MATERION

TECH BRIEF

SOLDERABILITY OF MATERIALS IN PRINTED CIRCUIT BOARDS

Engineers designing connectors in the electronics industry must consider a myriad of physical and mechanical properties when choosing a material to assure that the part will efficiently transfer a current or signal for the life the device. After going through all that, the part still needs to be attached to the device in a reliable way. One popular way to accomplish this, especially in printed circuit boards (PCBs), is soldering. The ability of a material to accept the solder and create a reliable fixed connection, also known as solderability, can drastically affect the total cost of manufacture, offsetting other performance measures.

TYPES OF SOLDERING

Soldering is done in the following three ways in decreasing speed and sensitivity to solderability.

WAVE SOLDERING

When soldering PCBs, there are two major types of soldering: wave soldering and reflow soldering. Wave soldering is when the board is passed over a pool of molten solder where pumps are used to create a wave in which the parts travel through. The part is then cooled, solidifying the solder fixing the component in place. Wave soldering is best used for through hole mounted components.

REFLOW SOLDERING

Reflow soldering is when the parts are stuck in place with glue or solder paste. They are then passed through a furnace where the paste, which includes both a flux and a solder, melts and wets the material, fixing the component once it is cools. This method is preferred for surface mounted parts, but it can also be used for through hole.

MANUAL

The part is placed on the board by hand and soldered with solder wire and an iron. This is process is usually saved for rework and hobbyists.

SOLDERABILITY

Solderability is the measure of the ability of a material's surface to be wetted by molten solder. An ideal surface will attract the solder. This is the case with most bare metals. However, most metals have oxides that both naturally develop and form during heat treatment even when done in an inert atmosphere. The main factor of solderability as a material property is the tendency of that particular material to develop a stable oxide. For example, stainless steel and aluminum have low solderability as a material property due to their protective oxide layers. In general, copper and copper alloys have good solderability, but exposure to certain environments and heat treatments not followed by a pickling process will reduce the solderability.

TABLE 1: BASE METALS AND RELATIVE SOLDERABILITIES

SOLDERABILITY	BASE METAL	REMARKS
Excellent	Tin Cadmium Gold Silver Palladium Rhodium	Noble metals dissolve easily in solders, resulting in brittle joints
Good	Copper Bronze Brass Lead Nickel-Silver Beryllium-Copper	High thermal conductivity of these metals requires high heat input during soldering. Oxidizes quickly so proper flux must be used
Fair	Carbon Steels Low-Alloy Steels Zinc Nickel	Solder joints become brittle in sulfur-rich environments. Avoid higher temperatures in the presence of lubricants (which contain sulfur).
Poor	Aluminum Aluminum-Bronze	Tough oxides on the surface prevent wetting (formation of the inter-metallic layers). Solders have to be specially selected to avoid galvanic corrosion problems.
	High-Alloy Steels Stainless Steels	Too much chromium oxide the surface needs to be cleaned with an aggressive flux.
Very Difficult	Cast Iron Chromium Titanium Tantalum Magnesium	Require pre-plating with a solderable metal.

Table 1: List of base metals along with their relative solderabilities. http://www.efunda.com/materials/solders/solderability.cfm

FLUX USE

The flux has three purposes:

1. To remove oxides
2. To prevent new oxides from forming during the process
3. To lower the surface tension of the solder to promote wetting

Fluxes vary in strength and are optimized for different uses. They all belong to one of three families: resin, organic, and inorganic. Both resin and organic type fluxes range from noncorrosive to weakly corrosive. Inorganic fluxes are all highly corrosive. Poor solderability can be compensated for using a more aggressive flux. However, when soldering it is best practice to use the mildest flux possible. Most fluxes require rinsing, but traces will always be left behind. The aggressive ones will lead to premature pitting and failure of the joint over time.

TYPES OF SOLDER

There are many different solder chemistries. Historically most solder used in the electronic industry was composed of tin and lead at different ratios depending on the application. This was used because the alloy system has a eutectic at a relatively low temperature. This allows for the minimum amount of energy to be used along with fast setting of the solder. Lead is now being phased out due to increased regulation in the European Union and elsewhere, specifically the ROHS and WEE.

