Solder plus Support

SOLDER PASTE POWDER: WHEN TO DOWNSIZE

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As components shrink in size, the demand for finer solder pastes increases. But the selection of solder paste is not just about matching component size, it's also about optimizing printing and reflow processes to prevent defects and ensure reliability.

This article explores the significance of solder paste powder size, particularly focusing on when and why manufacturers should consider downsizing from standard types to finer alternatives.

The Impact of Process Variations in Solder Powder Production

The exact method for creating solder powder, and ultimately solder paste, can vary significantly from one manufacturer to another. These differences in production methods can lead to very different outcomes when printing with a particular paste size.

In other words, you can end up with entirely different results when using a Type 5 paste from one manufacturer compared to that from another. Moreover, the inherent variation within a given solder powder production process will have a greater influence on the paste's performance the smaller the particle size gets.

Particle size classification is standardized by the IPC; however, it still allows for significant variation. The IPC specifies that only 80% of particles for a given type must fall within the nominal range (See **Table 1**). This leaves room for differences in particle size distribution among manufacturers, which can significantly affect solder paste performance, including printability, reflow behavior, and reliability.

Type	<0.5% larger than	<10% between	At least 80% between	<10% smaller than
Type 3	60 µm	45-60 µm	25-45 µm	25 µm
Type 4	50 µm	38-50 µm	20-38 µm	20 µm
Type 5	40 µm	25-40 µm	15-25 µm	15 µm
Type 6	25 µm	15-25 µm	5-15 µm	5 µm
Type 7	15 µm	11-15 µm	2-11 µm	2 µm

Table 1. Particle distribution limits per IPC J-STD-005A.

How to Decide When to Downsize Your Solder Paste

When considering whether to downsize your solder paste, you must take into consideration the size and spacing of components, the production environment and settings, and the potential challenges that can come with smaller powders.

In general, the smaller the paste, the more challenging the process. Because of this, the ultimate success of your process becomes increasingly dependent on all the variations in solder paste production methods described above.

The 5-Ball Rule and Its Implications

A common heuristic used to determine what powder size to use is the so-called "5-ball rule." The "5-ball rule" suggests that the smallest stencil aperture should be at least five times the diameter of the solder paste's largest particles (See **Table 2**).

For instance, with Type 4 solder paste, where particles range up to 38µm, the smallest printable aperture would be around 190µm/.004". However,

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as we move to finer powders like Type 6, with particles as small as 5-15µm, the practical applicability of the 5-ball rule becomes uncertain. This is because the extremely small particle sizes and tighter spaces have not been thoroughly tested, thus the rule may not hold true or require adaptation for these advanced types.

Type	Lower limit of stencil aperture diameter per 5-ball rule
Type 3	225 µm
Type 4	190 µm
Type 5	125 µm
Type 6	75 µm
Type 7	55 µm

Table 2. The lower limit for stencil aperture diameters based on the 5-ball rule.

Challenges of Downsizing Solder Paste Powder

Downsizing to a smaller powder comes with tradeoffs, especially at the smallest powder sizes. Namely, the following:

- Smaller powders are more difficult to produce, and hence come with a higher price point.
- Smaller powders have a greater surface area to mass ratio, and hence more potential for oxidation. This shortens shelf life and makes them more sensitive to process parameters, with requirements for nitrogen reflow for Type 6 and smaller.
- Manufacturing methods differ from one supplier to the next, so there can be substantial variation in the quality of a particular powder size in terms of sphericity of particles and particle size distribution. These variations can lead to unanticipated issues and defects.
- Stencil design adaptations might be needed for finer powders to avoid issues like stencil clogging or insufficient paste release. This involves considering stencil thickness, aperture size, and wall smoothness.
- In general, the smaller the powder, the smaller the process window, which means settings such as squeegee pressure and speed must be very carefully dialed in.

Why You Should Go with the Largest Feasible Powder Size

Because of the significant trade-offs that come when downsizing, if your application is near the threshold suggested by the 5-ball rule, it may be prudent to stick with the larger size. In fact, at AIM we have had several situations where our Type 4 paste outperformed Type 5 paste in situations that were borderline when it came to the downsizing decision.

As an example, suppose you must print boards in which the smallest components will be 01005s. IPC recommended stencil apertures for these components are 175 by 250µm, which may be outside of what Type 4 paste should be able to print (≥190µm).

However, with a little ingenuity, it's also possible to use a rounded square aperture design of side length 190µm or slightly larger for these components. This aperture shape maximizes volume in tight spaces while improving transfer efficiency.

In this scenario, transfer efficiency can be further maximized by using a nano-coated 4 mil or even 3 mil stencil. Hence, if 01005s are your smallest components, Type 4 paste can work and with few unintended side effects.

A Note on Half-Size Solder Pastes

Some manufacturers sell pastes labeled as Type 4.5 or Type 5.5, leaving process engineers to wonder if it might be a good idea to switch to a half size if their components are right on the edge, such as was the case described above.

However, there are no IPC specifications defining what these half types are. While you might expect a

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paste labeled Type 4.5 to have a particle size range between that of Type 4 and Type 5, the reality is that it could be larger, smaller, or simply more broad - such as you would get if you mixed Type 4 and Type 5 powder together.

If you are considering a half size paste, be sure to get a clear indication from the manufacturer as to the particle size distribution before proceeding.

Conclusion and Recommendations

Selecting the appropriate solder paste type is crucial for achieving optimal assembly outcomes. The 5-ball rule offers a foundational guideline for this choice, but it's essential to consider the broader context of your manufacturing processes and component requirements.

Before downsizing solder paste, assess the potential benefits against the associated challenges, such as increased oxidation or reflow issues. Optimization of existing processes with the current paste type may alleviate the need for downsizing, maintaining production efficiency and product quality.

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