Solderability and Soldering

1. SCOPE

The purpose of this manual is to describe soldering variables, some of the more common solderability problems, and solderability shelf life. This discussion will be limited to tin or tin/lead solders/plates. A check list intended to serve as a guide for obtaining information from customers having soldering problems is included.

2. FORMATION OF THE SOLDER BOND

Soldering can be defined as the formation of a metallurgical bond between two metal surfaces using a low melting point (MP) molten alloy that is quenched and solidified. The alloy must have a MP below the melting point of the materials in the surfaces soldered. Solderability is the ability of the material to be wetted by the solder and while wet, the metallurgical bond is formed.

There are three components to a solder bond. The obvious components are the base metals and the solder. A third component, the flux, is present only during the soldering process. When these three components are brought together with sufficient energy in the form of heat, a solder bond can be formed as long as an element(s) in the solder reacts with an element(s) in the base metal and forms either an alloy or an intermetallic compound (IC). The three components will be discussed individually.

2.1. Solder

A. The tin/lead phase diagram is given in Figure 1. There are two important features to the diagram. First, the liquidus temperature, the temperature at which the solder becomes fully liquid, varies with composition. Increasing the temperature above the liquidus enhances the fluidity and wetting ability of the solder. Contamination rates of the solder by dissolved elements also increase with temperature. The soldering temperature is a compromise between these two effects.

B. The second feature to be noted is the extent of the solid plus liquid or pasty region of the diagram. As the cooling solder enters this region it becomes an intimate mixture of liquid and small solid particles. This mixture has a pasty or mushy consistency. Any relative motion of the parts while the solder is in the pasty range results in a joint containing voids and/or cracks. Such "cold joints" have a frosty appearance and low reliability. Two reasons for the popularity of 60/40 or 63/37 solders are their low soldering temperatures and the minimal pasty region of these alloys. The low soldering temperature minimizes contamination and distortion effects while the small pasty range reduces the likelihood of cold joints.

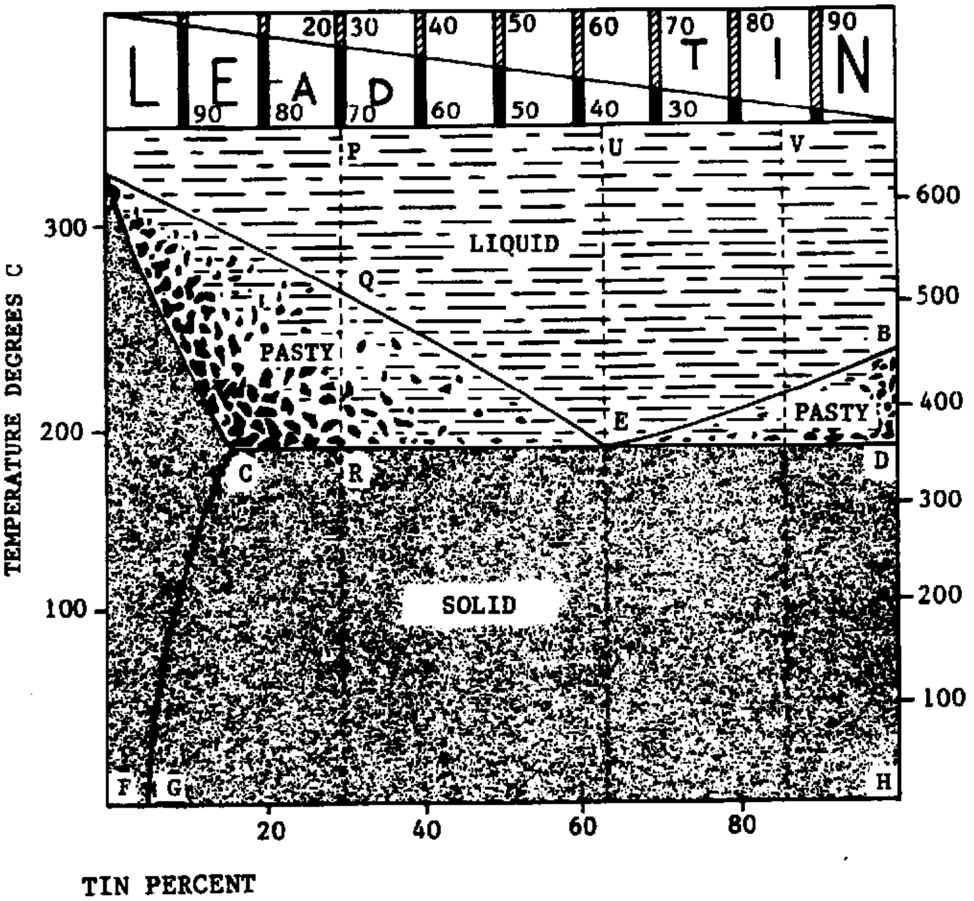

Figure 1

SnPb Phase Diagram

C. Solder is available in the following forms:

1. Ingot or bar - for solder pot application
2. Bar and Wire - for continuous feed to high volume solder pot application (wave or drag soldering)
3. Wire (some flux cored) - for hand use
4. Preforms (some prefluxed) - for hand use or mass reflow
5. Solder pastes - for hand use or mass reflow

2.2. Flux

A. The purpose of the flux is to remove surface tarnish and provide an active base metal for the solder wetting and alloying. The tarnish removal occurs through a chemical action which varies with the type of flux used. Fluxes are limited in their cleaning ability and are generally not capable of removing heavy, thick oxides, oil, grease, paint, organic coatings and many other surface contaminants. A separate precleaning operation is imperative if such contaminants are present. Traditionally, fluxes have been classified as three basic types.