The SAC chemistries, which are a combination of Tin (S) Silver (A) and copper (C), have been widely adopted to replace lead containing solder alloy chemistries.

These are more expensive and melt at a higher temperature. This makes the soldering processes more costly and harder to control. These changes make the intrinsic solderability of the material even more important.

SOLDERABILITY TESTING

As shown in Table 1, some alloys are prepositioned to be solderable. However, there is no guarantee of solderability. Things like the types of processing the material has undergone or storage conditions will influence the solderability. Therefore, testing is frequently done on materials to be able to predict how well the material will perform during soldering. Prior to testing, both dry bake and steam soaks can be conducted to simulate extended exposures to certain environments. There are two popular methods, the dip and look test and the wetting balance test.

DIP AND LOOK TEST

A material is dipped into a flux and then a molten solder. The surface is then analyzed to determine a passing test or failure. The speed of the dip, along with the surface condition indicating pass or failure, is determined by the solderability specification being used. A typical requirement is 95% dipped surface coverage with no pin holes, a very small hole in the solder surface.

Figure 1: Passing dip test coupon

Figure 2: Failing dip test coupon

WETTING BALANCE TEST

The wetting balance test measures the force over a prescribed amount of time when a coupon is immersed in a molten solder bath. Wetting force is the force applied as the solder adheres to the part's surface. The test involves hanging a small coupon from the material being tested from an apparatus. The weight of the coupon will put a small positive force on the apparatus. When the part is dipped into the solder, the initial buoyancy will create a negative force. If the part fails to wet, the negative force will persist throughout the test. If the solder adheres to the surface or wets, this will pull the part in, creating a positive force. The transition time from a negative to positive wetting force is what is analyzed to determine a passing test.

