UNITED STATES MARINE CORPS
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U-08B10
DEC 99

STUDENT HANDOUT

SOLDERING

Terminal Leraning Objective:

Given a schematic, a faulty generator set electrical system, and applicable tools and test equipment, with the aid of references, repair the generator set electrical system so that it functions properly in accordance with the appropriate equipment technical manual. (1142.1.2)

Enableing Learning Objective:

(1) Provided a Soldering Kit, tools, with the aid of references, solder a bifuricated terminal connection in accordance with the High Reliability Interconnection Handbook. (1142.01.03bc)

(2) Provided a Soldering Kit, tools, with the aid of references, solder a axial lead component connection in accordance with the High Reliability Interconnection Handbook. (1142.01.03bd)

(3) Provided a Soldering Kit, tools, with the aid of references, solder an cup terminal connection, in accordance with the High Reliability Interconnection Handbook. (1142.01.03be)

(4) Provided a Soldering Kit, tools, with the aid of references, solder an turret terminal connection, in accordance with the High Reliability Interconnection Handbook. (1142.01.03bf)

Outline:

1. **Soldering**:

a. Soldering is the process of connecting two pieces of metal together to form a reliable electrical path. I stress reliable because when you use mechanical methods of connecting metals you leave yourself open for one of the two major problems of mechanical connections. You cannot be sure of a good connection. Vibration or mechanical shock may work the connection loose or oxidation or corrosion will continually be building up on the surface, decreasing the electrical connection between the two metals. A soldered connection does away with these problems. You have good connections that vibration and shock will not work loose and oxidation cannot happen at the joint. Thus a continuous conductive path is formed. This is made possible by the very unusual property of solder itself.

(1) Solder is a metal alloy made by combining lead and tin in different proportions. When these proportions are equal, it is known as 50-50 solder. Therefore, 60-40 solder is 60% tin and 40% lead. You can usually find markings on the solder roll. The chemical symbol for tin is SN, so a roll of solder marked SN60 means that is 60% tin.

(2) The amazing fact about solder is that its low melting point is 375 degrees F. As you can see this is much lower than either metal. Melting, except for one case, does not take place at once. 60/40 solder starts to melt at 361 degrees F and is fully melted at 375 degrees F. Between these two temperatures solder exists in a plastic or semiplastic state. The plastic range of solder varies depending on the ratio of tin to lead. As shown here, you can see the various plastic ranges. With most ratios, solder begins to melt at 361 degrees F, but the full melting temperatures vary dramatically. The one special case where solder begins to melt and reaches the full liquid state at 361 degrees F is called SN63 or antimony solder. The solder most commonly used in electronic repair is the 60/40 type.

b. When soldering, be careful not to move any element of the joint during the cool down period. If you do, it will result in what is called a disturbed joint. Characteristically this type joint has a rough irregular appearance and looks dull instead of bright and shiny. This is an unacceptable joint in high reliability soldering

c. Soldering is not simply sticking metal together like some hot glue. What actually happens is far different. When the hot solder comes into contact with the copper surface, a metal solvent action takes place.

(1) Solder dissolves and penetrates the copper surface. The molecules of copper and solder blend together to form a new metal alloy with characteristics all its own. This action is called etting, and forms the intermetallic bond between the parts.

(2) Wetting can only occur if the surface of the copper is free of contamination and oxides. Even though a surface may look clean before soldering, it must be cleaned by using abrasives and solvents. To remove oxides, flux is used. Many types of fluxes are available in paste and liquid forms. The fluxes used in electronic work are basically rosin in a modified form and may contain mild activators to accelerate their action. Remember, fluxes that have an acid base should never be used for electronic repair because they remain corrosive at all temperatures. Rosin fluxes, although they are relatively noncorrosive when cool, should still be removed with a solvent after soldering.

d. In any kind of soldering the primary requirement other than solder, is the use of heat. There are many arguments for and against the various types of soldering irons available, but controlling tip temperature is not the real problem of soldering. The real problem is controlling the heat cycle of work, how fast the work gets hot, how hot the work gets, and how long it stays hot. This is affected by so

many factors that you will see that tip temperature is not critical at all.

(1) The first factor you must consider is the relative thermal mass of the joint. This means how much mass you have to heat to perform the solder job.

(2) The second factor is the surface condition of the metal or are
there any oxides or contaminates at the joint. These can and will form a barrier to the heat.

(3) The third factor to consider is thermal linkage or the area of contact between the iron tip and the work.

e. The area of contact will be greatly increased by using a solder bridge to provide more thermal linkage and thus assure the rapid transfer of heat.

(1) Just putting the iron against the object to be soldered creates a small linkage area.

