CHAPTER 5

SYSTEM TROUBLESHOOTING AND CALIBRATION

TABLE OF CONTENTS

CHAPTER 5

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PAGE

PAGE

CHAPTER 5
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5.0 SYSTEM TROUBLESHOOTING AND CALIBRATION

5.1 INTRODUCTION

In its simplest form, a weighing system consists of a load sensing device to measure a force, and a read-out device to interpret and display a force. However, in actuality, the makings of a weighing system are much more complex. The accuracy of a weighing system is dependent upon more than just the load sensing device and the read-out. The accuracy of a weighing system is dependent upon such system factors as the scale mechanical structure, surrounding structure, physical-restraint devices, and environment.

5.2 MECHANICAL STRUCTURE

The mechanical structure of a scale and the surrounding structure must be designed so that it applies the weight to the load sensing device without encountering physical impedances. For example, a scale platform must not deflect or sag under applied load so much that it comes into contact with sub-structures. Precautions, such as flexible rubber or canvas dust boots, must be taken to prevent build-up of dirt or refuse under a scale which can impede scale performance. Tilting or vibrating of the scale structure caused by weak supports, and/or nearby traffic can also deteriorate performance.

5.3 PHYSICAL RESTRAINTS

Physical restraint devices, such as stay rods that prevent a scale from sliding off load cells must not inhibit vertical deflection of the scale. Lateral restraint devices that are not installed truly horizontal, or that are excessively pre-tensioned can inhibit vertical deflection of a scale, deteriorating the scale's performance and accuracy.

5.4 ENVIRONMENT

The environment also plays an important role in the performance of weighing systems. Temperature variations can cause expansion and contraction of the scale structure or physical restraint devices. Corrosion caused by chemical atmospheres or high humidity can restrict scale deflection. Electrical connections and electronic circuitry must also be protected from corrosive atmospheres.

5.5 VISUAL INSPECTION

Prior to calibrating or troubleshooting a weighing system, a thorough visual inspection is absolutely essential. Locating mechanical restrictions and defects early can save countless hours of troubleshooting and re-calibrating weighing systems. In support of this philosophy to precede all scale maintenance with a visual inspection, the following examples are presented:

EXAMPLE #1

A major fiberglass manufacturer installed some scales at the output of a glass making furnace. Glass coming from the furnace was formed into small balls, similar to a marble for ease of transport. Wooden tubs were placed upon the platform scales and filled with glass balls. Diverter gates were automatically shifted when a tub was filled to a pre-determined weight. After several months of operation, the customer complained that the diverter gate failed to operate, overloading the wooden tub and covering the floor of the factory with glass marbles, creating a dangerous situation for employees. Visual inspection of the weighing system revealed a build-up of glass under the platform. As the platform deflected with weight, the underside came in contact with the build-up, preventing further scale deflection. The scale failed to show any further weight increase, so it never reached the trip point. The solution was to clean out the area under the platform scales and install a very soft, flexible rubber skirt around the platform preventing any future build-up.

EXAMPLE #2

A chemical manufacturer stated that a tank-weighing system suddenly began giving inaccurate weight readings. The weighing system indicator only registered about 75% of the weight of a full tank. Visual inspection revealed that a steel ladder had been welded to the side of the tank; the feet of the ladder were bolted to the floor. The ladder was supporting a portion of the weight that should have been supported by the load cells under the tank. The solution was to cut off the feet of the ladder, as it was rigidly welded to the tank, and inform the customer not to attempt to weigh anything with someone on the ladder.

5.6 SYSTEM CALIBRATION

Calibration of a weighing system insures proper and correct operation of the system. Calibration compensates for and corrects small errors in scale structure, load sensing element and read-out device. Calibration can be performed by several methods, but only dead-weight and dead-weight/material substitution methods are accepted by Weights and Measures agencies. Electronic calibration and calibrated material transfer methods of calibration will also be discussed.

5.7 ELECTRONIC CALIBRATION

Electronic calibration is performed by replacing a load cell in an electronic weighing system with a precision calibrator. Calibrators are available from system manufacturers. They are devices that electrically simulate the output of load cells. This method of calibration does not compensate for any mechanical errors that might arise, such as load cells out of plumb or mechanical restrictions on the weigh vessel or platform.

PROCEDURE

1. Replace load cell with calibrator per manufacturer's instructions and wiring codes. In multiple transducer systems, only one of the load cells need be substituted.

2. With calibrator set at zero, adjust the scale indicator to read zero.

3. Adjust calibrator to produce output of approximately full scale. In multiple transducer systems, the calibrator is set to the output of one cell times the number of cells, for example, four transducer system, each transducer puts out 2 mv/v at 10,000 lbs. Adjust calibrator to 8 mv/v to read full scale of 40,000 lbs.

4. Adjust instrument span control until read-out shows proper weight for signal applied.

5. Return calibrator to zero, apply weight simulating signal in several increments to full scale and check for proper linearity of the instrument.

5.8 CALIBRATED MATERIAL TRANSFER METHOD

The calibrated material transfer method of system calibration is performed by weighing a material on nearby scales of known accuracy and transferring the material to the system under test. Accuracies obtained using this method strictly depend upon the care taken in weighing and transferring the test material. For example, a tank truck may be weighed empty on a truck scale then filled with material and re-weighed. How much gasoline was consumed in the drives between weighings or in the drive to the transfer site? Did the driver stay in the truck during all weighings? How much material was lost in the transfer from truck to weigh vessel?

PROCEDURE

1. Adjust scale read-out to zero.

2. Apply approximately full scale weight to scale, and remove. This exercises the scale and insures basic operation.

3. Re-zero scale read-out if necessary after exercising.

4. Apply calibrated material to scale of between 80% and 100% of full scale, and adjust instrument span control for proper read-out.

5. Remove weight, check for zero return.

6. Apply calibrated material to scale, in increments of about 10% to full scale. This checks for system repeatability and linearity.

5.9 DEAD-WEIGHT METHOD

This method is suitable for high accuracy weighing systems, however, it is limited to about 12,000 lbs. due to the difficulty in obtaining and working with weights larger than 3,000 lbs. When certified weights are used, the dead-weight method of system calibration is acceptable to Weights and Measures agencies.

PROCEDURE

1. Adjust scale read-out to zero.

2. Apply approximately full scale weight to scale and adjust instrument span control for proper reading. This exercises the scale and sets the instrument calibration close.

3. Remove weights and re-adjust instrument zero, if necessary.

4. Add weights in increments of about 10% of full scale, recording readings at each step. System linearity is determined from these readings.

5. At full load, re-adjust span if necessary. If a large correction is necessary, it may be necessary to remove the weights and repeat steps 3 through 5.

6. Remove weights weights and check for zero return.

5.10 DEAD-WEIGHT/MATERIAL-SUBSTITUTION METHOD

The dead-weight/material substitution method of calibration is performed on high accuracy systems where it is not possible to use calibrated weights to system full scale. This method is acceptable to Weights and Measures agencies. Obtain certified weights of the largest capacity which can be conveniently handled. Ideally, the total amount of calibrated weights should not be less than 5% of total system capacity. For example, not less than 5,000 lbs. of weights should be used to calibrate a 100,000 lb. system. A suitable method must be devised to attach weights to the vessel, keeping in mind that the weights must be removed and re-attached several times during a typical calibration.

PROCEDURE

1. Exercise weighing system by applying approximately full scale weight to vessel.

2. Remove weight and adjust instrument to read zero.

3. Apply first increment of dead-weights. Record reading.

4. Remove dead-weights and apply substitute material to system until the exact reading as recorded in the previous step is obtained.

5. Re-attach dead weights and record reading.

6. Repeat this dead-weight/material-substitution procedure (steps 4 and 5) until desired full scale weight of system is achieved.

7. At full load, adjust instrument span if necessary. If a large correction is required, it may be necessary to remove the material and repeat steps 2 through 7.