1. Rosin based fluxes (including the activated rosins)
2. Organic acid (OA) fluxes
3. Inorganic acid fluxes

B. Recently a new group of fluxes, classified as “no clean” fluxes have begun to gain acceptance. This group of fluxes are actual low solids content fluxes with activators that become noncorrosive after soldering heat. The relative corrosivity (activity) or tarnish removing capability of the fluxes increases from rosin through OA through inorganic acid fluxes. The activity of the “no clean” fluxes tends to fall between the rosin and the OA fluxes. Inorganic acid fluxes should never be used in assembling electronic components such as AMP connectors as their residues are extremely corrosive. In order to produce fluxing action, the flux must meet the following requirements:

1. Chemical activity is produced when the flux is heated to a temperature that is sufficient to complex or reduce the tarnish and remove it from the base metal. The temperature at which a flux becomes active is variable for different types of fluxes; however, the temperature is always below the melting point of the solders with which they are used.

2. Wetting of both the base metal and the solder surfaces.

3. Thermal stability sufficient to clean the surface at soldering temperatures and times. The flux and its breakdown product must also be easily displaced by the molten solder as it wets the surface.

C. Additionally, the flux residues must be either noncorrosive or readily removable to assure high circuit reliability after soldering.

D. Some flux characteristics along with representative commercial designations are given in Figure 2.

Flux	Activity	Residue	Commercial Designation	
			Kester	Alpha
Rosin Based Type R (Nonactivated)	Low	Noncorrosive	115, 135, 145	100
Type RMA (Mildly Activated)	Mild	Noncorrosive Removal is recommended	185, 197	611
Type RA (Activated)	Medium	May be corrosive Removal is mandatory	1544, 1545, 1547	711, 809, 811
“No Clean” (Low Solids)	Medium	Noncorrosive	Multicore X-32	SM 32 D
Organic Acid Type OA	Medium to High	Residues are corrosive Removal is mandatory	1249, 2211, 2300, 2161, 2330, 2163, 2164, 2331, 2332, 1430	201, 709, 830, 857, 850
Inorganic Acid	High, not ordinarily used for electronic applications	Residues are corrosive Removal is mandatory	715, 751, 415, 737, 815, 541	200L, 90

Figure 2

2.3. Base Metal/Under Plates/Top Plates

A. Solderability of electronic and electrical interconnections is normally preserved by a coating over the base metal of the leads as illustrated in Figure 3. Electroplated or hot dipped coatings of tin or tin/lead alloys are the most popular top plates. Noble metals, such as gold, silver and palladium, are also used for top plates. These top plates prevent the substrate from tarnishing. Because the top plates protect the substrate surfaces, the original base material (or under plate) chosen is not a strong factor in the solderability of the resulting assembly.

B. During the soldering process the top plates generally either melt or dissolve into the molten solder. At this point the molten solder wets the substrate and upon solidification forms a bond with the substrate. The integrity of the bond depends on how well the solder and the substrate react/bond. In some cases such as with palladium and silver, the plate dissolves slowly and the solder bond can be to the plate itself. It should be noted that the substrate which the solder bonds to is the base metal. If an underplate (usually nickel or copper) is present, the solder bonds to the underplate. In this case the underplate is considered the base metal with respect to the solder.

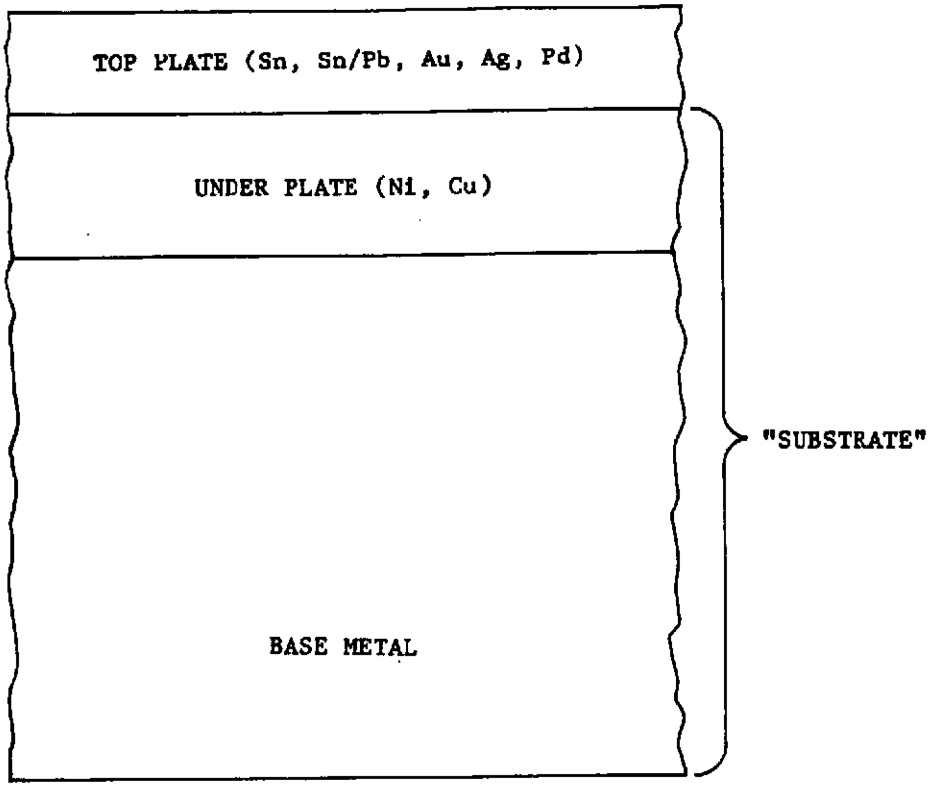

Figure 3

Typical Coating Sequence of a Solderable Interconnection Lead

C. Tin and tin/lead alloys are the best coating for a solderable surface on a product. The requirements for good solderability in tin and tin/lead plates are that the plate surface is clean and that it remains clean and wettable by the solder and flux. Four conditions are listed as the main reasons for the loss of solderability of tin and tin/lead plates. They are as follows:

1. Excessive thickness of the intermetallic layer that has reached the surface and oxidized.
2. An excessive amount of oxide and other surface contamination on the plate.
3. High levels of co-deposited carbon from the organic brighteners only in the bright tin and bright tin/lead plates.
4. Zn or Be diffused to the surface of the tin or tin/lead plates from the base metal.

