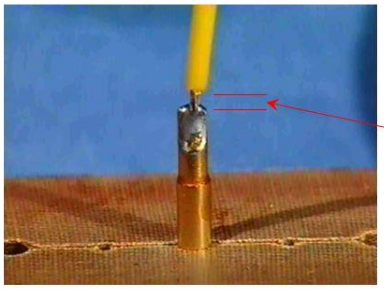
Solder cup

This soldering method common in end connectors and wall panels. How much wire you strip and the shape of the solder are important for proper electrical connections.

Soldering the Solder Cup

- Do not move wire until solder has solidified.
- No solder splash or overflow onto the outside of the cup terminal.





- Minimum insulation gap may contact the solder, but shall not be covered by solder.

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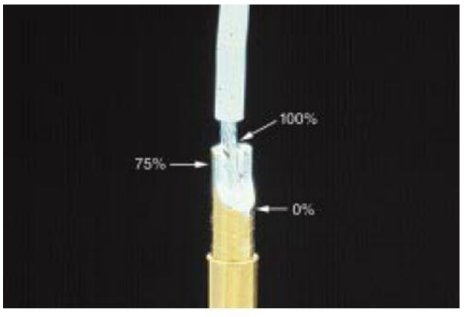
Inspecting Solder Cups



Target – Class 1, 2, 3

- Solder wets the entire inside of the cup.
- Solder fill is 100%.

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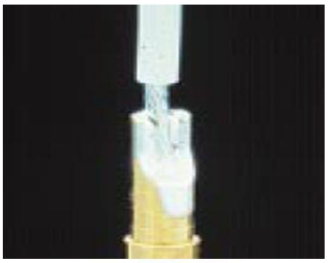
Inspecting Solder Cups (cont)



Acceptable – Class 1, 2, 3

- Thin film of solder on the outside of the cup.
- Solder fill 75% or more.
- Solder buildup on the outside of the cup, as long as it does not affect form, fit, or function.

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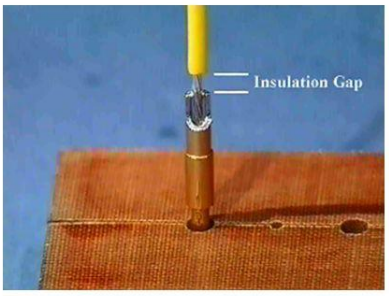
Inspecting Solder Cups (cont)

- Maximum insulation gap should be less than 2 times the wire diameter, or 1.5mm, whichever is larger. Target clearance is 1 wire diameter.



Example

- A 30 Ga. teflon insulated wire has a diameter over the insulation of .029". This would abide by the 1.5mm (.059") limit or less.
- A 16 Ga. teflon insulated wire has a diameter over the insulation of .075". The 2x guideline would be used so the max allowable insulation clearance would be .150" or less.

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PART VII

Things to avoid

- Solder creep

  In materials science, creep (sometimes called cold flow) is the tendency of a solid material to move slowly or deform permanently under the influence of mechanical stresses. It can occur as a result of long-term exposure to high levels of stress that are still below the yield strength of the material.

  Common failures are the solder “creeping” under the insulation and a break occurring that isn’t visible to inspection without test equipment.

- Solder bridges

  A solder bridge is an unintended electrical connection between two conductors by means of a small blob of solder. PCBs use solder masks to prevent this from happening.

- Overheated joint

  The solder has not yet flowed well, and the residue of burnt flux will make fixing this joint difficult.

  Repair: An overheated joint can usually be repaired after cleaning. Careful scraping with the tip of a knife, or little isopropyl alcohol & a toothbrush will remove the burnt flux.

- Cold Solder Joint

  A 'Cold Joint' is one where the solder did not melt completely. It is often characterized by a rough or lumpy surface. Cold joints are unreliable. The solder bond will be poor and the cracks may develop in the joint over time.

  Blowing on the solder joint to cool faster can lead to a version of a cold solder joint. It can cool the materials unevenly leading to cracks or uneven bonding.

  Repair: Cold joints can usually be repaired by simply re-heating the joint with a hot iron until the solder flows.

PART VII

Other resources

https://learn.adafruit.com/adafruit-guide-excellent-soldering/common-problems

https://www.neurochrome.com/choosing-solder/

https://learn.sparkfun.com/tutorials/how-to-solder-through-hole-soldering/all

https://www.instructables.com/id/How-to-solder/

https://www.youtube.com/watch?v=xPkc6k5uWUQ&t=250s

http://www.sal.wisc.edu/docs/Soldering%20Basics.pdf