8. Remove material and dead-weights; check for zero return.

5.11 TROUBLESHOOTING

Troubleshooting is the process of determining that a problem exists, identifying the problem symptoms, determining the problem, correcting the problem, and finally, verifying that a problem no longer exists. Any complete system will have these five basic functions: Input; Control; Process; Output and Feedback. Many individual pieces of equipment have all five functions and the ability to identify these functions is basic to troubleshooting. Besides a thorough knowledge of system operation, a good troubleshooter must know what types of equipment faults are common. All equipment faults can generally be categorized into three basic types; Manufacturer's defects, Installation or Maintenance errors and Component failure.

5.12 MANUFACTURER'S DEFECTS

Manufacturer's defects do occur. They result from defective material or workmanship and usually occur at or soon after installation. Defective workmanship frequently shows up as illogical fault; something not anticipated or thought of. Most often, manufacturer's defects result in complete breakdown of the equipment and can sometimes cause further damage. Often, systems have self-protection against anticipated failures, however, they never protect themselves from Manufacturer's defects.

5.13 INSTALLATION OR MAINTENANCE ERRORS

Installation or maintenance errors are the second general category of faults. They occur as a result of the installer not following plans, inserting components backwards, not aligning sub-parts according to specifications. How many times have you heard "close-enough?", "Is it really?", "Do you know what the acceptable tolerances are?" Frequently installation errors show up soon after an installation is completed, maintenance errors also follow closely on the heels of a maintenance attempt. The one maintenance error which takes time in showing up is the simple omission of regular preventive maintenance.

5.14 COMPONENT FAILURE

Finally and fortunately for us as troubleshooters, the most common cause of faults is component failure. They may simply wear beyond tolerance, fatigue, deteriorate from age or environment, be abused by improper use or infrequently be subjected to excessive stress because of improper design. Whatever the cause of a system fault, our job is to find it. Some knowledge of how it works, what it is supposed to do and what type of faults are likely, is a big boost in localizing the culprit.

5.15 TROUBLESHOOTING/BASIC TECHNIQUES

Regardless of the size or kind of system or equipment, good troubleshooting begins with an orderly logical approach. The more complex the system, the more important an orderly logical approach becomes. When trying to determine why your car bounces five times for every bump you run over, you don't remove the spark plugs to see if they are burning white. You apply your knowledge of the car, what is supposed to ease the bumps, and check your shocks and springs.

In electronic equipment, it is not always possible to go immediately to the trouble area simply from an evaluation of what is happening and your knowledge of what is supposed to happen. In this case our logic step is to establish a process of elimination. Find a mid point in our process system and determine if it is working properly. If so, move in logical sized steps toward the output. If not, move towards the input. This is called the split-in-half method. You continuously split sections in half until you come to the faulty section. Another approach is the stage-by-stage, either output to input or input to output. Which end you start on is best determined by you and your knowledge of the equipment, your evaluation of where the trouble is, near the input or near the output.

5.16 COMPONENT ISOLATION

Component isolation is a technique best resorted to after you have determined the exact stage in which the trouble exists. It is the process of checking each component part individually for proper size, shape, value, appearance, etc.

5.17 SUCCESSIVE APPROXIMATION

Successive approximation must often be used whenever symptoms occur only when equipment is in operation and repair or adjustment can be made only when equipment is not running. We are forced to stop the equipment, make adjustments in small controlled increments, run equipment and note results, stop equipment, make another adjustment and then try the equipment again. This sequence is repeated until proper operation is achieved.

5.18 TROUBLESHOOTING/GENERAL PROCEDURE

5.19 COLLECT INFORMATION

The first step in troubleshooting is to collect information. Talk to the operator, look at the output product, review the history and try to get a feel for what the symptom or symptoms are. Often, knowing there was a big power surge just before a failure can be a significant clue to the problem. Knowing that a problem occurs only when operated in a certain sequence and does not occur in other sequences of operation can be a definite clue of where to start looking for the cause.

5.20 INSPECT THE EQUIPMENT

The second step, inspecting the equipment, can often be performed while doing the first step. Use your senses; look, smell, feel and listen; however, don't rush in until you have carefully reviewed safety requirements. Check the rules, identify hazards, use caution. Your inspection for the cause of the trouble should check general conditions, signs of abuse, incorrect operation, by-passed interlocks and safeties, fuses and relays. Look for broken, burned, discolored, misshaped parts and components. Inspect cables for signs of wear, check that line power is available. Feel for temperatures, smell for unusual odors, listen for klunks, kinks and groans, anything your knowledge of the equipment tells you is unusual.

5.21 MAKE OPERATIONAL CHECKS

Verify for yourself that you know all

the symptoms. Review manuals and specification data to insure that you know what to expect as normal. Operate manually if possible to reduce the possibility of causing further failure. If necessary and safe, operate equipment under power. Observe all symptoms and define the operating conditions under which they occur. You must treat the true problem, not just the symptom. Too often, a worn or damaged part is unknowingly left in a machine and its effect only temporarily compensated for by re-adjustment, because the troubleshooter treated only the symptom.

5.22 FOLLOW STANDARD TEST PROCEDURES

Review your knowledge of how the equipment is supposed to work. All equipment has a logical system of operation and your procedure should follow along this logic, sometimes it is defined by a series of check lists, or a troubleshooting chart or table. When you don't have these aids, you need to determine a logical sequence of checks to conduct. This sequence must be one which follows along in the system sequence or is opposite it, i.e., input to output or output to input. If you are going to check the power supply, check all voltages delivered from it. If you are following a signal that is as it should be (moving towards the output where the output is incorrect) stay with it until you come to an incorrect indication.

5.23 MAKE NECESSARY REPAIRS

Once you have identified the cause of the problem you must make necessary repairs. This may mean simple adjustment or complete overhaul or anything in between. The important thing is that you corrected the cause of the problem; not just compensated or counterbalanced it.

5.24 DEMONSTRATE CORRECT OPERATION

Once repairs have been completed, demonstrate operation. Prove that your repair corrected the problem. Check to see if other problems masked or hidden are now apparent. Let the operator use and prove to himself that the equipment is working correctly.

As a troubleshooter, it is also your responsibility to leave the work area clean and in order, removing all debris and materials from the floor and equipment. This extra step is a good habit to develop; it shows professionalism and the mark of a good technician.

5.25 TROUBLESHOOTING/TEN STEP PROCEDURE

Problems in equipment can be located and corrected by many procedures. The proper one depends on 1, the problem; 2, test equipment; and 3, your approach in solving it. You may have several ideas of how to approach a certain problem and you may use all of them before deciding on the best one.

In troubleshooting a system in the customer's plant or store, you are generally in a strange location with little or no test equipment. Your only objective is to get the equipment back into proper operation in a minimum amount of time.

There are several procedures to pinpoint a problem, all requiring a logical approach to isolate that defect by using effect-to-cause reasoning which can be broken down into a 10-step procedure (See Table 5.1, Effect-to-Cause-Reasoning, 10-Step Procedure).

STEP 1. DETERMINE THE TROUBLE

To save time, ask the operator, question him and listen. This is particularly true if the problem is intermittent and happens occasionally. Remember, in questioning the customer, he may not understand technical terms, so keep your questions in terms he will understand. Ask him to describe the problems. You can get a better idea of the exact nature of his complaint. Sometimes it is impossible to get someone to give the true indication of the complaint, so go to STEP 2.

STEP 2. CONFIRM THE PROBLEM

Know the equipment, how it should work. Check its performance to decide if the operator has given you the true picture. This can save considerable time. Frequently, it is a simple defect, but always keep in mind, "Is the problem in the electronics or from some outside source such as low or high power, mechanical problems, vibrations, interference?" Remember, the output is only as good as the input on electronic indicators (GI/GO - garbage in; garbage out).

STEP 3. EFFECT-TO-CAUSE REASONING

After you have determined and confirmed the complaint from STEPS 1 and 2, apply reasoning to isolate the defect to one section of the equipment. Often the information you have already received will lead you directly to the defective section, or even a stage of the section. Sometimes the information may be so general that you cannot reach a definite conclusion, then you must make tests to isolate the section.

