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Sandia National Laboratories

Solder Cup Wire Insertion Study

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Should 100% wire insertion remain a requirement for soldering during cable fabrication?

Three conditions required by the Association Connecting Electronic Industries for acceptable solder cup connection (IPC-A-610) (Fig. 1):

- Wire leads must contact back wall of cup
- Wire leads must be inserted to the full depth of cup
- Solder must vertically fill at least 75% of the visible cup.

X-ray micro computed tomography (μCT) scans show that solder cups which visually appear to be 100% filled can contain significant voiding (Fig. 2). Solder joints from connectors were examined via μCT and joints were tensile tested to correlate wire insertion, solder fill, and joint angle with joint strength to determine whether the 100% insertion requirement is necessary.

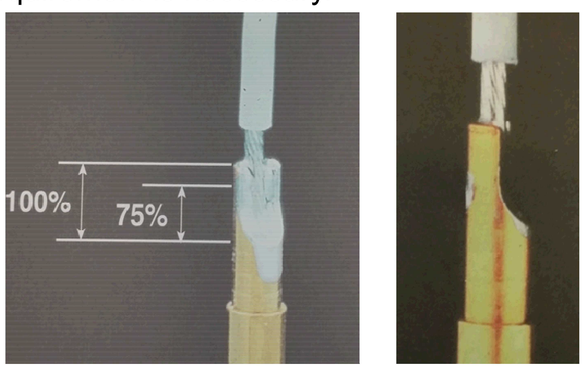

Fig. 1 Acceptable solder joint per IPC-A-610 Rev G. The 75% VISIBLE solder fill requirement is highlighted in the left image.

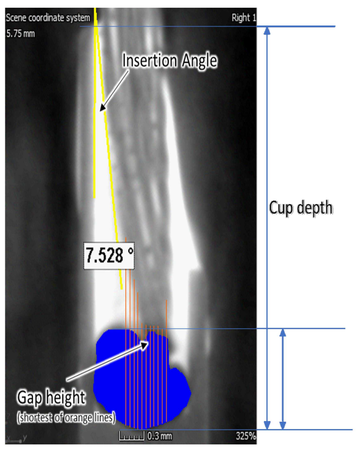

Fig. 2 μCT scan of solder joint.

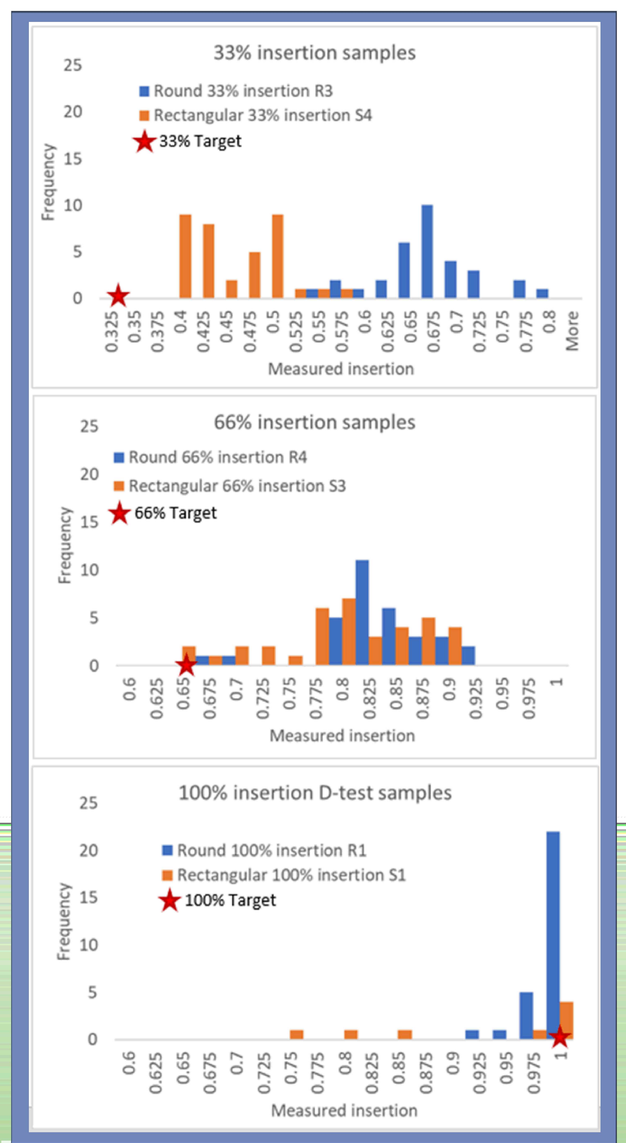

Fig. 10 Distribution of the achieved wire insertions. The red star indicates the targeted insertion level.

