Solder Paste Properties and Test Methods

CATEGORY/ PASTE PROPERTY	IMPACT ON SMT PROCESS	HOW TO TEST	TEST CRITERIA
Print Characteristics			
Transfer Efficiency & Print Variation	• Insufficients, opens, bridges, solder balls, HIP, frequent wiping	1) Print solder paste and measure deposits with automated SPI 2) Analyze: • Volumes of small deposits • Areas • Heights of rectangular deposits • Positional offsets	Cpks using standard +/- 50% spec limits • Volumes: higher is usually better • Areas: higher is usually better • Heights: • < stencil thickness: higher is usually better • > stencil thickness, lower is often better
Wipe Frequency	• Solder defects, excessive use of consumables, line downtime during wipes	1) Analyze print statistics on 10 print test 2) Print 8 boards, wipe 3) Compare Cpks between prints 8 and 9	• Cpk pre-wipe vs. Cpk post-wipe in both print directions
Abandon time	• Poor quality first print • Requirement to knead paste before returning to production and clean/dry/ reuse PCB	1) Determine typical abandon time to test, usually 2-4 hours 2) Measure deposits with SPI	• Cpk pre-abandon vs. Cpk on first print post-abandon • Number of prints needed to return to steady state process
Print Definition	• Solder Defects, frequent wiping	Compare to visual scale *Often used when SPI is not available*	• Subjective observation: visual scale grades deposit appearance from 1-5

Stencil & Assembly Line Behavior			
Cold Slump	• Bridges, random solder balls	IPC or alternate slump patterns 1) Print, place in ambient environment for 20 minutes 2) Read pattern again visually or with SPI	• Visual: Smallest gap to bridge • Quantitative: Ratio of deposit area SPI readings before and after 20 minute wait
Hot Slump	• Bridges, HIP, Insufficents on PTH, solder buildup in oven from PTH drips	IPC or alternate slump patterns 1) Print, place in oven at 182°C for 20 minutes 2) Read pattern again visually or with SPI	• Visual: Smallest gap to bridge • Quantitative: Ratio of deposit area SPI readings before and after 20 minute wait
Stencil Life	• Solder defects, frequent wiping • Poor coalescence, solder balling, bridges	1) Cold slump after extensive print or knead strokes and/or environmental conditioning 2) Print quality before and after extensive knead/environmental conditioning	• Visual: Smallest gap to bridge • Quantitative: Ratio of deposit area SPI readings before and after 20 minute wait • Cpk pre- and post-knead or exposure • Reflow graping or balling
Tack	• Positional errors on components, tombstones, solder balls, missing or transient components	1) Hold printed PCB for a period of time before placing and reflowing	• Quantitative: AOI or End of Line number and type of defects

Reflow Properties			
Wetting	• Insufficients, opens, tombstones, solder balls, skews, non-wets, HiP, perceived voiding	1) Print test patterns with different coverage on substrate and examine wetting on 10x10 mm pad 2) Assemble PCB with known difficult-to-wet components and inspect solder joints	• Visual inspection: Wetting to PCB pads, spatter, wetting to components • Rank order in performance
Spread	• Insufficients, opens, solder balls	1) Print solder paste on exposed traces with increasing gaps between the paste deposits and observe the distance of the gaps that bridge closed in reflow	• Largest gap to flow closed on each trace
Coalescence	• Solder balls, graping, poor pull back on over prints	1) Print deposits of varying sizes onto small round pads on FR-4 substrate and reflow	• Visual: Inspect for coalescence and rate as Preferred, Acceptable or Unacceptable as IPC standards apply to ceramic substrate
Random Solder Balls	• May require manual removal	1) Print, populate and reflow PCB 2) Inspect for random solder balls, or satellites, near overprinted pads, around the leads of fine pitch devices or in random locations on the PCB 3) Check gold fingers, if applicable	• Quantitative: the number of balls larger than the smallest gap between conductors on the assembly, or, the assembler's or customer's internal specification
Solder Beads or Mid-Chip Solder Balls	• May require manual removal	1) Print, place and reflow small chip components 2) Inspect for solder beads visually or with X-ray	• Quantitative: Number of balls larger than the smallest gap between conductors on the assembly, or, the assembler's or customer's internal specification
Voiding	• Poor thermal heat sinking or electrical gounding on BTC, potentially weaker solder joints	1) Print, place, reflow, X-ray 2) Analyze for: • Overall Void % • Number of voids	• Quantitative • < 30 % or customer specification • Lower is better