STEP 4. INSPECT FOR SURFACE DEFECTS

Look for defects such as cable connections, both interconnections from remote sources, power plug in, PCB out of sockets, blown fuses, broken or shorted prints on PCB, bad solder connections. Listen for strange noises, arcing, etc. Notice odors such as burned components. Touch components, they may be loose, or an IC component may be warm, indicating it may be defective.

STEP 5. ISOLATE THE DEFECTIVE SECTION

There are many clues that will help determine which section is defective. The fact that some problems affect both the major indicators or some remote indication such as adding machines, tape punches, score boards, etc.; removing these will tell which is the defective section of a system. By applying effect-to-cause reasoning, you can often by-pass this step; but in some cases it may be necessary to make some preliminary tests to isolate the defect to one section.

STEP 6. ISOLATE THE DEFECTIVE STAGE

Use signal tracing, signal simulation or other service procedures to isolate the defective stage. Once you have localized the trouble to one stage, effect-to-cause-reasoning will lead you to make certain tests, unless the trouble is easily solved by a replacement, such as a printed circuit board.

STEP 7. ISOLATE THE DEFECTIVE CIRCUIT

When you have narrowed the problem to one circuit, you may be able to go directly to the defective stage, then you can go directly to the defective part.

STEP 8. ISOLATE THE DEFECTIVE PART

Now that you have located the faulty circuit, it is possible that you may spot the part that is bad by visual inspection or you may have to use your test equipment to make voltage or resistance measurements.

STEP 9. REPAIR OR REPLACE DEFECTIVE PART

If the replaced part is repairable, such as a printed circuit board, it is to everyone's advantage that to the best of your knowledge, you have pinpointed the faulty component and proven the board is bad. This information stated on all paperwork will greatly increase the repair time of bad boards once they are received at a repair department.

STEP 10. CHECK PERFORMANCE

After making repairs, try the equipment to be sure the customer's complaint has been eliminated. Let him see the operation. It is most important that you remain until the operator of the equipment checks out the operation. This is only proper and makes for good customer relations.

5.26 WORKMANSHIP STANDARDS

This section describes the requirements for installing component parts in conventional assemblies either with terminals or etched circuit boards. These standards are presented as a guide to assist with the installation of these parts in an assembly.

Good workmanship insures that the performance or physical characteristics of the components are not degraded by handling or installation, and that service can be performed expeditiously.

5.27 INSTALLATION/ASSEMBLY OF COMPONENTS

Care should be exercised to avoid unnecessary bending of leads. Components should be installed so that leads do not cross over other parts as shown in Figure 5.1

TABLE 5.1

EFFECT-TO-CAUSE REASONING	
10-STEP PROCEDURE	
1.	DETERMINE THE COMPLAINT Question the customer.
2.	CONFIRM THE COMPLAINT By checking performance.
3.	EFFECT-TO-CAUSE REASONING Try to figure the cause logically by observing the indication and go directly to the section, stage or part if possible. If not, follow the remaining steps.
4.	INSPECT FOR SURFACE DEFECTS Use your senses; sight, sound, touch and smell.
5.	ISOLATE THE DEFECTIVE SECTION By professional technique.
6.	ISOLATE THE DEFECTIVE STAGE By professional technique.
7.	ISOLATE THE DEFECTIVE CIRCUIT By professional technique.
8.	ISOLATE THE DEFECTIVE PART By professional technique.
9.	DEFECTIVE PART Repair or replace.
10.	PERFORMANCE Check.

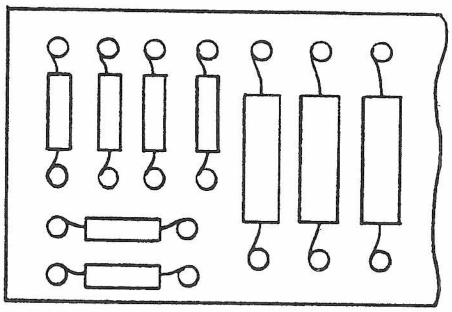


Figure 5.1. Preferred Component Layout

Wires and leads should not be connected to terminal posts or lugs by overlapping other wires and leads. Figure 5.2 shows acceptable practices.

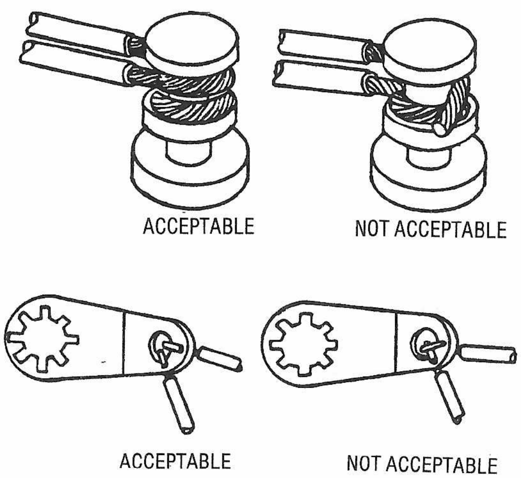


Figure 5.2. Terminal and Lug Wiring

5.28 READABILITY OF COMPONENT MARKINGS

Component parts are to be installed so that color coding, part identification marks, or inspecting marks are visible, as far as possible. Components should also be installed in such a manner that will not obscure markings or printed circuit boards, component boards, chassis, etc., consistent with good installation practices. See Figure 5.3 for preferred methods.

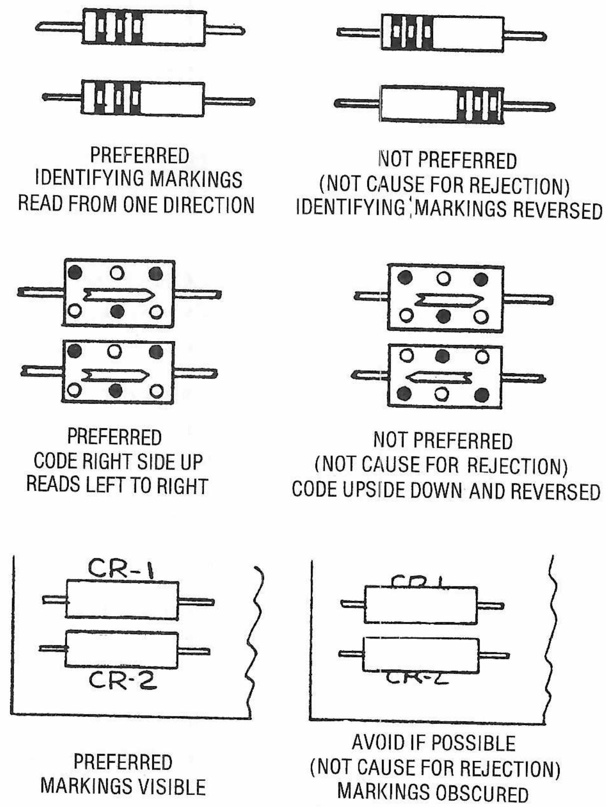


Figure 5.3. Layout for Readability

5.29 LEAD FORMING

Part lead forming should not stress the part body nor strain the lead-to-body connection. Leads should be formed as indicated in Figure 5.4. All leads should be formed using appropriate tools or by an automatic lead forming device approved for the application using a suitable holding mechanism to hold the lead firmly while bending is performed.

The minimum inner bend radius for a component part lead should not be less than the lead diameter as shown in Figure 5.4a. The working of a component part lead should begin no closer that 1/16 inch from the body seal or weld. See Figure 5.4b. Under no circumstances should the lead be bent or the part physically stretched in a soldered condition.

When using slotted terminals, the lead should be inserted as shown in Figure 5.4c. In areas where there is danger of injury or hazards to adjacent parts or wires, the wire or lead should be bent in either direction away from the outside of the mounting.

