A GUIDE TO SOLDERING

Introduction:
Soldering may be defined as the technique of uniting metal to metal by means of flux, a solder alloy, and heat...the flux making it possible for the molten solder to go into solution or “wet” with the parts to be joined when heated above the melt temperature of the solder alloy.

Soldering Prerequisites:
To unite two parts with solder, several things are necessary. Remembering these basic requirements will save much time and effort and assure excellent results.

1. **Solderability** The metals or surfaces to solder must be of the types which will go into solution with the tin-lead alloys.
2. **Heat** A heat source capable of rapidly bringing the temperature of the surface to roughly 100 degrees over the melt point of the solder must be used.
3. **Flux** A chemical flux must be used to loosen the oxides from the metal to be soldered so that molten solder can go into solution with the metals being joined. When soldering any part of an electrical or electronic circuit, use only a rosin or activated rosin flux in either liquid, paint, or flux cored solder form. Never use a water soluble organic or inorganic flux for soldering circuitry.
4. **Solder** The correct solder alloy or tin to lead ratio is the one which will go into solution with the parts being joined and, at the same time, meet the specific job requirements of strength, conductivity, surface coating, and adhesion.

The Solder Joint:
The reliability of a soldered joint is influenced by many factors. These must be considered before the joint is made and during the soldering process. The following steps are basic requirements in making a soldered joint:

1. **Joint fit** Parts to be joined should be in intimate contact to assure that the finished joint is mechanically strong and electrically sound.
2. **Surface preparation** The surfaces of the parts to be joined must be cleaned before tinning or soldering according to the following procedures:
   a. Grease and oils must be removed with suitable organic solvents.
   b. Heavy oxides, scale, and dirt must be removed by mechanical means.
   c. Chemical methods of cleaning may be used where tests prove that no corrosive residue results.
3. **Heat** The surfaces being joined must be heated above the flow temperature of the solder. The application of heat should be controlled during the soldering operation to prevent damage to components of the assembly. Heat sinks should be used when necessary to protect heat sensitive parts during the soldering operation.
4. **Solder** The quantity of solder used should be no more than is required to make a satisfactory joint. Solder should be touched to or laid in the joint area. Solder should not, except in special instances, be carried to the work on the iron. When this is necessary, fresh solder should be applied to the clean well-tinned tip and transferred to the joint as quickly as possible to avoid contamination of the solder as the result of prolonged
heating. When using wire or foil performs in a joint, all surfaces of the perform and joint should be coated with a thin film of flux before heating.

5. **Cooling the joint** No liquids shall be used to cool a soldered joint. After soldering, the soldered joint must not be disturbed until the solder has completely solidified and should not be stressed until it has cooled.

**Dressing and Tinning of Soldering Iron Tips:**

**Clad tips:**
Follow manufacturers instructions. Generally, do not file clad tips.

**Copper and copper alloy tips:**
1. Insert a clean tip into a core (handle) which is free from scale. **Caution** – The tips must be bottomed in the barrel and secured in place.
2. Dress (file or sand) tips to remove oxides and pits.
3. Apply cored solder to tip as the iron is heating. Tin the entire working surface. **Note:** The solder must flow evenly on the tip. If tinning is not complete, redress and repeat steps (2) and (3) until satisfactory results are obtained. When the tip becomes dirty or discolored with use, it may be quickly restored by applying cored solder and wiping on a pad, brass brush, or damp cellulose sponge.
4. Store iron in holder during idling with a minimum amount of solder on the tip (to reduce pitting).

**Tinning the Conductors:**
Tinning of lead wires is a process of applying a thin coating of solder to the exposed surface of the stripped lead. Wires are tinned to bond the strands together to prevent fraying during handling and to preserve the solderability of the surface. Tinning on wires should not be closer than approximately 1/16 inch to the insulation. This space permits the operator to observe solder flow at the time the wire is terminated and thus assists in control of solder wicking during final termination.

**Tinning Standards:**
The following tinning standards apply:
1. **Full Tin** Tin entire stripped ends to within approximately 1/16 inch of the insulation
2. **Tip Tin** Tip of wire tinned approximately 1/8 inch to prevent fraying. Solder used in tinning should be the same as that which will be used for final junction.
3. Solder on leads should be kept to a minimum and should not obscure the strands. The tinning time should be as short as possible, consistent with good solder flow.