(2) By making a solder bridge we have now created a large linkage area. As should now be apparent, there are more factors than tip temperature that will affect how quickly any given joint will heat up. What makes it so critical is time. The general rule for high reliability soldering on printed circuit boards is apply heat for no more than two seconds. Any longer than this and you may begin to damage the board or the component. It would appear that the soldering process is too complex to control in such a short period of time. There is a simple solution to it. This is the work piece indicator or W.P.I.

f. W.P.I can be defined as the reaction of the work piece to the work actions being performed on it. These are actions that are discernible to the human senses of sight, touch, smell, taste, and sound for soldering. The primary work piece indicator is heat rate recognition or how fast heat is flowing into the joint. In practice this means observing the rate at which solder melts, which should be one or two seconds. The rule is to get in and out as fast as you can. Remember, board damage comes mainly from heat and pressure. The pressure on the iron should be no more than the weight of a pencil resting on its tip.

g. A 30 watt pencil soldering iron with changeable tips is a good all around iron for electronic soldering. To prepare the tip, check for full insertion into the heating element or the element will develop a hot spot and burn out. Remove the tip daily to prevent oxidation scale from accumulating. Maintain a bright thin continuous surface on the tip to ensure proper heat transfer and to avoid the transfer of impurities to the solder connection. Maintain the hot tinned tip by wiping it lightly on a noncontaminating brush to remove flux and burned solder. Then shake off the oxides on a wet sponge. Apply the iron tip to the maximum thermal mass point of the joint to be soldered. Solder will flow from the cooler area to the hotter

area. Solder applied to a cleaned, fluxed and properly heated surface will melt and flow without direct contact with the heat source and provide a smooth, even surface, filtering out to a thin edge.

2. **Turret Terminal Connection**:

a. Strip and tin insulated wire before soldering to these terminals. There are many types of strippers, one type is a mechanical stripper that must be calibrated. This is the type of stripper that we will be using for this class. The wire stripper/cutter with the V notch should never be used because it will nick the opening. The safest and easiest method is with a thermal wire stripper.

b. Pre-tin stranded wire to prevent bird caging of the wire. Do not disturb the natural lay of the wire. Also, do not let solder run up under the insulation. This action is called wicking. The clearance gap should be one to two times the insulated wire's diameter. This is done by placing the iron on the table, placing the conductor in the center of the tip, moving the conductor towards the insulation and then back down to the end of the conductor always feeding solder on the tip.

c. Wrap the wire around the terminal using a pair of round nose pliers. This loop may be 180 degrees or 270 degrees. The 360 degree wrap is no longer recommended. When only connecting one conductor, place it in the lower section flat down against the base. This will cause any mechanical stress to be transferred more readily to the board. When two wires are attached, bring them both in from the same direction and wrap them in the same direction. You may place the second conductor on top of the first conductor or you may place it on the next platform. The insulation clearance, not to be confused with the insulation gap, should be one to two times the insulated wire's diameter.

d. The soldering procedure has four basic steps. Apply the iron at the point of maximum thermal mass.

(1) Make a solder bridge between the tip and the work to increase the thermal linkage.

(2) Apply solder to a point opposite that which the tip contacts. Paint it on using a light touch and remove it.

(3) Then remove the iron using a forward wiping motion.

e. Now inspect the finished joint. Clean it with solvent to remove all flux and impurities. It must have a bright and shiny surface with solder feathering out smoothly which indicates good wetting, and no pits on the surface. The fillets on the side of the joint must be CAGightly concave with good adherence of solder to wire and terminal. You should also see the outline of the individual strands of wire of the conductor.

3. **Cup Terminal Connection**:

a. A cup type terminal is actually a hollow cylinder into which the conductor is inserted and then soldered.

b. The preform solder method is the recommended procedure. Insert the pretinned wire into the cup to measure for the correct length and trim it to provide the proper insulation clearance of one to two wire diameter.

(1) Twist a short length of 22 gauge solder tightly to make the preferred, then insert it into the cup and cut it off flush with the top of the terminal.

(2) Apply the iron until the solder melt is observed.

(3) Insert the wire and gently rock it to the front and rear twice. This will remove all air left in the cup.

c. The preferred joint has the wire fully inserted to the bottom of the cup. There is an insulation clearance of one to two lead diameters. The surface of the solder is bright and shiny and the fillets are CAGightly concave. There is good wetting of the surface and no pockets of gas or flux trapped in the solder joint. Finally, solder must not be spilled over and down the sides of the cup.

d. Because soldering to cup terminals is often done in small areas, and the heat from the tip of the iron may burn adjacent wires, a resistance soldering tool may be used. The tool has a pair of electrodes that grip the cup and allow current to be sent through it. The electrical resistance of the terminal creates a power dissipation of sufficient degree to provide enough heat for the solder to flow. Power to the electodes is cut off before the electrodes are cut preventing arcing and burns.

4. **Bifurcated Terminal Connection**:

a. Wires may enter these terminals in several different ways, from the side, top, or bottom. The most common entry is the side entry. The wrap may be either a 90 degree or 180 degree wrap. The 180 degree wrap is used on wire of 28 AWG or less. First you put the tinned wire across the terminal to obtain the proper insulation clearance. Then form a 90 degree bend using a pair of long nose pliers. Position the conductor and trim for 90 degree bends. The lead should not protrude beyond the diameter of the terminal.

b. Apply the iron to the point of maximum thermal mass.