The preferred order of assembly of leads and wires on terminals is shown in Figure 5.4d. Note that service wires are those that are not completely contained within a subassembly. Service requirements or special design may dictate the use of alternate methods of lead arrangement and should be specified on the engineering document.

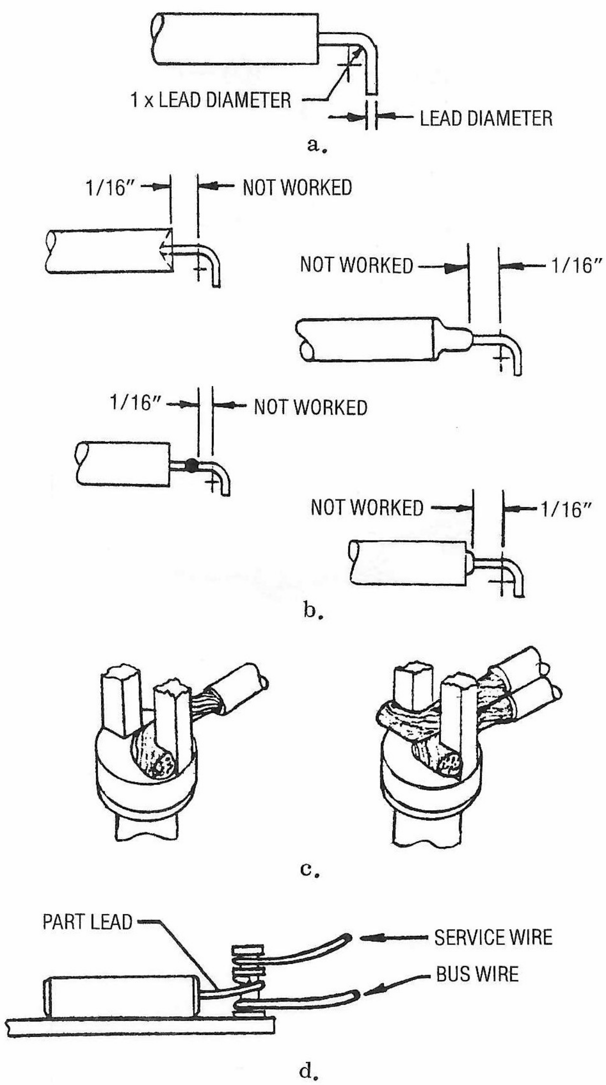


Figure 5.4. Lead Forming

5.30 NUMBER OF WIRES/LEADS PER TERMINAL

A maximum number of three (3) wires or leads can be terminated per hole in circular grounding lugs, terminal lugs (soldered type) (Figure 5.5b) or at a single-sided post, single-sided, single-section turret terminal (Figure 5.5c). This also applies to each section of a multi-section turret terminal and to each side of a double-sided terminal. Figure 5.5 shows the appropriate connections.

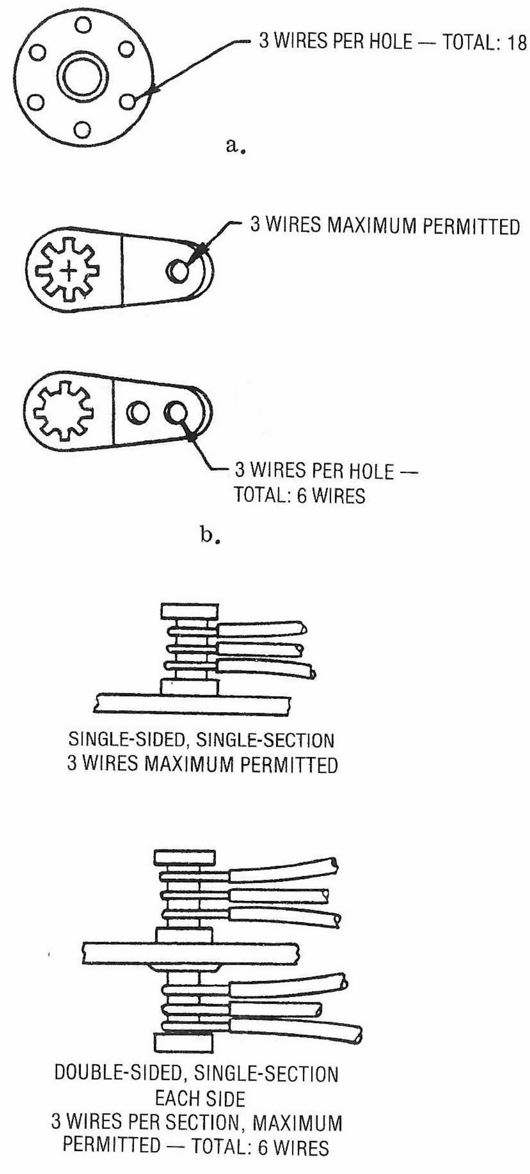
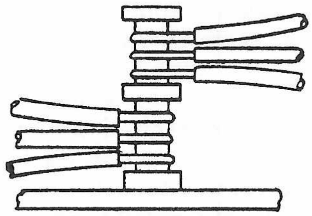
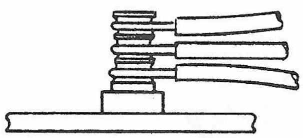


Figure 5.5. Wires/Leads per Terminal (continued)





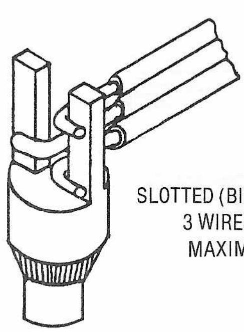
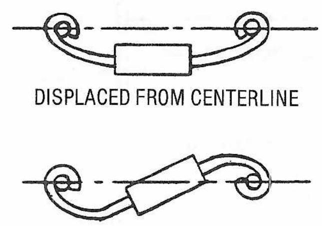


Figure 5.5 Wires/Leads per Terminal

5.31 COMPONENT PART MOUNTING AND SUPPORT

Component parts require careful handling to prevent damage. They should not be jarred nor subjected to strain through the connecting leads during installation. Either displace the component from the centerline of the terminal or mount diagonally, as shown in Figure 5.6a.

Component parts to be supported should be mounted close to the board before applying adhesive. When parts are to be covered with conformal coating, the other parts should rest on or be close to the board as shown in Figure 5.6b.



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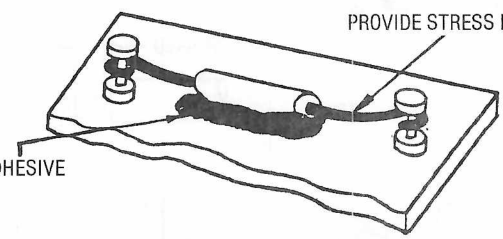


b.

Figure 5.6 Component Mounting and Support

5.32 WIRE PREPARATION

5.33 STRIPPING

Insulation should be stripped from the wire or leads with thermal or other approved stripping tools. Care must be taken to avoid nicking or damaging the wire or remaining insulation. The number of damaged strands in a single lead should not be more than indicated in Table 5.2. Slight discoloration of the insulation from using thermal stripping techniques is acceptable.

NO. OF STRANDS	MAXIMUM ALLOWABLE DAMAGED STRANDS
LESS THAN 7	0
7-15	1
16-18	2
19-25	3
26-36	4
37-40	5
41 OR MORE	6

Table 5.2. Wire Damage Limits

5.34 TINNING

All wire should be carefully tinned before wiring and/or soldering, except for #12 gage or larger and solderless terminal connections.

5.35 TWISTED PAIR WIRE

The number of twists in 16 to 24 size wire should not be less than 6 nor more than 15 per foot.