D. An illustration of how solderability degrades due to IC growth with increasing time is shown in Figure 4. A design with 80 microinches of tin plate had good solderability for a period of time up to just over 100 days. From that time forward solderability failures were observed. There are two diagonal lines drawn on the figure. They represent a boundary area between solderable (above the upper line) and nonsolderable (below the lower line) conditions. The area in between is the undefined area where product will have questionable solderability.

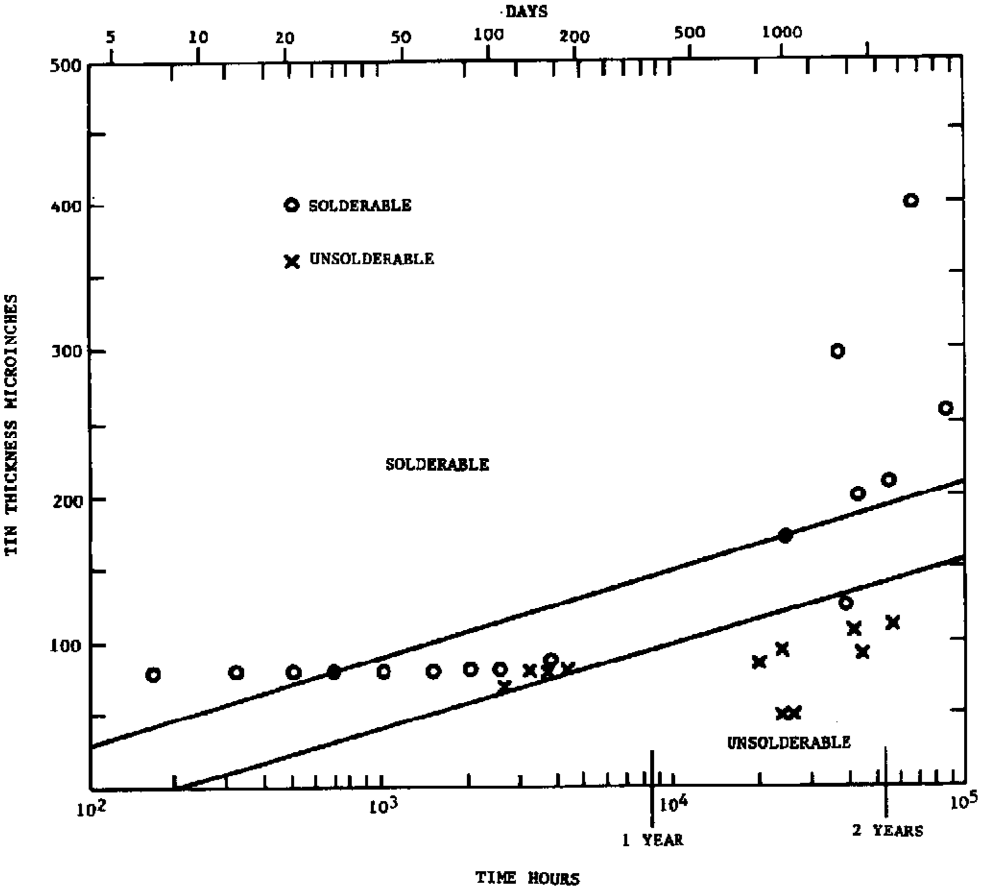

Figure 4

Predicted Solderability Lifetime @25° C
Matte Tin, 112-16-3 Over /Copper or Phosphor Bronze

2.4. Shelf Life Recommendations

A. Tin and tin/lead thickness recommendations for solderability shelf life are shown in Figure 5. The coating thickness recommendations were established to provide a solderable surface to AMP Specification 109-11-1 (Solderability - Type R flux, 5 second dip in 245° C 60:40 Sn:Pb solder, 95% minimum coverage of surface for acceptance) when the connector is stored at room temperature for the period of time specified. The thicknesses are dependent on the type of plate and underplate. Further, an underplate of copper or nickel, 100 microinches minimum for copper and 50 microinches minimum for Ni is recommended to prevent Zn diffusion from brass.

B. No matter what the thickness of material or how well the process is controlled, tin based coatings will slowly degrade on storage and eventually fail. Therefore, it is extremely important to control the storage conditions and storage time of components to be soldered. Product that was perfectly solderable as delivered will not remain so indefinitely.