(1) Make a solder bridge to increase thermal linkage.

(2) Apply solder to the opposite side of the iron.

(3) Remove the iron with a wiping motion. Due to this terminal's large thermal mass, remove the iron before removing the solder and then paint the solder on between the forks to cover the

hole. Use extreme care here. If solder flows down into the hole, it is an unacceptable solder connection.

c. The joint should be smooth and bright with an undisturbed surface. A concave fillet should exist on all sides of the conductor. Individual conductor strands should be visible. The end of the conductor should not exceed the diameter of the terminal and the hole of the terminal should be covered without excessive solder flowing into it.

5. Soldering Axial Lead Connection:

a. Examples of axial lead components are resistors and diodes. Soldering components to circuit boards requires extreme caution due to the heat sensitivity of both the board and component. You must remember to apply heat only for one to two seconds after solder melt, and use only the pressure equivalent to the weight of a pencil resting on its point.

b. Clean the leads of the component before soldering. The preferred method is to tin the lead. Do this in the same manner as tinning wire. Then bend the leads using a component forming tool or pliers with nonserrated jaws.

c. To use the component forming tool, span the distance between the holes and then tighten down the knob. Center the component in between the forming post and roll the leads to an upright position. The component should be able to fall into place without force.

d. For straight through lead termination.

(1) Cut off the inserted lead not to exceed the length of the pad's radius. For a clinched lead termination at a pad track combination, first insert the leads and semiclinch them and then cut to a length equal to the pad diameter.

(2) Press the end of the lead flat with a nonmetallic tool along the center line of the track.

e. To solder the leads, first make a solder bridge with the solder iron tip on the lead and pad, because this is the point of greatest thermal mass in the joint.

(1) Then paint the solder on and remove it.

(2) Then remove the soldering iron with a wiping motion to cover the end of the lead with solder.

f. The acceptable joint straight-through lead is a smooth and well feathered surface out to the edge, with no pits or holes, or

evidence of flux. The appearance of the surface is bright and shinny and shows a CAGight concave characteristic.

g. The acceptable joint for a clinched lead is smooth and well feathered to the edge; no pits, holes, or evidence of flux; bright shiny surface with CAGight concave fillet characteristics. The shape of the underlaying conductor must be visible. The work piece indicator for this solder joint will be the length of the solder flow along the track. Excessive solder flow indicates too long of a heat dwell time.

h. The most common unacceptable joints are:

(1) Rosin joint caused by too little heat applied which leaves a
quantity of solidified flux between the conductor and the terminal.

(2) Cold solder joint caused by withdrawing the heat too soon. The solder never reaches the liquid stage. The solder beads up and may show peaks.

(3) Disturbed joint caused by the movement of the lead while the solder is solidifying. It will have a frosty and granulated surface and may also show cracks.

(4) Overheated joint caused by repeated attempts to repair a joint that does not wet properly due to contamination or lack of sufficient flux. This joint will have a chalky, dull, or crystalline appearance.

REFERENCE:

1. HRITH HANDBOOK

LIST OF SUPPORTING PAPERS

1. STUDENT HANDOUT

2. ITV TAPE BASIC SOLDERING FOR ELECTRONICS

3. ITV TAPE REWORK AND REPAIR FOR ELECTRONICS

4. CAGIDES:

CAG #1	TITLE PAGE
CAG #2	OBJECTIVES
CAG #3	PLASTIC RANGE
CAG #4	WETTING ACTION
CAG #5	FLUX
CAG #6	SMALL LINKAGE AREA
CAG #7	LARGE LINKAGE AREA
CAG #8	WORK PIECE INDICATORS
CAG #9	CROSS SECTION VIEW
CAG #10	MECHANICAL WIRE STRIPPERS
CAG #11	TURRET TERMINAL BENDS
CAG #12	TURRET TERMINAL STEPS
CAG #13	ACCEPTABLE TURRET TERMINAL JOINTS
CAG #14	CUP TERMINAL PREPARATION
CAG #15	CUP TERMINAL STEPS
CAG #16	ACCEPTABLE CUP TERMINAL JOINTS
CAG #17	RESISTANCE TOOL
CAG #18	BIFURCATED TERMINAL LEAD PLACEMENT
CAG #19	BIFURCATED TERMINAL STEPS
CAG #20	ACCEPTABLE BIFURCATED TERMINAL JOINTS
CAG #21	AXIAL LEAD COMPONENT FORMING
CAG #22	AXIAL LEAD COMPONENT PLACEMENT
CAG #23	AXIAL LEAD COMPONENT STEPS
CAG #24	ACCEPTABLE STRIGHT-THROUGH LEAD JOINTS
CAG #25	ACCEPTABLE CLINCHED LEAD JOINTS
CAG #26	UNACCEPTABLE JOINTS