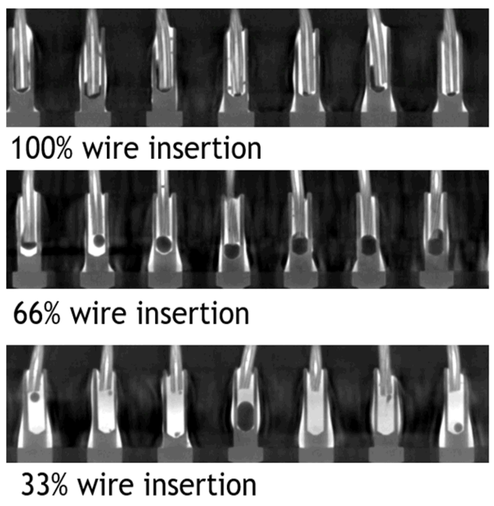

Fig. 3 μCT scan of solder joints prior to testing.

Approach

1. Fabrication: Solder joints in both round and rectangular connectors of cable assemblies were fabricated at targeted 100%, 66%, and 33% wire insertion (Fig. 3). After soldering, the joints were subjected to the steps in Fig. 4.

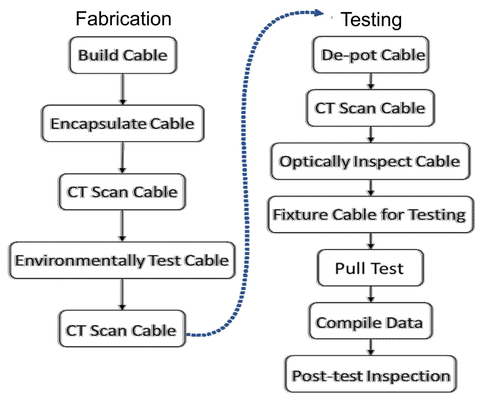

Fig. 4 Chronological history detailing cable lifetime for this study.

2. Pre-Test Analysis: The μCT scans of each solder joint were analyzed as shown in Fig. 2 to determine the wire insertion level, the solder fill percentage, and the angle of the wire with respect to the back of the cup.

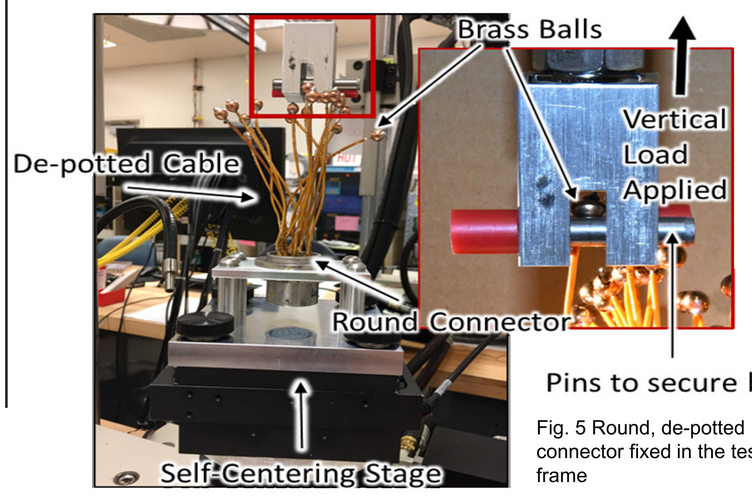

Fig. 5 Round, de-potted connector fixed in the test frame

3. Tensile Testing: Brass balls were hand soldered onto wire ends. The connector was placed into a self-aligning fixture (Fig. 5). A vertical load was applied to the wires until failure (0.01 in/sec). Failures occurred either in the wire or solder joint (Fig. 6). 335 joints were tested.

Fig. 6 Broken joints and wires

Results

μCT: Targeted insertion levels were rarely reached (Figs. 3 & 10), illustrating the joint fabrication difficulty.