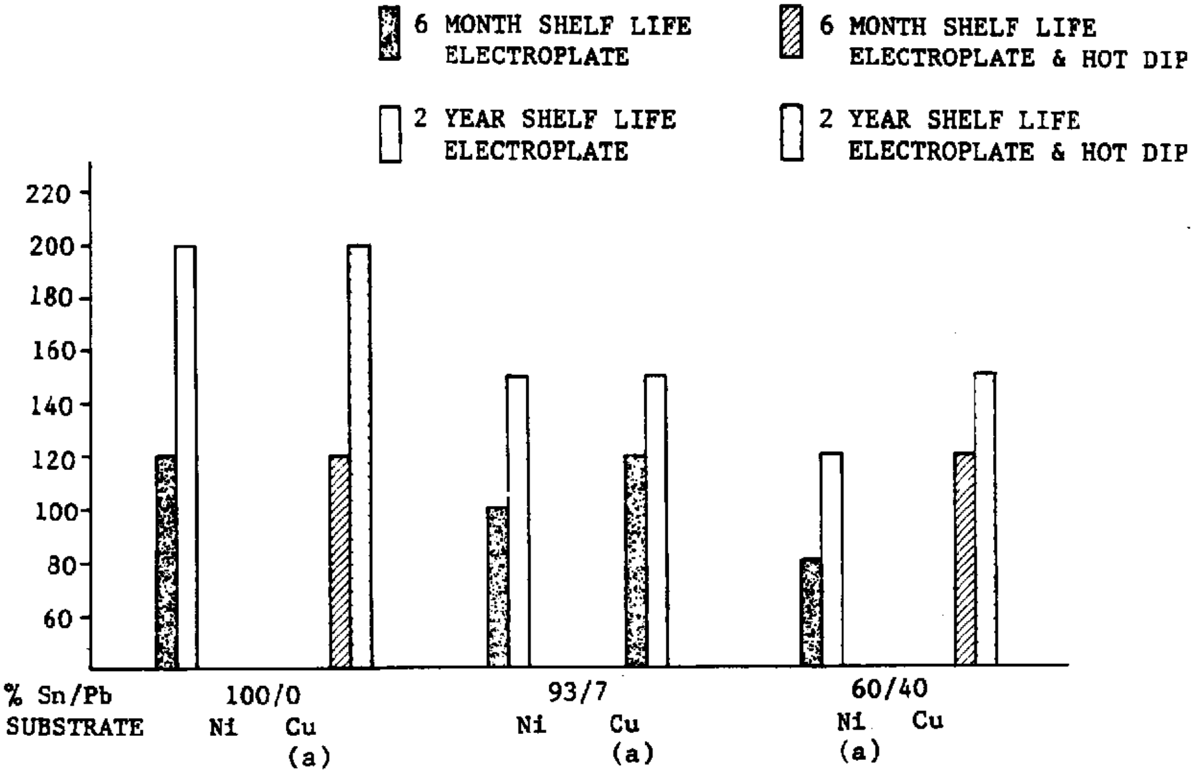

Figure 5

Minimum Coating Thickness for 6 Month and 2 Year Shelf Life Requirements.

3. SOLDERING PROCESSES

The type of soldering process used to build an assembly is determined by a number of factors such as: assembly/component size and geometry, through hole and/or surface mount components, and production volumes. The two general categories of soldering processes are hand soldering and mass soldering processes. The different processes will be discussed below.

3.1. Hand Soldering Processes

A. Hand soldering processes are typically used for low volume production and secondary soldering operations. The secondary operations include attachment of odd form components and rework. Hand soldering is actually a reflow technique as the solder is introduced in a solid form to each joint individually and then reflowed by adding a heat source. The heat source can be in the form of a soldering iron or a hot air gun.

B. Hand soldering techniques have some serious quality drawbacks as the joint produced is entirely dependent on the operator producing it. This leads to the possibility of poor reproducibility of quality joints. Also, hand soldering can lead to heat damage of the boards and components.

3.2. Mass Soldering Processes

The vast majority of AMP product is processed using mass soldering techniques. These techniques accommodate low to high production volumes and can be process controlled. There are two general categories of mass soldering processes. They are wave/drag soldering processes and reflow soldering processes.

A. Wave/Drag Soldering Processes

1. Wave soldering is the most popular process for soldering AMP product. Drag soldering is limited in its application. These processes are popular because they are reproducible processes that produce high quality solder joints in a variety of different assemblies. Equipment is currently available to solder both through hole mounted and surface mounted components. The process is fast and relatively forgiving. It is limited in its ability to process fine line technology components.

2. In wave and drag soldering mass soldering is accomplished by moving the assembly through molten solder. The assemblies are carried by their sides on a conveyor system. In these processes the flux is first applied independently to the assembly, usually by a foam or wave fluxer. The assemblies are preheated after the fluxing operation to provide an adequate topside heating of the assembly. The assemblies are carried over a flowing wave of solder in wave soldering. The hydrodynamic forces assist in promoting wetting of the surfaces and in the formation of the solder joint. In drag soldering the assembly is lowered into a mass of molten, static solder and removed.

3. In these processes the solder and heat are brought to the joint area at the same time. In both cases the major portion of energy (heat) is supplied to the assembly by the large reservoir of molten solder. Typically, temperatures of the molten solder are approximately 500° F. The joint is usually in the solder wave 2-3 seconds. The time in the drag soldering pot varies. Due to the size of the solder reservoir, local areas of elemental gradients, such as Au and Ag, are minimized. The large solder (heat) reservoir also compensates somewhat for poor surface preparation. Drag soldering has recently become popular for processing large assemblies due to smaller printed circuit board (PCB) distortions.

B. Reflow Soldering Processes

1. Reflow soldering is popular for soldering surface mounted components. It can also be used for processing through hole product. Surface mounting of components allows both sides of the PCB to be loaded with components. The assembly can be more densely packed. This leads to increased function, speed and frequency at reduced size and cost. Because of these reasons surface mount technology (SMT) is becoming widely used. Most components are available in a surface mount version.

2. In reflow soldering the solder and flux are provided discreetly to each joint. The energy (heat) is provided separately to the assembly. There are several different reflow techniques currently in use, such as vapor phase reflow (VPR), infrared reflow (IRR), laser reflow, hot bar reflow, and conductive belt reflow. Currently, VPR and IRR techniques are by far the most widely used processes and will be discussed in further detail below.

C. Vapor Phase Reflow

1. VPR is actually condensation reflow soldering. Assemblies are placed into the vapors over a boiling liquid. Both the vapors and the liquid are inert. The vaporized fluid condenses on the assembly giving up its latent heat of vaporization which heats the assembly. The primary advantages of this reflow method are:

    a. The assembly is heated at a constant temperature and cannot be overheated.

    b. The boiling fluid/vapor prevents oxygen from entering the chamber and since the vapor/fluid is inert with respect to the solder, no oxidation of the molten solder occurs.

    c. The assembly is heated in a uniform manner which minimizes shadowing and component/assembly geometry considerations.