	• Expensive and risky rework		*Note: For any overall void %, more, smaller voids are generally preferable to fewer, larger voids*
Head-in-Pillow (HIP)	• Expensive rework, scrap or warranty returns	1) Print, place and reflow BGAs 2) Inspect with X-ray	• Quantitative: Defect count
Tombstones or Skews	• Defect that requires rework • Risk of defect increases as package size decreases	1) Print, place and reflow small chip components 2) Inspect visually or with AOI	• Quantitative: Defect count
Joint Appearance	• Inspection time and accuracy	1) Inspector-dependent based on wetting angle, flux residue, shine, other *Can be highly subjective*	• Visual grade among inspectors or rank order • Quantitative: False fails at AOI *if applicable*
Flux Residue Appearance	• Inspection time and accuracy • Customer perception	1) Inspector-dependent based on color, clarity and consistency *Can be highly subjective*	• Visual grade among inspectors or rank order • Quantitative: False fails at AOI *if applicable*
Testability			
Residue Probe-ability Brittle or Ductile	False Fails & Retests ($)	1) Visual and tactile assessment 2) Probe-ability testing if available	• Rank order the assessments • Quantitative if probe-ability testing
Post-reflow pin probe window	Easy-to-probe residues can become difficult to probe after a certain period of time False Fails and Retests ($)	1) Number of days in test window	• Minimum set by assembler • Rank order or pass/fail
Contact Resistance	False Fails & Retests ($)	1) Resistance measurements	• Quantitative: track resistance over period of days
Test Fixture Maintenance	False Fails & Downtime for maintenance	1) Evaluation by Test Engineering & Operations	• Quantitative: Number of points probed between required maintenance • Subjective: technician assessment

Reliability			
Surface Insulation Resistance (SIR)	• Post-SMT dendritic growth • Field failures and warranty returns	1) 3rd party verification in SIR chamber	• Quantitative: MUST pass with resistance > 10^8 Ohms per J-STD-004B
Complete Removal of Residues	• Dendritic growth, field failures, warranty returns	1) Resistivity of Solvent Extract (ROSE) - internal process tests the overall cleanliness of the wash/rinse water but not in specific areas of the PCB	• ROSE tester (ionic contamination) <6 µg NaCl equivalent per $inch^2$
Complete Removal *Under Low-Standoff Components*	• Dendritic growth, field failures • Very important but often difficult to achieve	1) Ion chromatography (IC) – quantitative, focused, conclusive test on cleanliness of the assembly under low standoff components	• Quantitative: IC under low standoff components. • Various ionic species have different allowable maximums
Post-Assembly Materials Compatibility	• Improper flow or cure of underfill, potting or conformal coating materials • Field failures and warranty returns	1) Various inspection methods: acoustic, X-ray, UV fluorescence or others depending on the material 2) Accelerated Life Testing (ALT) for high reliability products	• Complete flow, encapsulation and cure • No longer term interactions between the materials • Pass ALT
Supplier Rating and Value Proposition			
Supply Chain	• Local distribution usually preferred • Direct has potential to shut lines down for paste shortages or quality issues	1) Interview or site visit to review ordering and handling procedures	• Minimum 2 lots on hand at all times
Technical Support	• Local distributor knowledge • Access to suppliers' engineers	1) Invite supplier to support paste evaluation 2) Engage support personnel and evaluate	• If supplier does not support evaluation, they will not support production • Level of knowledge of products or processes on your horizon
Shelf Life/Storage Conditions	• Improper handling of temperature-sensitive pastes can cause a multitude of defects	1) Review handling and storage procedures in documentation 2) Ask if its ok if the paste gets warm and goes back into refrigeration	• Minimum 2 weeks without refrigeration, longer is better

Similar fluxes in tin-lead and lead-free pastes	• Only applicable if running both	1) Ask solder paste providers	• Satisfactory reflow on coolest tin-lead profile and hottest lead-free profile
Compatibility with understencil wipe chemistry	• Only applicable if running wet wipe • If not compatible, new solvent must be identified and specified	1) Ask solvent provider if specific solder pastes are compatible 2) Ask paste supplier about solvent compatibility	• Cleanliness and drying time
Reclaim services	• Primarily necessary if wave soldering • Can save money by bundling materials and services	1) Ask and evaluate	• Financial incentive for better reclaim pricing is a plus but should drive paste selection