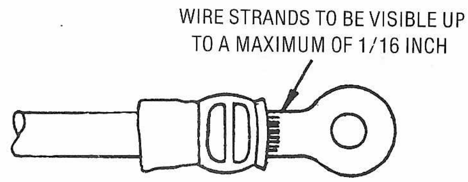
5.36 LUGGING

Crimping of solderless terminal lugs should be done so that the connection will meet the tensile strength requirements established on a sample basis made on terminals crimped at the same time as the equipment terminals are clamped. The solderless insulated terminal should be applied so that the insulation bottoms inside the terminal and the conductor projects through the terminal and is visible to a maximum of 1/16 inch. Tinning is not necessary. The terminal should be crimped over the lead insulation and conductor so that no motion or looseness exists between the terminal and conductor. See Figure 5.7a.

CAUTION

No insulation should exist in the inner conductor crimp area of the lug.

Assemble solderless uninsulated terminals with conductor and insulation clamping tabs so that the insulation stops about halfway between the two tabs as shown in Figure 5.7b. Clamp one set of tabs to the insulation and the other set to the conductor so that no motion or looseness exists between terminal and conductor.



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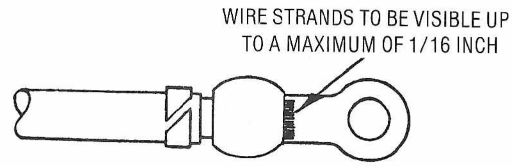


b.

Figure 5.7. Using Solderless Terminal Lugs

5.37 SPLICING

Wires in a continuous run between two terminals should not be spliced.

5.38 IDENTIFICATION REQUIREMENTS

Engineering drawings should specify and identify characters to be applied, the location, size, color, and applicable marking process. The actual identification characters that are applied should show evidence of good workmanship.

5.39 READABILITY OF WIRE MARKINGS

When specified, wire markings should be placed on conductors so as to permit the identifying characters to be readable. Whenever possible, cabling should be routed so as to not cover the markings on the chassis or components. See Figure 5.8.

5.40 LACING

Wire bundles should be laced using methods shown in Figure 5.9a. Lacing terminating knots should be heat sealed to prevent untying or unraveling. Lacing material should be flat braided nylon tape. Lacing should be tight enough to prevent slippage

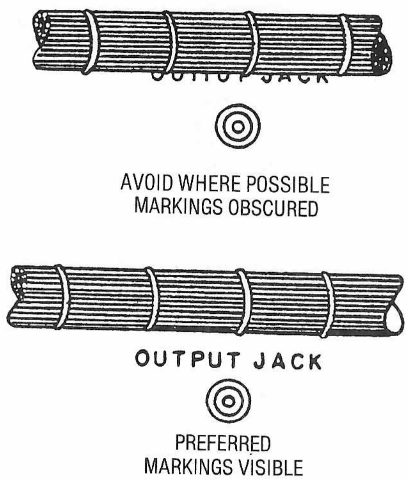


Figure 5.8. Readability of Markings

of the harness but not tight enough to cut the insulation. See Figure 5.9b.

When there is no longer any need for a conductor wire which forms a part of a harness, both ends of the wire should be clipped off even with the insulation (no bare copper wire permitted), folded back into the harness and secured. See Figure 5.9c.

5.41 SERVICE LOOPS

All harness wires to and from electronic component parts should have service loops except solid wire jumpers and stranded strapping wire or cable and connector assemblies. Single leads should not extend unsupported for more than six inches as shown in Figure 5.10a. Figure 5.10b through g show suggested methods of service loops or applicable wiring. Clamps, when used, should hold the cable or harness tightly enough to prevent movement within the clamps without damaging insulation of the clamped wire. Care should be taken so that harness wiring does not come into contact with heat generating parts.

Wire connecting two structural members that are capable of movement relative to each other should be securely clamped to each member with sufficient slack between to prevent mechanical strain.