2. The fluids used as the primary fluids are perfluorocarabons. Different formulations with different boiling points are available. The most commonly used fluid has a boiling point of 215° C.

3. There are two basic VPR processes used in industry. Batch processing is used for low to medium production volumes. It is a vertical system where an elevator lowers and raises the assemblies into and out of the primary vapor. Most batch systems have a lower boiling point secondary vapor blanket above the primary vapor blanket. The secondary vapor serves as a preheat area for the assembly and also reduces primary vapor loss. In-line VPR processes are used for low to high production volumes. The in-line system uses a horizontal conveyor to transport the assembly through a preheat area, typically using IRR preheaters, into the primary vapor zone and out of the system.

4. Originally, VPR systems had several disadvantages such as tombstoning (lifting of one side of the component) and solder balling associated with rapid heating of the assemblies. These problems have been largely eliminated by the addition of preheat areas before the assemblies are placed in the primary vapor. Currently the largest disadvantage of VPR processes are their high costs, both original equipment and operating costs.

D. Infrared Reflow

1. IRR soldering uses infrared energy to heat the assemblies. The process is an in-line noncontact process. IRR systems are used for low to high volume production. The systems parameters can be changed in a relatively short period of time to accommodate different assemblies. Further, IRR systems are relatively inexpensive to purchase and to operate. IRR processing is rapidly becoming the reflow process of choice in the surface mount industry.

2. There are three basic types of IRR systems used. The distinctions between the three are based on the IRR emitters used and the way the heat is transferred. The three general categories are lamp emitters, panel emitters, and forced air convection. Different emitters possess different processing characteristics. These characteristics are presented in Figure 6. The main drawback to IRR processing is the uneven heating of components on the assembly. The techniques are somewhat mass, geometry and color sensitive, depending on the process used. The temperature differences can be severe with smaller components suffering thermal damage and the solder on the leads of larger components not reflowing. Connectors tend to be large massive components. In general, either panel emitters of forced convection units work best for processing large components such as connectors. Forced convection systems also have the advantage of a constant maximum temperature which prevents the overheating of components/assemblies.

IRR Source (Emitter Type)	Emission	Processing Characteristics
Lamp Emitters	Near IR	- Rapid setup and changeover of equipment - Shadowing by Components - Color selectivity - High temperatures (possible overheating of components/assemblies) - Mostly radiant heat transfer
Panel Emitters (Secondary area source Emitters)	Middle to Far IR	- Slow setup and changeover - No shadowing - No color selectivity - Moderate temperatures (still possible overheating of components/assemblies)
Forced Convection	Middle to Far IR	- Slow setup and change but relatively insensitive to load - No shadowing - No color selectivity - Constant maximum temperature (no chance of overheating components/assemblies) - Conductive/convective heat transfer

Figure 6

Characteristics of Infrared Sources

4. SOLDERABILITY PROBLEMS

Solderability problems can be caused by:

A. Material problems which include soldering materials, such as solder and flux, and component/assembly materials.

B. Poor PCB processing which involves processing under the wrong conditions.

When solderability problems occur, proper information regarding the problem and the process has to be obtained if an effective failure analysis is to be performed. This will be addressed in the next section. The remainder of this section will focus on several of the more common solderability problems.

4.1. Material Related Problems

A. Solder Related

1. Contamination of the solder bath is the major solder related problem. Discussion will be limited to a description of the effects of some common contaminants to provide awareness of this possible source of customer problems.

2. Two types of contaminants exist:

   a. Contaminants which affect flow and solidification characteristics only.

   b. Contaminants forming intermetallic compounds with tin or lead.

3. Zinc and aluminum fall into the first category. If present in amounts as small as 0.01%, these elements severely affect the soldering process. Solder flow is degraded to the extent that a 100 to 200°C increase in the soldering temperature is required to restore solderability. The solder joint is dull and frosty appearing. This appearance is due to a dendritic structure as opposed to the homogeneous structure of a good joint. The dull dendritic joint has inferior electrical and mechanical properties. The main source of aluminum contamination is from fixturing. Aluminum is not readily wet by solder and is sometimes used for this purpose. Zinc contamination is uncommon unless large numbers of brass parts are being soldered.

4. Copper, nickel, silver, gold, and iron are some elements which form intermetallic compounds with tin. Copper is particularly important since it is present in nearly all electronic assemblies. Formation of fine particles of copper/tin intermetallic causes the solder to become sluggish in flow and gritty in appearance. Again, increases in temperature are required to restore solderability. Unfortunately increasing the soldering temperature also increases the rate of copper dissolution from the material being soldered. Proper corrective action would be to change the solder in the pot.

5. Monitoring the solder bath composition at regular intervals is the effective method to control solder contamination problems. Contamination levels can be established to alert the operator when problems are likely to arise. A second danger level should also be established at which the solder should be scrapped even though no unacceptable reject rate has yet occurred.

B. Flux Related

1. There are at least three possible flux related problems:

   a. Improper activation of the flux (including under/over heating of flux).

   b. Contamination of the flux and control of solids/solvent ratios.

   c. Improper removal of flux and flux residues.

2. The type of flux used must be active enough to remove the surface tarnish of the surface to be soldered. Proper activation of the flux requires a combination of time and temperature which is both flux and process dependent. Too low a fluxing temperature, or insufficient time at temperature results in inadequate tarnish removal, possible spattering or flashing due to inadequate solvent volatilization and poor solderability. Too high a temperature may result in flux decomposition and recontamination of the surface. Decomposed fluxes are also more difficult to remove after soldering.

3. Contamination of the flux may occur in any operation in which the flux is recycled. Common contaminants are soldering oil, pump oil and various residues from the parts to be soldered. Regularly scheduled changing of the flux charge is the proper corrective action for this problem. Control of flux viscosity is another important factor in any flux recycling.