Tensile: Compiling the results of the tensile testing with the μCT results shows that joint failure is less likely as the insertion level increases and that increased insertion level leads to more consistent performance of the joint (Figs. 7 & 8).

Fracture analysis: While solder joint failure may be more likely at low wire insertion levels, underfilled cups and/or poor solder wetting will promote solder joint failure even at high wire insertion levels (Fig. 9).

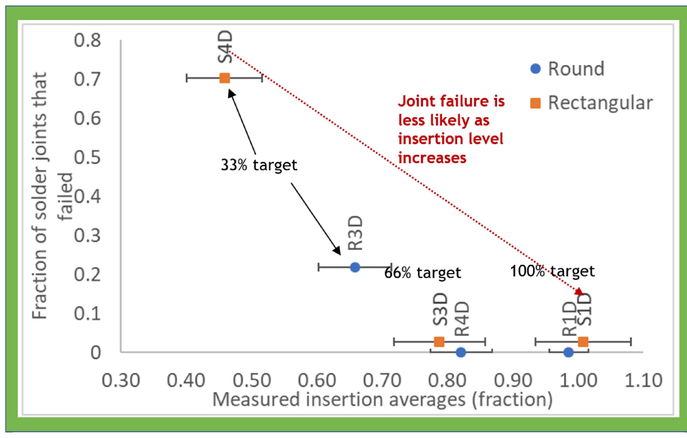

Fig. 7 Fraction of solder joint failures as a function of wire insertion levels reflecting both the round and rectangular connectors.

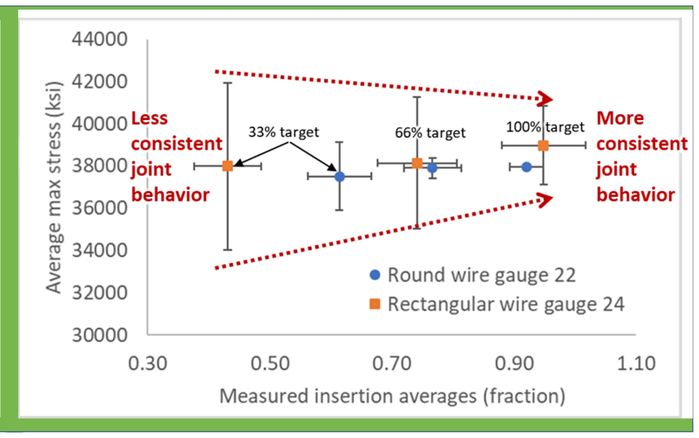

Fig. 8 Average measured maximum stress values for each set of insertion targets, reflecting both the round and rectangular connectors.

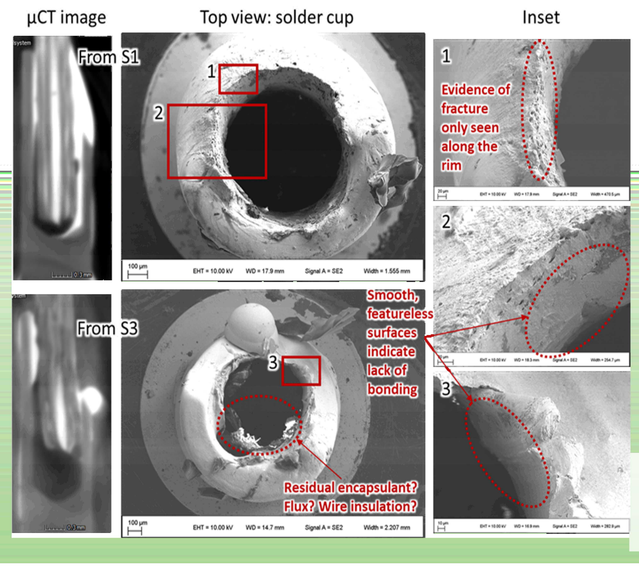

Fig. 9 SEM images of solder joint failures with high wire insertion levels. Side view μCT scans are shown to the left of the corresponding solder cup top views, and insets are shown on the right.

Conclusion

- It is difficult to make consistent solder joints even in a controlled environment; therefore setting an insertion level requirement less than 100% may reduce process consistency.
- Greater wire insertion leads to better solder joint strength.
- Low solder fill/poor solder wetting leads to poor joint performance despite greater wire insertion.

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