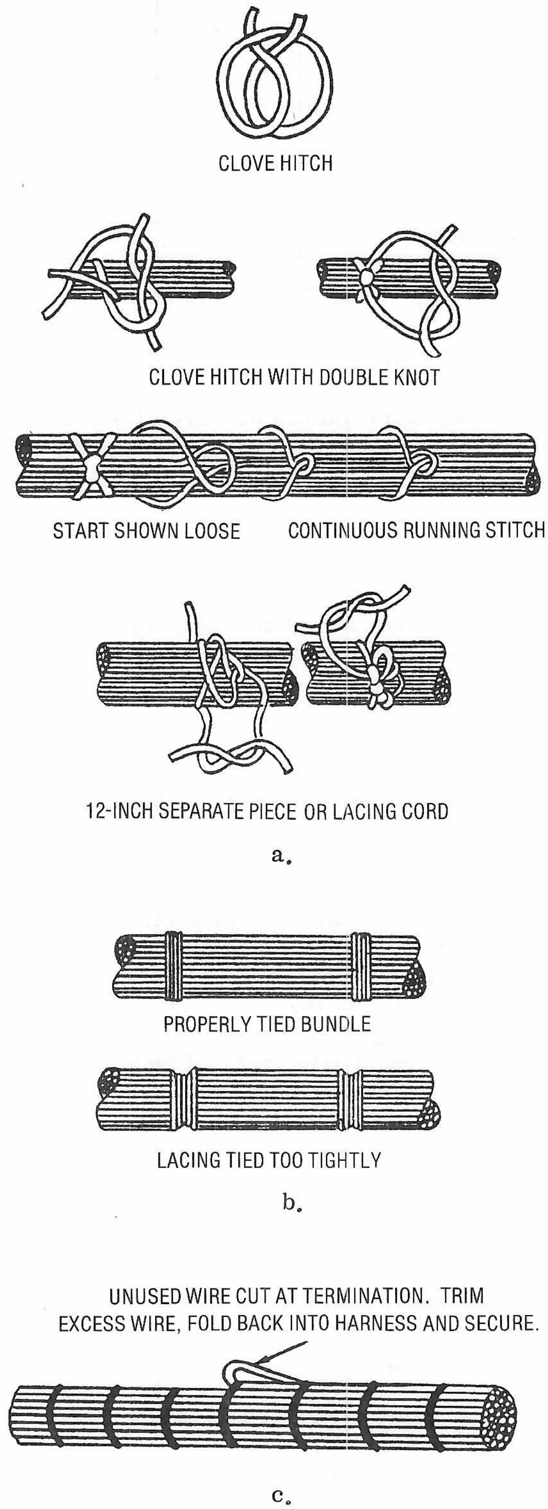


Figure 5.9. Lacing Techniques

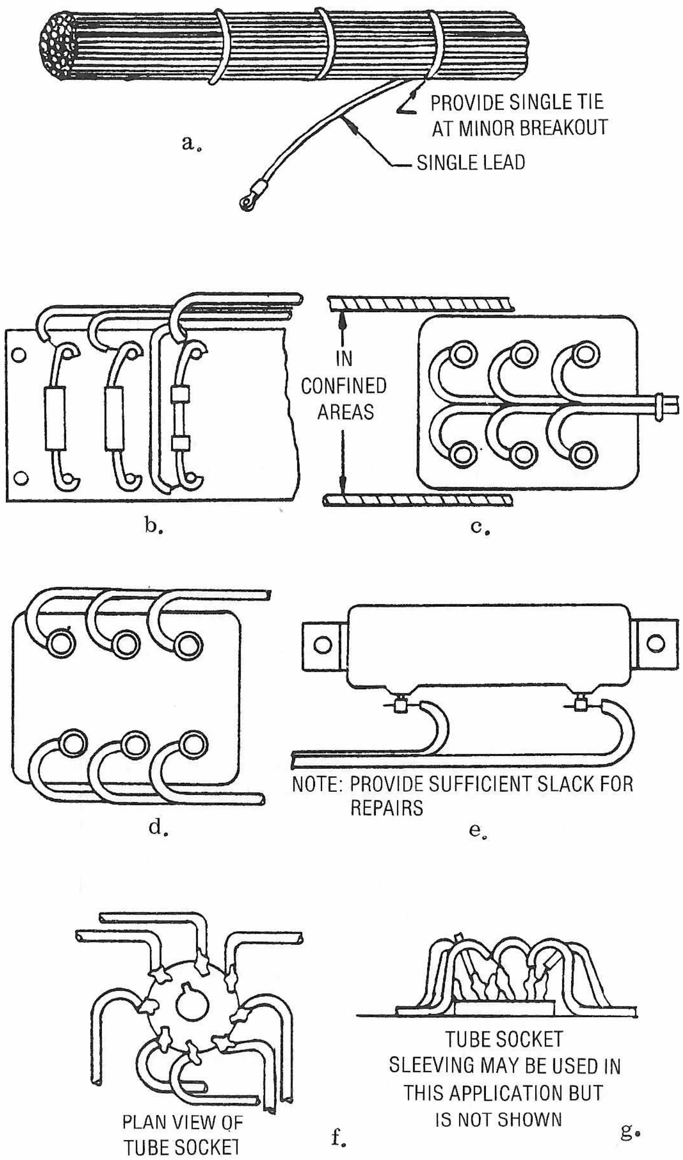


Figure 5.10. Service Loops

5.42 SOLDERING

5.43 CLEANING

Lead, wires, and surfaces should be clean before tinning or soldering. Oxides, scale, and dirt should be cleaned from surfaces to be soldered by scraping and cutting with an abrasive or by chemicals.

5.44 TINNING

Wire should be carefully tinned before wiring and soldering. Wires should be tinned only far enough on the wire to take full advantage of the terminal or receptacle. Wires to be soldered should be twisted with lay and tinned. Avoid burning insulation during soldering.

5.45 FLUX AND CLEANING AGENTS

Use an approved non-corrosive flux. Remove flux residue from surfaces of electrical contacts or other surfaces where the flux may interfere with the operation of the components. Ultrasonic cleaning may be used on printed circuit boards prior to assembling any components other than terminals or lugs.

5.46 SOLDERING TO TERMINALS

5.47 TURRET TERMINALS

Wire wraps or leads to be soldered to a turret terminal around the terminal a minimum of 1/2 turn to a maximum of one full turn without lead extension or crossover. See Figure 5-11a.

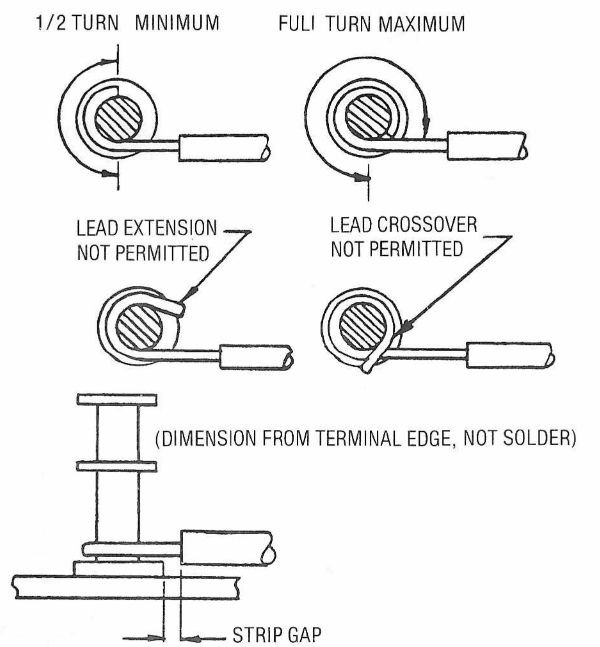
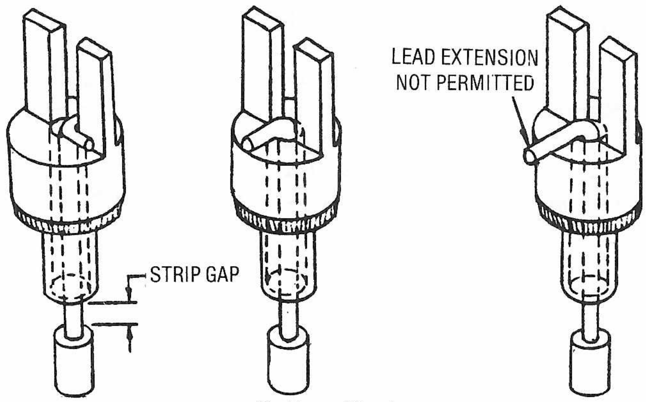


Figure 5.11. Soldering to Turret Terminals

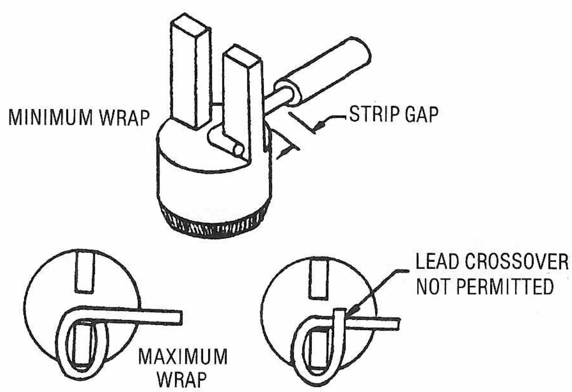
5.48 SLOTTED TERMINALS (BIFURCATED)

Solder a wire or lead to slotted terminals using any of the following methods as indicated by the terminal design.

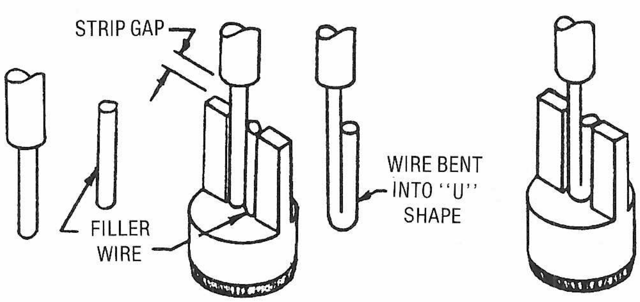
a. Bottom Route. Terminate wire or lead with a 90-degree bend around post, in contact with terminal bare and no lead extension. Alternate method is also shown in Figure 5.12 a.



a. Bottom Route



b. Side Route



c. Top Route

Figure 5.12. Soldering to Slotted Terminals

b. Side Route. Wire or lead enters perpendicular with 90-degree bend around post; is in contact with two surfaces of the terminal. Alternate method also shown in Figure 5.12b.

c. Top Route. Wire or lead enters mounting slot parallel to axis of the terminal. See Figure 5.12c for alternate methods.

5.49 HOOK AND PIERCED TERMINALS

Solder wires or leads to hook and pierced terminals as shown in Figure 5.13. When more than one lead is terminated at a common terminal, secure alternately from opposite sides of the terminal.

5.50 CUP TERMINALS

Bottom wires and leads in cup terminal before soldering. All wire strands should be within the cup. See Figure 5.14.

5.51. FEED-THRU TERMINALS

Wires and leads should protrude a miminum of 1/16 inch to a maximum of 1/8 inch before soldering as shown in Figure 5.15.

5.52 STRIP GAP

The maximum exposed conductor, referred to as strip gap in the illustrations on the following page, should be 1/16 inch or the outer diameter of the insulation, whichever is greater. There should always be some visible clearance. See Figure 5.16.

5.53 STRESS RELIEF FOR MOUNTED LEADS

Provide stress relief as shown in Figure 5.17 for all leads.

5.54 TERMINATING LARGE DIAMETER WIRE

When a relatively large diameter wire is terminated at a pierced terminal with thin cross section, bend the wire back upon itself in a hook. If the pierced terminal is too small wrap the wire around the terminal as shown in Figure 5.18 without crossing over.