4. Proper flux and residue removal is necessary to assure high circuit reliability. The ionic components of the flux can migrate over the surface of the circuit board under heat and humidity conditions, resulting in electrical leakage between conductors in close proximity. Many fluxes, particularly the type OA fluxes, leave corrosive residues that attack tin plating and copper alloys. In addition, flux residues, even noncorrosive ones, can coat the contact surfaces of separable connections and cause open circuit conditions.~~ Additional information on flux removal can be found in Corporate Bulletin 401-35.~~ A brief description of cleaning procedures for different types of fluxes is presented in Figure 7.

Flux	Removal Procedure
Rosin Based	Removal is only necessary when separable connections may be affected by rosin films.
Type R	
Type RMA	Removal necessary only in high reliability circuits and in separable connections.
Type RA	Removal necessary in most applications, as residues can cause leakage and, in some cases, corrosion. Removal necessary for separable connections. The removal of rosin fluxes can be done both in organic solvent cleaning systems and in specially formulated aqueous saponifying solutions.
“No Clean” Flux (Low Solids)	No cleaning necessary if properly applied.
Organic Acid Type OA	Removal is mandatory in all applications. Residues are corrosive and will cause electrical leakage. The removal of organic acid fluxes can be done using water based cleaning solutions. Neutralizers and/or alkaline detergents are recommended strongly to ensure removal of residues and neutralize acid components.
Inorganic Acid	Not to be used with electrical components. Removal is mandatory in all applications. Residues are highly corrosive and will cause electrical leakage. Removal can be achieved in water solutions. Neutralization is essential and can be done using sodium bicarbonate or ammonium hydroxide.

Figure 7

Flux and Flux Residue Removal Procedure

C. Component/Assembly Related

1. Surface Contamination

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Since the cleaning ability of fluxes is limited, precleaning of the solderable surfaces is often necessary to remove different types of surface contamination. Lubricants, organics, soils and plating/rinsing deposits from prior operations must be removed. Many degreasing techniques from simple rinses to ultrasonic cleaners are available. If an abrasive cleaning is used, care must be taken to remove all residual particles. The proper cleaning procedure is the one that does the job with minimum complexity.

2. Surface Materials

a. As stated above, different techniques are used to maintain solderability by protecting the base metal from the environment. The simplest is the application of a lacquer of organic coating. These coatings are protective only and proper base metal preparation is essential. The coatings are, to differing degrees, permeable to the environment and the protection offered is limited. The use of these protective coating is also limited.

b. The most common method of maintaining solderability of the base metal is the application of a tin/lead coating. Tin and tin/lead coatings can be applied either as a hot dipped deposit or as an electroplated deposit. When properly applied using the thickness recommendations in Paragraph 2.4., tin or tin/lead coatings can provide a solderable surface for 2 years or longer. However, several different failures can be attributed to the tin/lead coatings:

(1) The most common failure mechanism is due to the growth of intermetallic compounds. The tin in the plate will react and form an intermetallic layer at the interface of the underplate, or basis metal in the case of no underplate, until the soldering process is performed. Intermetallic growth is a function of time and storage temperature, and will eventually grow to the surface of the plate. At the surface, or possibly starting just below the surface, this intermetallic layer will oxidize. It is this oxidized intermetallic layer that will not solder. Therefore, in the case of solderability failure by exposed intermetallic, it is the time in storage and the temperature of storage that determines if soldering will occur. Experiments performed to measure growth of the Cu-Sn intermetallic compounds, Cu_3 Sn, and Cu_6Sn, have shown the growth to be linear when plotted against the square root of time,

$$X = K\sqrt{t}$$

(2) Where:

X = thickness of the intermetallic layer
t = time
K = a constant (temperature dependent)

(3) A plot of the CuSn average intermetallic thickness at 24° C (75° F) and 50° C (122° F) for pure tin, 90% Sn - 10% Pb, and 60% SN - 40% Pb over copper is given in Figure 8. The layer is very irregular as shown in the insert of Figure 8. It is possible that for any given average thickness, there may be peaks which could be twice as high as the average. When enough of the peaks reach the surface, where they become oxidized, the plating will not solder. The intermetallic growth rate increases rapidly with temperature. The graph in Figure 8 shows why it is important to store plated parts in a relatively cool environment.

(4) There are at least two Ni - Sn intermetallics which are formed in a tin plate over nickel underplate. One intermetallic, Ni_3Sn_4, grows much slower than the Cu_6Sn_5 intermetallic at common storage temperatures and it forms a uniform continuous layer. The other intermetallic, $NiSn_3$, grows as platelets. These platelets will rapidly grow to the surface of the tin plate. As with Cu - Sn intermetallic, $NiSn_3$ intermetallic will become oxidized and may result in solderability failures.

(5) At common storage temperatures the effect of Pb in the tin plate is to slow down the rate of Cu - Sn intermetallic growth, Figure 8. This is not true at higher temperatures. For example, at 170° C the rate of intermetallic growth is higher in 60% Sn 40% Pb plate compared to pure tin. It is an important consideration when selecting an elevated temperature accelerated aging test. In Ni - Sn intermetallic growth, however, it has been observed that 10% Pb will greatly reduce, and 40% Pb will essentially eliminate $NiSn_3$ intermetallic platelets.