**Soldering with Rosin Cored Solder:**
The following general considerations are essential to obtain good solder joints:
1. Ensure that parts to be joined are clean.
2. Ensure that any mechanical bond is secure (3/4 to 1 turn wrap). Inspect leads for damage to strands.
3. Keep insulation of wire out of the joint area.
4. Check iron for proper heat. Touch cored solder to tip and see that it flows freely.
5. Wipe soldering iron on pad to remove excess solder and dross. **Note:** the tinned soldering tip should be smooth, clean, and bright.
6. Position heat sinks if required.
7. Apply the flat of the tip to the joint to get maximum contact between tip and joint. Heat the surfaces being joined to above flow temperature of solder. **Caution:** Be careful not to touch the wire insulation or nearby components with the iron.
8. Apply the cored solder at the junction between the wire and terminal. **Note:** Solder should be melted on surfaces to be soldered. Solder should not be carried to work by the iron. Apply only enough solder to complete the joint.
9. When sufficient solder has flowed onto the junction and the joint exhibits proper wetting action, the solder is removed first and then the tip is withdrawn with a wiping motion. **Caution:** Do not allow the joint to move while the solder hardens. Do not hold iron on junction longer than necessary.
10. The operator shall determine that the joint has the following characteristics before proceeding to the next termination.
   a. Proper amount of solder
   b. Adequate coverage and properly formed fillets.
   c. Solder has flowed on mating parts and exhibits a smooth even surface showing the approximate outline of the joint.
11. Proceed to the next joint. Normally it is not necessary to clean iron tip between each terminal when making a series of joints unless required.

**For Electrical Connections:**
The following items should be checked on all connections:
1. Soldering flux in use should be specified for the specific application. Rosin type flux is generally used for electronic assembly. Rosin flux residues on connections or on adjacent areas where it has been deactivated by heat should be permitted, provided they do not interfere with the function of the device.
2. The solder in use should be 60% tin, 40% lead unless otherwise specified.
3. Characteristics of a good solder joint.
   a. Smooth continuous flow of solder
   b. Solder shows evidence of wetting the surface of the wire and the terminal. This is characterized by a condition in which the solder forms a tapered or feathered blend (fillets) on the wire and terminal.
   c. Mating surfaces of the joint are adequately covered with solder in such a manner that the approximate contour of the objects soldered is discernible.
   d. Connections free from entrapment of foreign materials.
   e. Pin holes or small areas not covered by solder are acceptable. The amount of unsoldered area should not exceed approximately five percent of the joint area.
   f. Insulation close to the joint, but not included. The insulation back should not exceed 1/8 inch measured from insulation to the normal periphery of the terminal or solder joint, whichever is greater. Optimum insulation, back on all terminals, is 1/16 inch.
   g. Wire ends cut off close to terminal and firmly held with solder.
4. **Defects** These are characteristics of solder joints which may be cause for rejection.
   a. **Excessive solder** Excessive solder is a condition which completely obscures the joint configuration.
b. **Cold solder joint** A solder joint where the solder has flowed around the wire, lead, and/or terminal, but has not bonded the wire and terminal together. This condition is characterized by the lack of wetting action or feathering (formation) of the solder to the terminal and/or wire.

c. **Fractured joint** A fractured joint is caused by movement of the parts while the solder is in the semi-liquid or plastic range. It is characterized by strain marks and fractures on the surface and may be grainy in appearance.

d. **Rosin joint** This joint is similar in appearance to a cold solder joint, but in addition often shows excessive flux residue. This flux residue may separate and partially insulate the components of the joint at one or more points, producing a loose and often an electrically intermittent joint.

e. **Insufficient solder** This defect is characterized by lack of adequate solder coating of the joint. **Caution:** Exercise care in handling components, wires, and devices in the process of inspection. Use a properly insulated probe if aid is required. Do not use lead pencils as a probe; graphite is a conductor and may cause electrical shorts. Scribers or sharp pointed probes should not be used unless specified.

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**Physical Appearance of a Solder Joint:**

**Acceptable joints** Good solder joints, regardless of construction, will have similar general appearance. The solder will be clean, smooth and bright (the degree of brightness will vary with the solder alloy being used). The surfaces being joined will be covered with a coating of solder which leaves the general outline of the surface visible. A smooth fillet between the surface should taper to a feathered edge away from the joint.

**Dross:** Oxide scum thrown off from molten solder.

**Fillet:** A concave junction formed where the solder unites with two or more separate surfaces.

**Flux:** A substance applied to surfaces to clean them and help promote their union.

**Heat sink:** Any of a number of metal devices used to dissipate heat.

**Solder:** One metal or a mixture of metals used for joining metal surfaces together.

**Solder wicking:** Is the controlled flow of molten solder up a stranded wire; similar to capillary action.