5.55 GENERAL SOLDERING PRACTICES

a. MECHANICAL FASTENERS. Screws, bolts, nuts, rivets, etc., should not be soldered unless specified.

b. HEATING. All areas of joint to be soldered should be at or above flow temperature

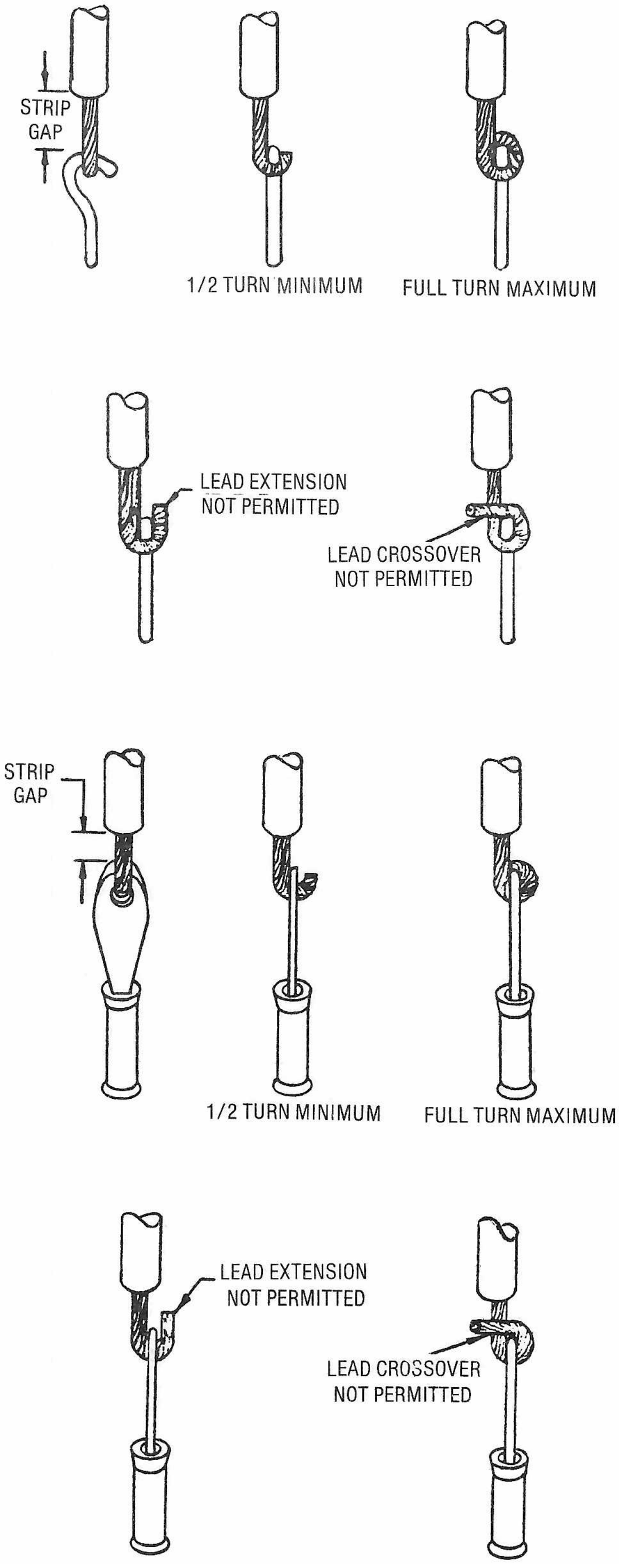


Figure 5.13. Soldering to Hook and Pierced Terminals

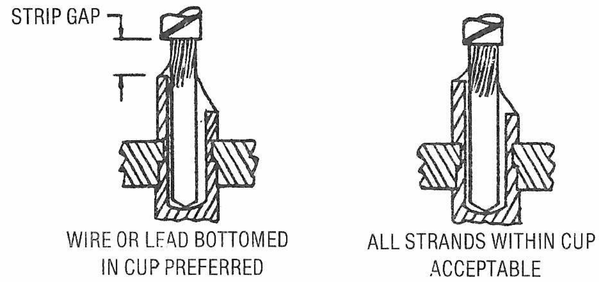


Figure 5.14. Soldering to Cup Terminals

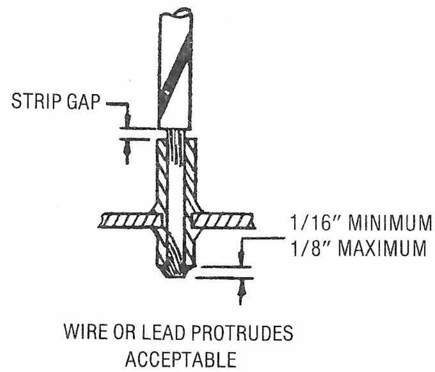


Figure 5.15. Soldering to Feed-thru Terminals

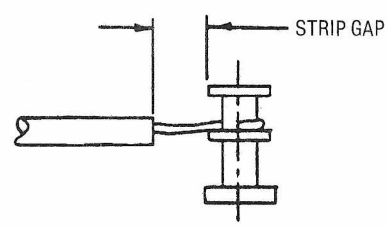


Figure 5.16. Strip Gap

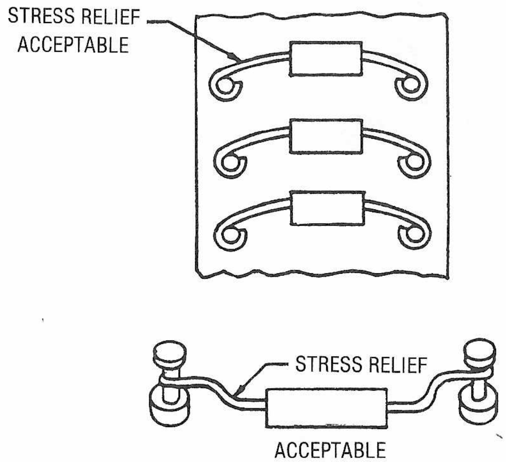


Figure 5.17. Stress Relief

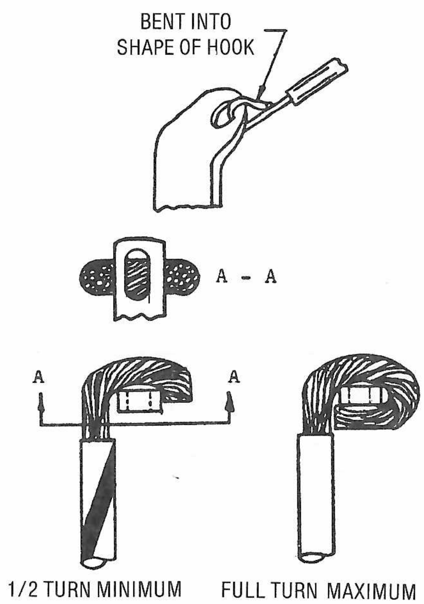


Figure 5.18. Terminating Large Diameter Wire

of the solder so that solder melts on the part. Solder should be applied directly to the joint not the soldering iron.

c. SOLDERING IRON. Select a soldering iron that will provide heat to produce a good joint without overheating. Hold heating time to a minimum to prevent damage to component.

d. MINIATURE CONNECTORS. Special care is necessary when soldering to miniature connectors so that insulation is not softened or damaged. Remove excess flux from connector.

e. HEAT SINKS. Use suitable heat dissipating clamps or devices when hand soldering to leads or components with critical heat tolerance, i.e., transistors, diodes, precision resistors, etc. Heat sinks are not necessary when soldering under a controlled time cycle approved for the application.

f. HANDLING. Do not disturb joint until solder has solidified. Do not use liquid to cool a solder joint.

g. ACCEPTABLE JOINTS. Solder joints must be clean, shiny, and smooth. The outline of the wire and terminal should be evident. The wire and terminal should be covered with solder as the joint and the solder should be bonded to the metals being joined. Use only a small amount of solder, well sweated into the joint, to cover and bond the wire to the terminal feathered to a thin edge indicating proper flowing and wetting. Excess wire should be cut off and insulation dressed back from the terminal. In the case of a small wire in a large terminal wire, it is not necessary to cover the entire hole with solder. Use only enough for a well-bonded connection.

h. SOLDER. Solder to be used should be tin/lead, rosin-flux core as specified on engineering drawings.

i. WICKING. There should be no excessive wicking of solder back along the wire under the insulation. Wire strands must be discernible at the insulation termination.

j. UNACCEPTABLE SOLDER JOINTS. Solder joints must not have the following defects:

1. Cracks, separation, poor solder flow due to improper heating or cleaning.

2. Frosty appearance, indicating overheating or movement before solidifying.

3. Flux inclusions and porosity characteristics of a rosin joint.

4. Excessive, spattered, or solder run down outside of terminal.

5. Insufficient solder.

6. Swelled or burned insulation.

7. Chipped, cracked, or swelled insulators.

8. Unlaying of stranded wire.

5.56 COMPONENT PART MOUNTING

Mount component parts so that all or a part of the body of the component is close to or in contact with the printed circuit board. Insulated parts mounted over a conductor may be in direct contact with the conductor otherwise use a jacket for the component part or place a pad of insulation material between component and conductor or mount component 1/16 inch above the conductor.

When the design prevents contacts with the board, the part should be mounted as shown in Figure 5.19.

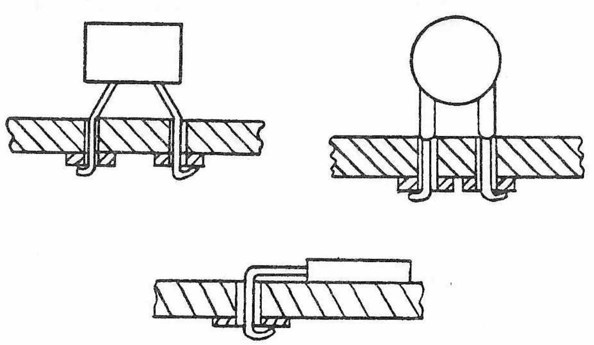


Figure 5.19. Special Mounting Methods

5.57 SOLDERING PRINTED CIRCUIT BOARDS

When soldering leads in plated-thru holes on double-sided boards, a fillet should be formed on both sides of the board. Solder should cover 80% of the terminal area and 80% of the component side. See Figure 5.20 for acceptable soldering.

On funnel-flanged eyelet holes, a solder fillet should be formed on both sides of the board under the flange. Solder should cover

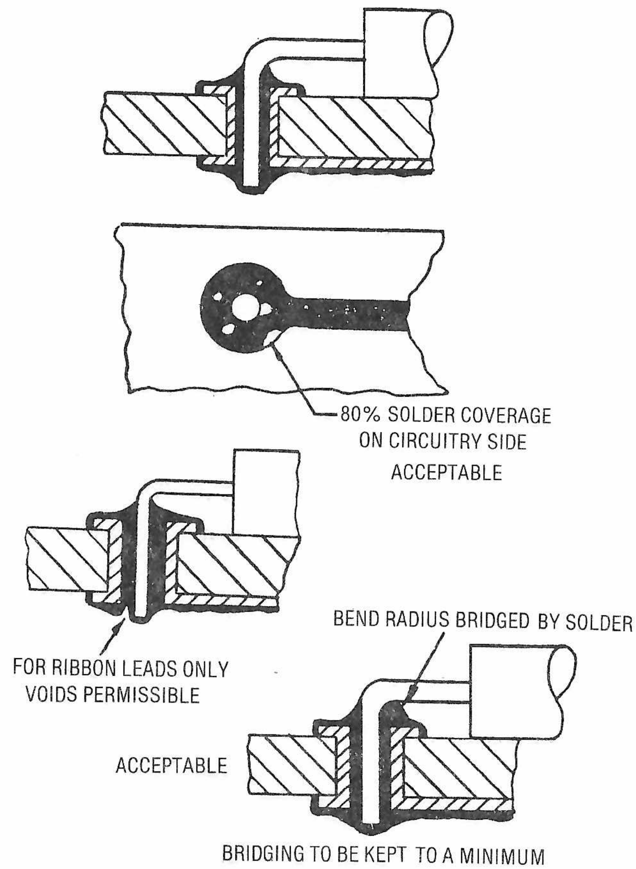


Figure 5.20. Soldering Plated-Thru Holes

80% of the area on both sides. See Figure 5.21. Solder that bridges across the bend radius of a lead is not acceptable.

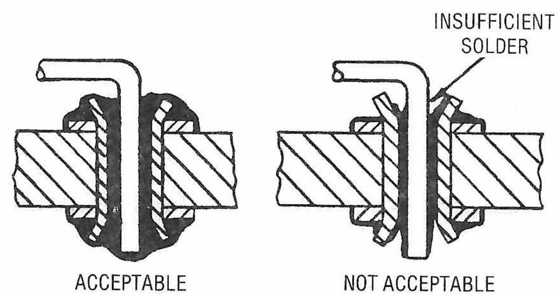


Figure 5.21. Soldering to Eyelet Holes

When soldering funnel-flanged standoff terminals, a solder fillet should be formed covering 80% on both sides of the board including the funnel flange as shown in Figure 5.22.

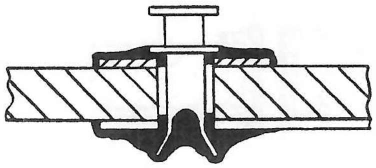


Figure 5.22. Soldering Flanged Terminals

When soldering leads in an updated hole on single-sided boards, a solder fillet should be formed on the terminal side covering 80% of the terminal area including the lead as shown in Figure 5.23. Where a flatpack ribbon lead is being soldered, a void is acceptable between the lead and the wall of the hole. The solder need not be drawn up the entire length of the hole.

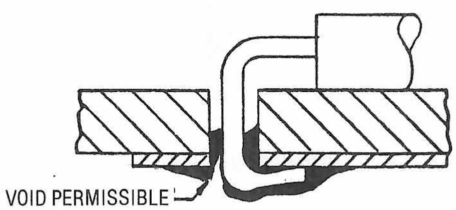


Figure 5.23. Soldering Unplated Holes

When using standoff terminals on single-sided boards the solder fillet formed on the circuit side should cover 80% of the terminal area including terminal flanges as shown in Figure 5.24.

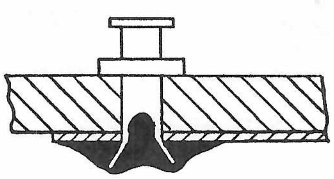


Figure 5.24. Soldering Standoff Terminals

5.58 MECHANICAL ASSEMBLY

5.59 EYELETS AND STANDOFF TERMINALS

Eyelets and standoff type terminals should be mechanically secured to the printed circuit board in such a manner that prevents movement of the eyelet or terminal prior to soldering when finger pressure is applied. Eyelets and terminals should be secured with funnel flanging with an included angle of 55 to 120 degrees. Radial splits in the flanges are acceptable but circumferential splits or missing parts of the flanged end and splits of the shank are not acceptable. Terminals must be mounted in complete contact with the surface of the board. See Figure 5.25.

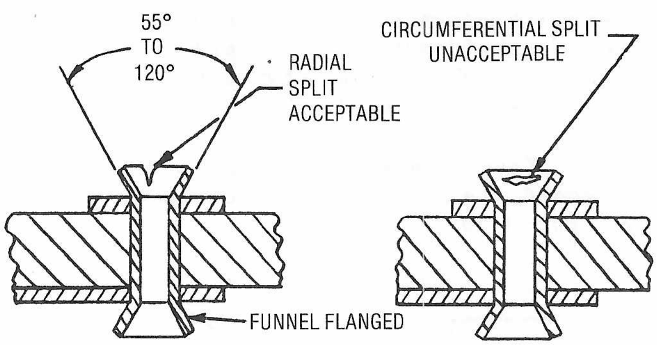


Figure 5.25. Mechanical Assembly of Eyelets and Terminals

5.60 CONNECTORS

Connectors are mechanically secured to the mounting surface before soldering.

5.61 QUALITY ASSURANCE

Inspection must be performed to assure compliance with the requirements of engineering drawings and these standards.