WETTING BALANCE RESULTS

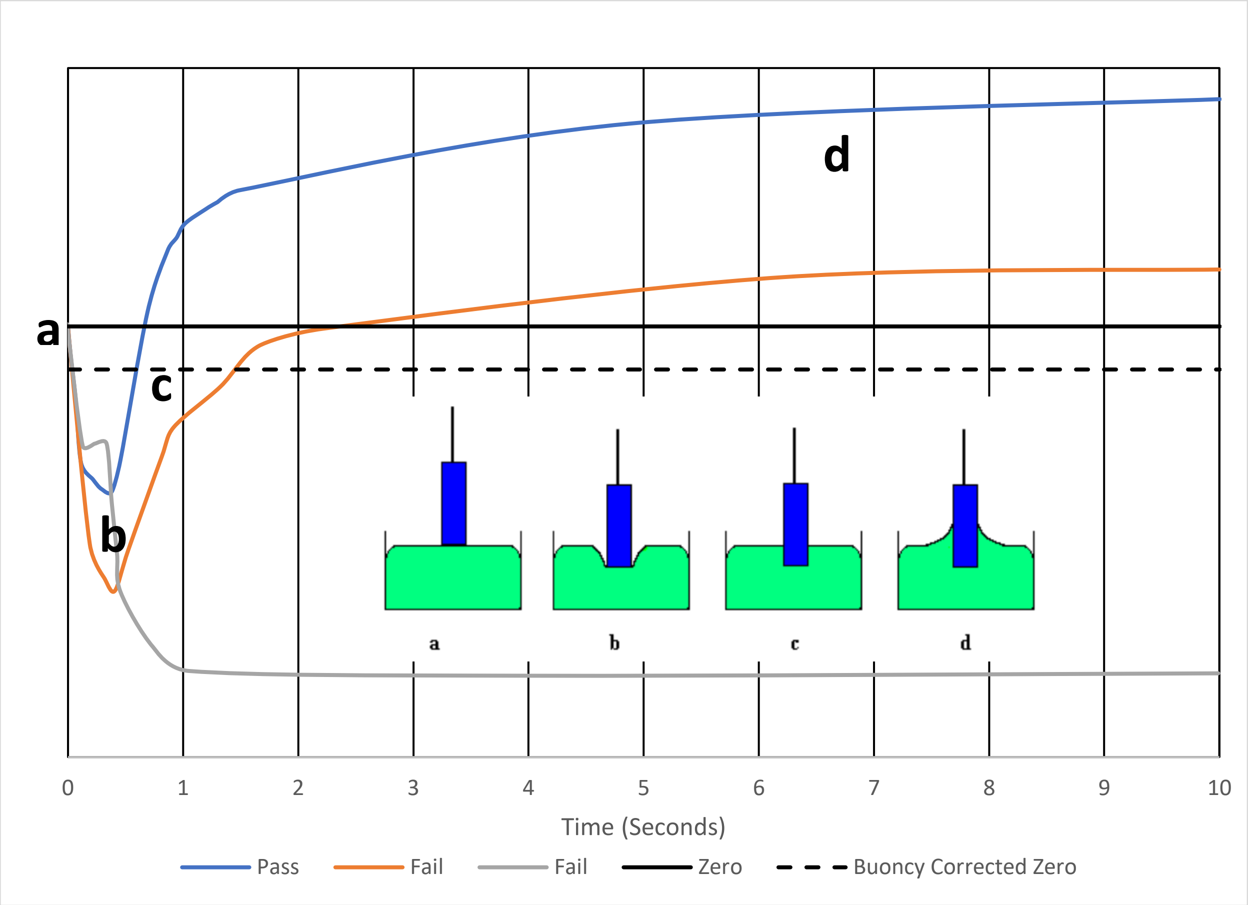

Figure 3: Sample wetting curves with image visually depicting a passing sample throughout the curve. The approximate regions a-d depicted on the overlaid image are indicated on the passing curve.

WETTING BALANCE RESULTS

Materion uses a 60 40 lead tin lead solder alloy to do a dip and look test before shipping out strip products. If there is a failure, the material is sent back for an additional pickle (acid clean) and retested. More companies are switching over to lead free solder. In response to that, Materion had several of its alloys used in applications requiring soldering, along with some competitive materials, tested using the wetting balance test for lead free components using lead free solder (F1) in J-STD-002. The spec calls for SAC-305 to be used along with a mild flux. The major passing criteria per J-STD-002 is the force reading reaching zero within one second as corrected for the buoyancy of the part in the solder. In general, samples perform better when pickled. Materion does not certify their materials for solderability.

TABLE 2: WETTING BALANCE TEST RESULTS

Alloy/Temper	Pretreatment	Flux	Time for positive force (Seconds)	Pass/Fail
EtchMet TM20 Pickled	No Pretreatment	Mild Flux per Spec	.389	Pass
EtchMet TM20 Pickled	1 Hour in 93 C steam	Mild Flux per Spec	.482	Pass
EtchMet TM20 not pickled	No Pretreatment	Mild Flux per Spec	N/A	Fail
EtchMet TM20 not pickled	No Pretreatment	Superior 71 Stainless Steel Soldering Flux	.45	Pass
BF158 TM16 not pickled	No Pretreatment	Mild Flux per Spec	N/A	Fail
QMet 200	No Pretreatment	Mild Flux per Spec	.659	Pass
QMet 200	1 Hour 93 C with steam	Mild Flux per Spec	2.257	Fail
Qmet 300	No Pretreatment	Mild Flux per Spec	.564	Pass
QMet 300	1 Hour 93 C with steam	Mild Flux per Spec	.790	Fail
GMX215	No Pretreatment	Mild Flux per Spec	.633	Pass
GMX215	1 Hour 93 C with steam	Mild Flux per Spec	N/A	Fail
C7035	No Pretreatment	Mild Flux per Spec	.282	Pass
C7035	1 Hour 93 C with steam	Mild Flux per Spec	.307	Pass
C1990	No Pretreatment	Mild Flux per Spec	N/A	Fail