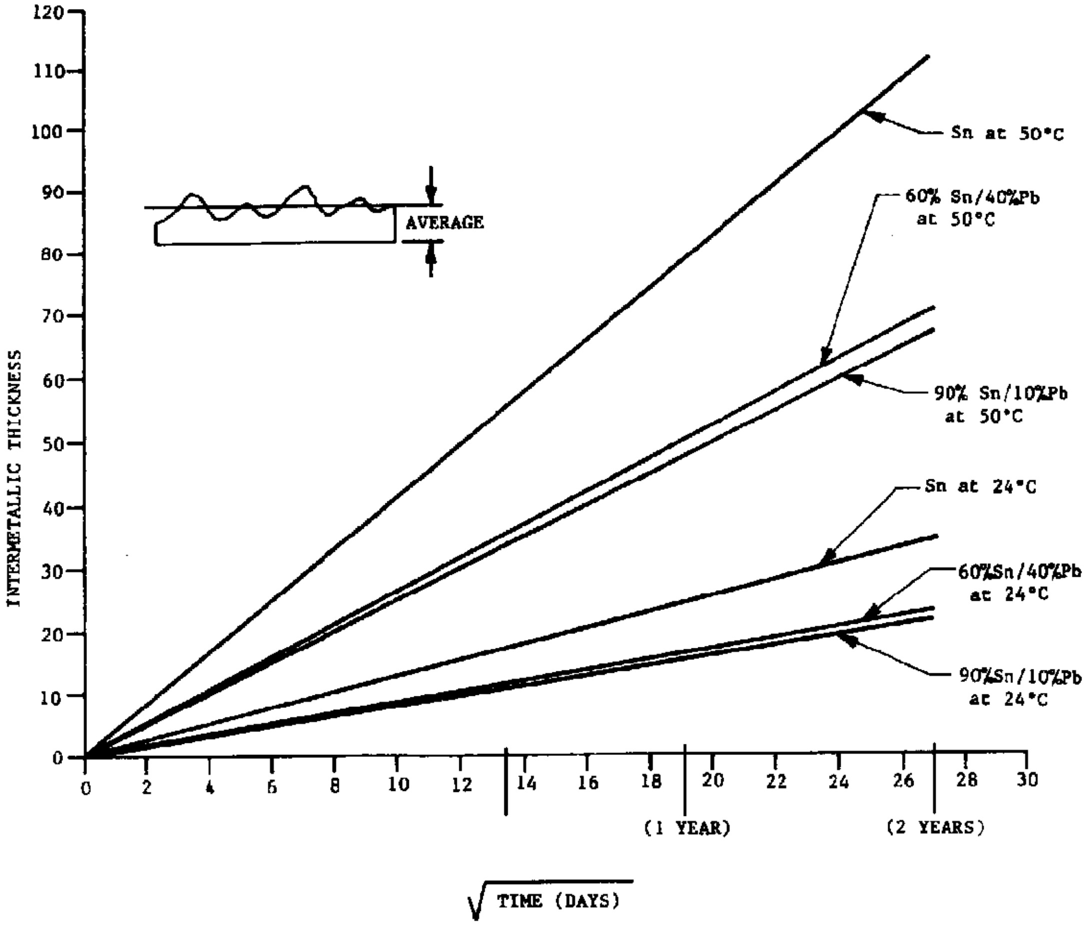

Figure 8

Average Intermetallic Growth in Matte Tin and Tin-Lead Over Copper at 24° C and 50° C

(6) Another common failure mechanism is the result of excessive oxide growth. When stored close to room temperature in dry air, the oxide formed on the tin/lead surface is easily removed by flux and therefore does not adversely effect solderability. However, elevated temperatures, high humidity, and corrosive gasses can lead to excessive surface film growth which will affect solderability. Again this shows the need to control the storage condition of the parts.

(7) Diffusion of Zn through the tin/lead plate to the surface can cause solderability problems. Zinc will also diffuse through a gold plate, causing solderability defects. The problems can be eliminated by underplating Zn bearing alloys with either a copper or a nickel underplate before gold or tin/lead plating. It has also been suggested that Be, as from a Be copper, can diffuse through gold and possibly tin/lead plates. It is therefore recommended that an underplate be used with Be bearing alloys as well.

(8) In the past addition of excessive carbon to the plating bath in the form of organic brighteners has been responsible for solderability failures. It is believed that the carbon accumulates at the growing intermetallic-plate boundary, and when the part is soldered the carbon causes solderability defects. A study has shown that with careful control of the brightener level the solderability of bright platings is equivalent to unbrightened, matte platings.

(9) Poor quality of the tin/lead coatings can cause solderability problems. The most common quality problems are:

(a) Porous/cracked plate - this allows the substrate to oxidize.

(b) Poor activation of substrate before coating - this leaves an oxide on the substrate.

(c) Over brightened tin/lead electroplated deposit.

(10) Gold has also been widely used to preserve solderability, especially in military applications. High purity, soft gold will provide a solderable surface as long as it is a good quality deposit at least 5 microinches thick. Hardened golds have caused many solderability problems, as the hardening agent migrates to the surface and oxidizes. Gold should not be used to preserve the solderability of surface mount solder joints. The small volume of solder present in a surface mount solder joint is rapidly saturated (>4-5 wt.%Au) with Au and the Au - Sn intermetallic is formed. This is not as critical in through hole application processed by wave/drag soldering due to the large volume of solder present and the flushing action of the process.

4.2. Process Related Problems

A. The way the assembly is processed can affect the quality of the solder joints. The components may be solderable when tested but may not be solderable under the conditions of the assembly processed. Some of the process variables that can affect solderability are:

1. Preheat
2. Line speed
3. Solder temperature

B. As long as the surface is solderable with the flux used, the limiting factor is the energy; (i.e., the heat), supplied to the assembly. The energy must be sufficient to compensate for the mass of the component/assembly.

5. CHECKLIST

5.1. Solderability failures can be caused by unsolderable components or by improper testing/processing. Therefore, to do a proper failure analysis you must have representative samples and also completed information about the customer’s process and type and frequency of failures.

All this should be done at the front end. Frequently, if the proper samples are not obtained at the front end, they may be difficult to acquire as the customers may have used the rest of the suspect lot or may have reworked the problem assemblies. By providing proper samples and complete information, the failure analysis can proceed much faster and the probability of finding the cause of the failure is greatly increased. The proper sample group should include the following, if at all possible:

A. Several (5 or more if possible) of the "virgin" components in question. They must be from the same lot or Date Code as the components that caused the problems. If they are not available, components from lots that were close to the problem should be used.

B. One or more of the failures as produced by the customer. If the failures occur during the assembly process, a complete assembly yields the most information.

NOTE *Desoldering the part from the board usually destroys the evidence. It is strongly recommended that an entire assembly or a cut assembly be obtained.*

5.2. Specific information about the failures should be obtained. This includes, but is not limited to:

A. Criteria of failure - specification failure, nonwetting/dewetting, poor fillet formation, bridging, wicking, etc.

B. Location of failures - where on the component, on only one or all different assemblies using the component in question, different locations or the same area of the assembly, etc.

C. Frequency of failure.

NOTE *This information on failure characteristics is extremely important for field failure analysis as different answers to the above questions will lead the analysis along different paths.*

5.3. Specific information about the customer's testing/production processes should be obtained. This includes, but is not limited to:

A. Types of testing/soldering equipment used - be specific with respect to types of fluxer, preheats, wave, IRR source, arrangement of IRR sources, VPR, conveyor type, fixturing, etc.

B. All operating parameters:

1. Preheater temperatures
2. Primary heater temperatures (reflow)
3. Board top temperatures
4. Temperature profiles (reflow)
5. Solder temperature
6. Line speed
7. Solder contact time
8. Flux brand and type
9. Solder composition
10. Solder paste (reflow)

C. Cleaning - types of equipment, solvents, operating parameters, etc.

D. Process Control - It is important to have an idea how well the customer controls his process as this has a direct bearing on whether a recent problem is process related or is a product defect. Process control information is usually the most difficult information to obtain; therefore, it has to be carefully examined. If you do not see hard copies of the information, it should be regarded as suspicious.

5.4. The attached checklist is intended to serve as a guide for obtaining information from customers having soldering problems. Accurate definition of the nature of the problem is important in pinpointing the possible causes. Commercial names and numbers convey maximum information with minimum ambiguity and should be obtained if possible.

SOLDERABILITY PROBLEM CHECKLIST

Nature of Problem

Nonwetting ____________
Dewetting ____________
Poor coverage ____________
Spotty coverage ____________
Bridging ____________
Icicles ____________

Poor fillet ____________
Blow holes ____________
Cracks ____________
Cold joints ____________
Discoloration ____________
Residues ____________

Description of Problem:

____
____
____

Frequency of Problem:

____
____
____

Description of Samples Sent for Analysis (Mark problem measures)

____
____
____

Precleaning Procedures

Technique:

Solvents:

Solder

Form - Pot, bath, wave, etc. ____________

Flux core wire __________

Preform ____________

Paste ____________
(Manufacturer, PN, Metal Content, Flux, etc.)

Composition __________ Lead __________ Tin __________ Other (name)
(Include brand name and number)

Flux

Commercial Name if Available ______________________________

Rosin - Type R __________ Type RMA __________ Type RA __________

Organic ____________________

Chloride ____________________

Other ____________________

Soldering Surface

Base Metal Alloy ______________________

Protective Coatings

Type ________________________

Thickness ____________________

Platings

Composition - Top Plate ____________ Under Plate _____________

Thickness - Top Plate ____________ Under Plate _____________

As Plated ___________
Fused ______________

Type of Part

P.C. Board - Single Sided _____________

Multilayer (No. of Layers) _____________

Plated Thru Holes _______________
Size of Board __________________
Problem Side ___________________
Problem Area of Board ___________

Component(s) Commercial Name(s) __________________

Part Number(s) _________________
Description of Part(s) ____________
Problem Area of Part _____________

Soldering Method

Manual

Dip Soldered

Flux Application Method ______________________________

Preheat - Technique __________________________________

Temperature ____________ °C ____________ °F

Dwell Time _____________ sec

Soldering Cycle - Rotary _____________

Continuous _________

Other ______________

Soldering Temperature __________ °C __________ °F

Dwell Time ____________ sec

Wave Soldering (P.C. Boards Assumed)

Line Speed

Fluxing

Application

Wave ____________

Foam ____________

Other ___________

Solids Content ___________%

Capacity of Fluxer _________________________

Maintenance Schedule ______________

Post Flux Leveling

Air Knife ____________________

Brush ________________________

Other ________________________

None _________________________

Preheating

Heater - Radiant ______________

Resistance ____________

Forced Air ____________

Temperature

at heater ________ °C ________ °F

at board _________ °C ________ °F

Dwell in Preheat Zone ______________ sec

Solder

Wave Geometry

Single Sided ________________

Double Sided ________________

Lambda ______________________

Cascade _____________________

Temperature _________ °C _________ °F

Dwell Time __________ sec

Oil Used __________ Yes __________ No __________ Type

Controls

Pot Capacity __________ Pounds

Contamination Monitoring

Time ___________

Parts __________

Reflow Soldering

Paste Application Method ____________________

Paste Curing Time ___________ Temperature ___________

Type of Reflow Equipment

IRR Equipment (Brand Name and Model No) ____________________

Type of Emitters

Forced Convection __________ Yes __________ No

VPR Equipment (Brand Name and Model No)

Batch ___________________________

In-Line _________________________

Vapor Temperature _______________

Operating Conditions

Line Speed ___________

Emitter Temperatures (Include VPR Preheats)

	Zone 1	2	3	4	5
Top	______	______	______	______	_______
Bottom	______	______	______	______	_______

Assembly/Component Temperature Profile

	Zone 1	2	3	4	5
Component	______	______	______	______	______
Assembly	______	______	______	______	______

Post Soldering Cleaning

Method

Wash, Wave ____________

Spray _________________

Brush _________________

Solvents Used ____

Temperature ___________ °C ___________ °F

Other Comments: