Application Report

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# Factors That Influence Side-Wetting Performance on IC Terminals

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**ABSTRACT**

A designed experiment evaluated the influence of several variables on appearance and strength of Pb-free solder joints. Components, with leads finished with nickel-palladium-gold (NiPdAu), were used from Texas Instruments (TI) and two other integrated circuit suppliers. Pb-free solder paste used was tin-silver-copper (SnAgCu) alloy. Variables were printed wiring board (PWB) pad size/stencil aperture (the pad finish was consistent; electrolysis Ni/immersion Au), reflow atmosphere, reflow temperature, Pd thickness in the NiPdAu finish, and thermal aging. Height of solder wetting to component lead sides was measured for both ceramic plate and PWB soldering. A third response was solder joint strength; a "lead pull" test determined the maximum force needed to pull the component lead from the PWB.

This paper presents a statistical analysis of the designed experiment. Reflow atmosphere and pad size/stencil aperture have the greatest contribution to the height of lead side wetting. Reflow temperature, palladium thickness, and preconditioning had very little impact on side-wetting height. For lead pull, variance in the data was relatively small and the factors tested had little impact.

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# 1 Introduction

The ceramic plate test (CPT) or surface mount process simulation test [(1)] has been used in the industry since the early 1990s to evaluate solderability of component terminals. The CPT simulates the environment that surface mount devices encounter during solder reflow. In this method, solder paste is screened onto a ceramic substrate, the test devices are placed on the printed solder paste, and the ceramic substrate is processed through a reflow cycle and allowed to cool. After reflow, the units are easily removed from the ceramic for inspection. The beauty of this test is that the IC devices are subjected to the same solder paste and reflow environment seen in printed wiring board (PWB) processing, and use of a ceramic substrate allows for inspection of the soldered lead surface (underside of lead foot). However, use of a CPT in place of PWB soldering introduces a variable that may influence solder joint shape: the ceramic is, by design, a nonsolderable surface, while a PWB pad is a solderable surface. This difference in wetting properties of the substrates may influence lead side wetting. Another substrate factor that could influence lead side wetting is the pad size/stencil aperture size. Process factors that could influence lead side wetting are reflow atmosphere, reflow peak temperature, and solder paste. Factors related to the components that might have an influence are palladium thickness and preconditioning. In this study, PWB finish (ENIG) and Pb-free paste were held constant.

As the industry moves into Pb-free processing with reflow environments and materials different from tin-lead (SnPb) soldering, it is imperative to understand the impact of these variables on solderability, particularly solder joint shape, when testing using CPT and PWB methods.

(1) See Test S/S1 in J-STD-002 or Method 2 in JESD22-B102D.

## 2 Experiment

A designed experiment (DOE) evaluated the effect of several variables (Table 1) on component lead side wetting and lead pull performance.

**Table 1. DOE Input Variables**

| I.D. | Variable | No. of Levels | L1 | L2 | L3 |
|---|---|---|---|---|---|
| Pad | Pad Size/Stencil Aperture | 3 | CUST | IPC | TID |
| RA | Reflow Atmosphere | 2 | Air | N2 | |
| RT | Reflow Temperature | 2 | 230C | 240C | |
| PDT | Palladium Thickness | 2 | 0.01 µm (0.4 µ") | ≥0.02 µm (0.8 µ") | |
| AG | Precondition | 2 | None | 16 hr, 155°C | |

The IC package used for these evaluations was an 8-pin SOIC (see Figure 1 and Figure 2).

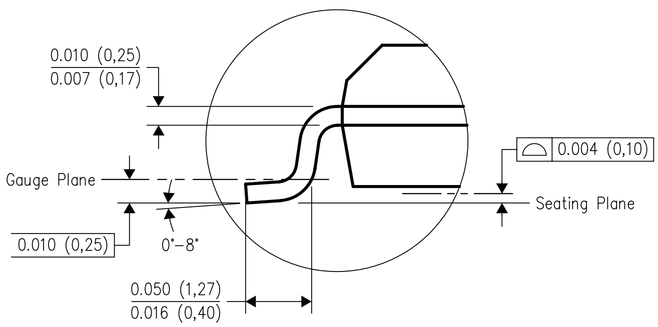



**Figure 1. TI SOIC Package End View**

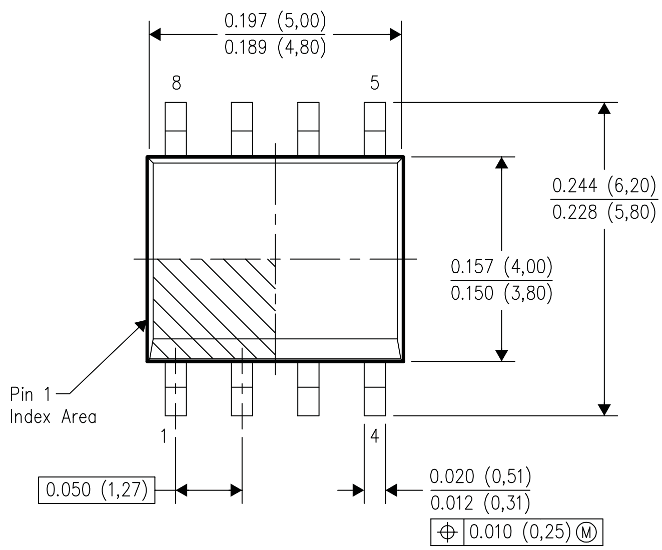



**Figure 2. TI SOIC Package Top View**

Three levels were evaluated for the PWB pad size/stencil aperture opening. CUST is a customer design, TID is a TI design, and IPC is from the IPC guidelines. All were included on each board. The pad dimension correlated 1:1 with the stencil aperture. Dimensions and areas of the three pad levels evaluated are shown in Table 2 and shown graphically in Figure 3.

**Table 2. PWB Pad and Stencil Aperture Size**

| Pad/Aperture Opening | Length (mm) | Width (mm) | Area (mm2) |
|---|---|---|---|
| CUST | 1.2 | 0.6 | 0.72 |
| IPC | 1.9 | 0.55 | 1.045 |
| TID | 1.52 | 0.76 | 1.155 |

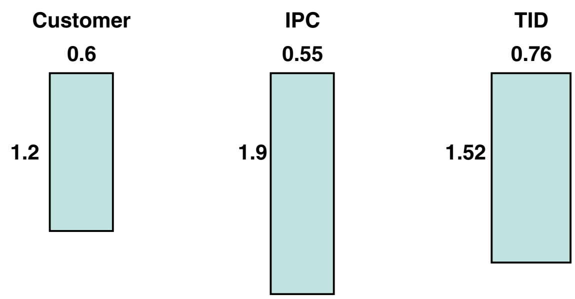



**Figure 3. PWB Pad Dimensions**

RA was either air or nitrogen (N2) purge (~50 ppm remaining $0_2$). A commercial Pb-free SnAgCu solder paste was used with a RT of 230°C and 240°C. To evaluate the impact of different palladium thicknesses, Pb-free NiPdAu-finished components from three different suppliers were used, as shown in Table 3.

**Table 3. Different Palladium Thicknesses**

| Component | Pd Thickness – μm (μ") |
|---|---|
| TI | 0.01 (0.4) |
| Competitor 1 | 0.05 (1.97) |
| Competitor 2 | 0.04 (1.57) |

Preconditioning (thermal aging) was another variable. The two levels were no preconditioning and 16 hours/155°C dry heat.

The designed experiment layout is shown in Table 4.

**Table 4. Layout of Designed Experiment[1]**

| Run | Pad | RA | RT | PDT | AG |
|---|---|---|---|---|---|
| 1 | CUST | Air | 230 | 0.01 | 16 hr |
| 2 | CUST | Air | 230 | >0.02 | 0 |
| 3 | CUST | Air | 240 | 0.01 | 0 |
| 4 | CUST | Air | 240 | >0.02 | 16 hr |
| 5 | CUST | N2 | 230 | 0.01 | 0 |
| 6 | CUST | N2 | 230 | >0.02 | 16 hr |
| 7 | CUST | N2 | 240 | 0.01 | 16 hr |
| 8 | CUST | N2 | 240 | >0.02 | 0 |
| 9 | IPC | Air | 230 | 0.01 | 16 hr |
| 10 | IPC | Air | 230 | >0.02 | 0 |
| 11 | IPC | Air | 240 | 0.01 | 0 |
| 12 | IPC | Air | 240 | >0.02 | 16 hr |
| 13 | IPC | N2 | 230 | 0.01 | 0 |
| 14 | IPC | N2 | 230 | >0.02 | 16 hr |
| 15 | IPC | N2 | 240 | 0.01 | 16 hr |
| 16 | IPC | N2 | 240 | >0.02 | 0 |
| 17 | TID | Air | 230 | 0.01 | 16 hr |
| 18 | TID | Air | 230 | >0.02 | 0 |
| 19 | TID | Air | 240 | 0.01 | 0 |
| 20 | TID | Air | 240 | >0.02 | 16 hr |
| 21 | TID | N2 | 230 | 0.01 | 0 |
| 22 | TID | N2 | 230 | >0.02 | 16 hr |
| 23 | TID | N2 | 240 | 0.01 | 16 hr |
| 24 | TID | N2 | 240 | >0.02 | 0 |

(1) Pad = pad dimension, RA = reflow atmosphere, RT = reflow temperature, PDT = Pd thickness, AG = preconditioning

Responses were lead side-wetting height in the CPT and PWB mount, and lead pull measurements after PWB mount. The degree of lead side wetting was judged on a scale of 0 to 1, with 0 being no solder wetting the side of the lead and 1 showing solder to the top edge of the lead, i.e., 100% of the lead side was covered with solder (Figure 4). Statistical analysis of the output was performed using a common statistical analysis software package, and output data is summarized in an Analysis of Variance (ANOVA) and Effects table.

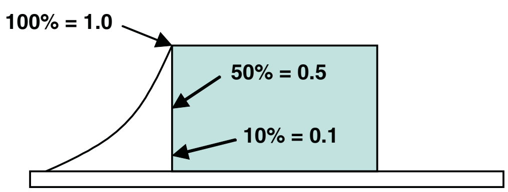



**Figure 4. Side Wetting Classification Examples**

Figure 5 through Figure 7 show examples of unit placement on the PWBs. Note the 1:1 design of the stencil and PWB pad. The devices were not pushed into the solder paste print.

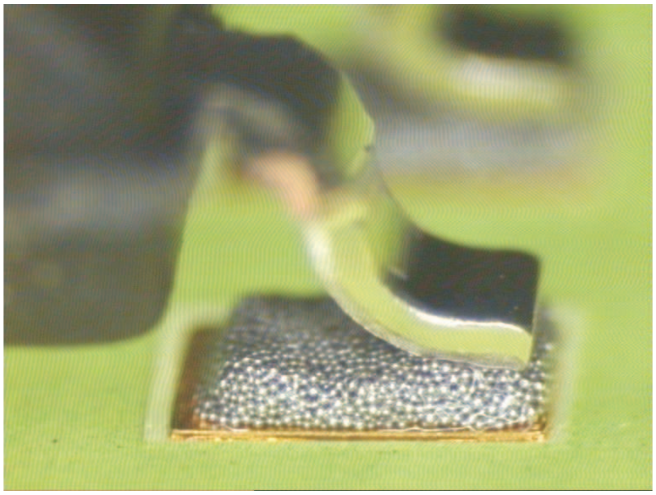


**Figure 5. Component Placed Onto Customer Pad**

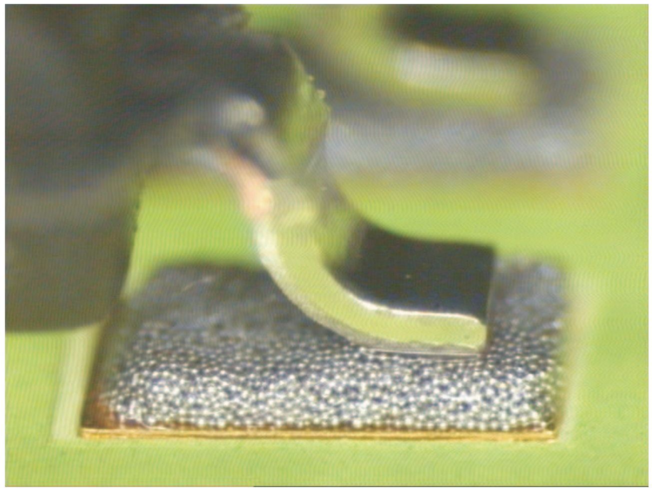


**Figure 6. Component Placed Onto TID Pad**

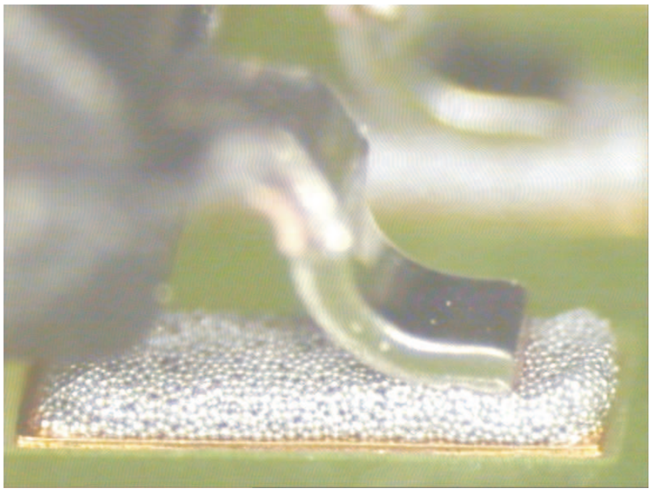


**Figure 7. Component Placed Onto IPC**

Figure 8 through Figure 13 show the lead pull test method using a 20-pin SOIC package. The method is the same when testing an 8-pin SOIC package as in this experiment. First the component is soldered onto a test PWB. The package body is cut using a diamond blade and removed. The component leads are bent up for the pull test. The individual leads are pulled vertical to the PWB.

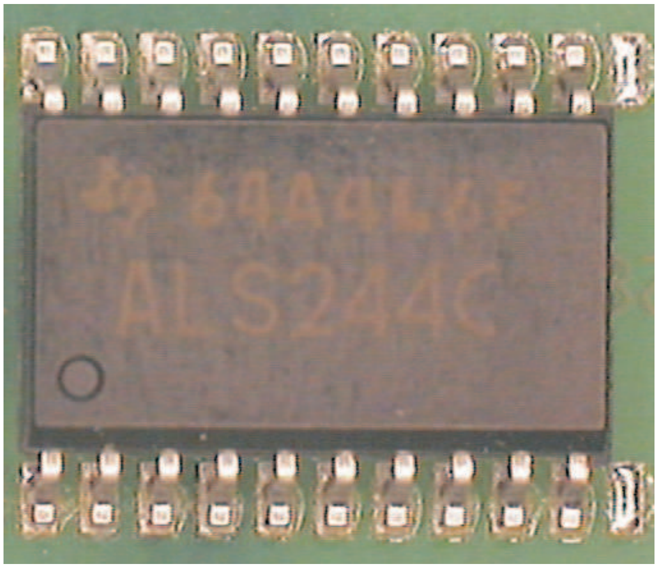



**Figure 8. Soldered Device on PWB**

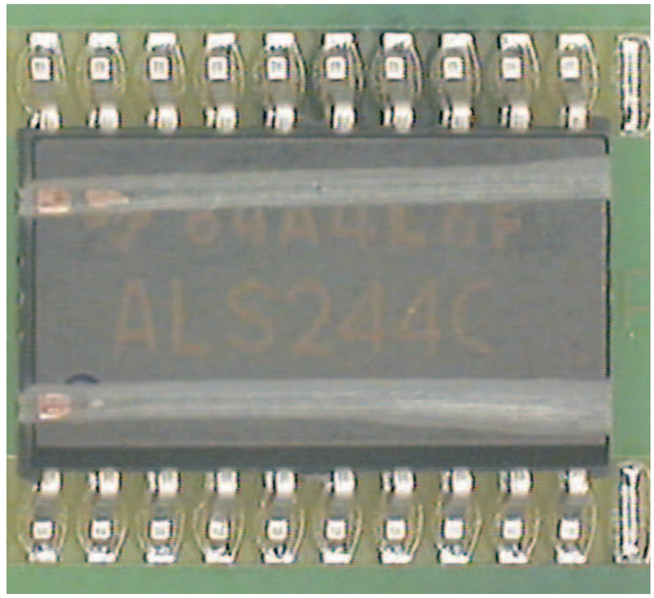



**Figure 9. Package Body Cut Using Diamond Blade**

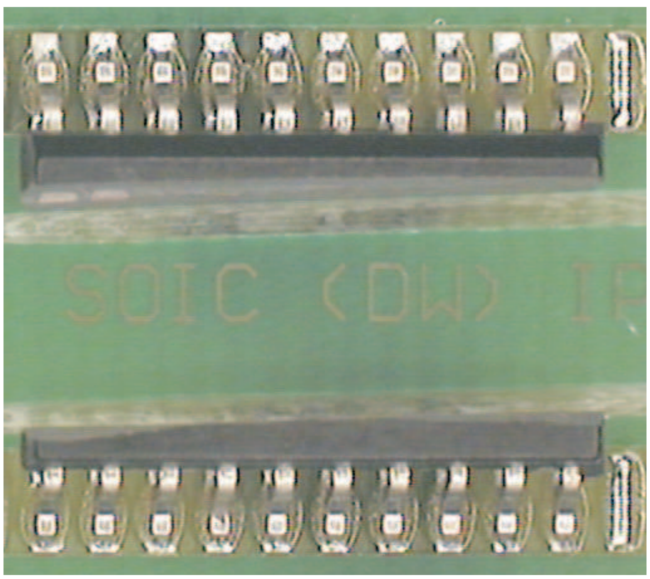



**Figure 10. Package Body Removed**

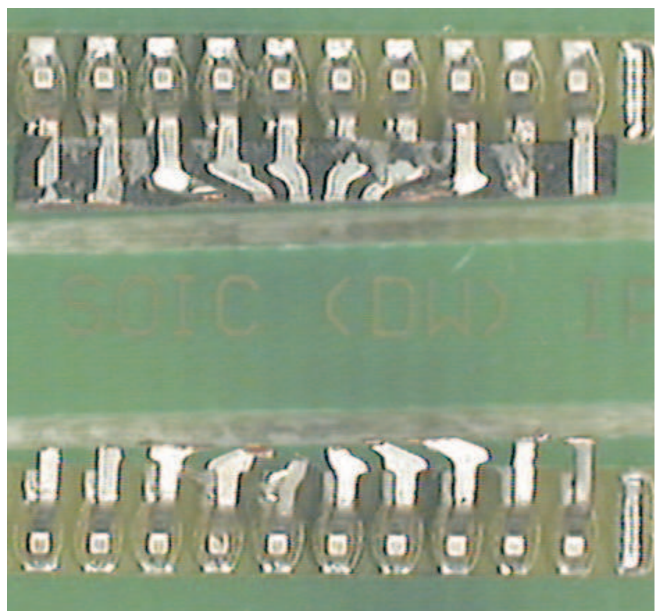



**Figure 11. Mold Compound Removed**

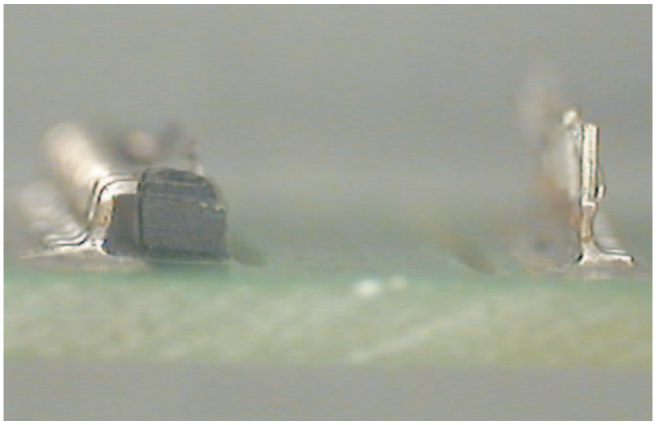


**Figure 12. One Set of Leads Bent Up For Pull Test**

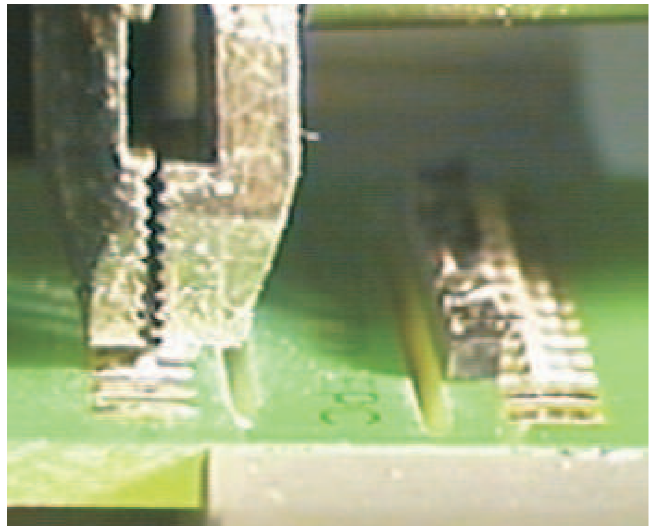


**Figure 13. Pull Test Performed Vertical to PWB**

The unit of measure for lead pull test data in this experiment is kilograms (kg) pull force.

The results are presented in Section 3 as TI components versus Competitor 1 components and TI components versus Competitor 2 components, looking at CPT, PWB mount, and lead pull results, in that order.

# 3 Results: TI Versus Competitor 1

## 3.1 Lead Side-Wetting Height in CPT Test Method

Analysis of Variance (ANOVA) results for CPT lead side-wetting height of TI versus Competitor 1 are shown in Table 5.

**Table 5. ANOVA Results for CPT Side Wetting, TI Versus Competitor 1**

| Rank | Source | Df | SS | F Ratio | Prob > F | % Contribution |
|---|---|---|---|---|---|---|
| 1 | RA | 1 | 7.287526 | 206.286 | <0.0001 | 44.92 |
| 2 | Pad (IPC and CUST-TID) | 1 | 4.245326 | 120.171 | <0.0001 | 26.17 |
| 3 | PDT | 1 | 1.438151 | 40.709 | <0.0001 | 8.86 |
| 4 | Pad (IPC and CUST-TID)*RA | 1 | 1.325013 | 37.507 | <0.0001 | 8.17 |
| | Pad (IPC and CUST-TID)*PDT | 1 | 0.7190755 | 20.355 | <0.0001 | 4.43 |
| | Pad (IPC-CUST) | 1 | 0.2691016 | 7.617 | 0.0061 | 1.66 |
| | Pad (IPC-CUST)*RT | 1 | 0.2197266 | 6.22 | 0.0131 | 1.35 |
| | AGE | 1 | 0.206276 | 5.839 | 0.0162 | 1.27 |
| | Pad(IPC-CUST)*RA | 1 | 0.175352 | 4.964 | 0.0265 | 1.08 |
| | RA*PDT | 1 | 0.170859 | 4.847 | <0.0001 | 1.05 |
| | RA*AGE | 1 | 0.162526 | 4.601 | 0.0326 | 1 |
| | RT | 1 | 0.005859 | 0.166 | 0.6841 | 0.04 |
| | Total | | 16.224792 | | | 100 |

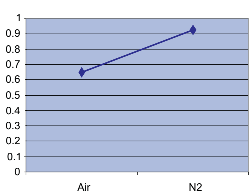
RA and Pad have the strongest contribution to side-wetting height in the CPT method. Other factors (PDT, RT, and AG) and interactions all have lesser or no contribution.

The average effects table for individual factors is shown in Table 6. An effects table shows the mean value for each factor level setting in all runs. For instance, under the column heading RA, the average value for AIR was 0.648 and the average value for N2 was 0.923. This tells us that N2 provided higher lead side wetting than AIR.

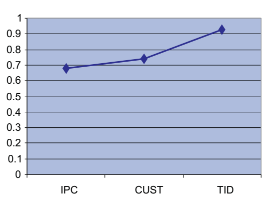
Effects plots are shown for each factor immediately under Table 6. An effects plot is a graphical representation of the average effects data. An effects plot provides an easy to understand visual representation of the average effects data. Basically if the effects plot is flat (horizontal line), there is little to no effect. If the effects plot has a slope (slanted line), there is some effect from the factor. The greater the slope of the line, the greater the effect.

**Table 6. Average Effects Table for CPT Side Wetting, TI Versus Competitor 1**

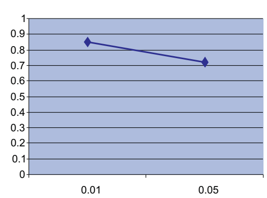
| RA | | Pad | | PDT | | AG | | RT | |
|---|---|---|---|---|---|---|---|---|---|
| AIR | 0.648 | IPC | 0.679 | 0.01 | 0.847 | 0 | 0.809 | 230 | 0.79 |
| N2 | 0.923 | CUST | 0.744 | 0.05 | 0.724 | 16 | 0.763 | 240 | 0.782 |
| | | TID | 0.934 | | | | | | |



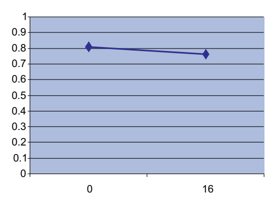

RA



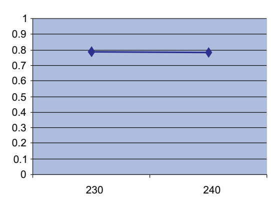

Pad




PDT




AG




RT

The effects table and plots clearly show that reflow atmosphere and pad/aperture size have a strong effect. N2 provides higher side-wetting performance. For factor of Pad, the wider the pad and aperture opening the higher the side wetting. Thinner Pd showed higher side wetting. The effects of aging and reflow temperature are minor.

## *3.2 Lead Side-Wetting Height in PWB Soldering*

ANOVA results for PWB lead side-wetting height of TI versus Competitor 1 are shown in Table 7.

**Table 7. ANOVA Results for PWB Lead Side Wetting, TI Versus Competitor 1**

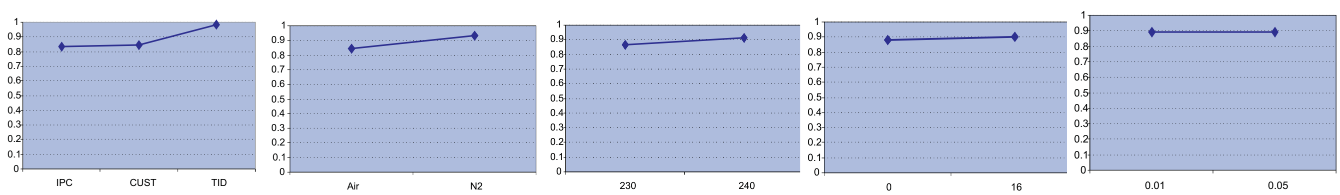
| Rank | Source | Df | SS | F Ratio | Prob > F | % Contribution |
|---|---|---|---|---|---|---|
| 1 | Pad (IPC and CUST-TID) | 1 | 1.8116 | 131.448 | <0.0001 | 53.85 |
| 2 | RA | 1 | 0.735 | 53.332 | <0.0001 | 21.85 |
| 3 | RT | 1 | 0.2301 | 16.696 | <0.0001 | 6.84 |
| 4 | Pad (IPC-CUST)*AG | 1 | 0.18598 | 13.495 | 0.0003 | 5.53 |
| | Pad (IPC and CUST-TID)*RA | 1 | 0.17824 | 12.933 | 0.0004 | 5.3 |
| | Pad (IPC-CUST)*RT | 1 | 0.10973 | 7.962 | 0.005 | 3.26 |
| | RA*RT | 1 | 0.065104 | 4.724 | 0.0304 | 1.94 |
| | AGE | 1 | 0.04167 | 3.023 | 0.0829 | 1.24 |
| | Pad (IPC-CUST) | 1 | 0.0066 | 0.479 | 0.4893 | 0.2 |
| | PDT | 1 | 0 | | | 0 |
| | Total | | 3.364024 | | | 100 |

Pad and RA have the strongest contribution to side-wetting height in PWB mount. Other factors (PDT, RT, and AG) all have lesser or no contribution.

The average effects table for individual factors is shown in Table 8.

**Table 8. Average Effects Table for PWB Lead Side Wetting, TI Versus Competitor 1**

| Pad | | RA | | RT | | AG | | PDT | |
|---|---|---|---|---|---|---|---|---|---|
| IPC | 0.836 | Air | 0.846 | 230 | 0.865 | 0 | 0.879 | 0.01 | 0.89 |
| CUST | 0.846 | N2 | 0.933 | 240 | 0.914 | 16 | 0.9 | 0.05 | 0.889 |
| TID | 0.987 | | | | | | | | |




Pad RA RT AG PDT

The effects table and effects plots show that Pad has a strong effect and RA has a moderate effect. Once again for the Pad factor, the wider pad opening yields higher lead side wetting. For RA, N2 provides higher lead side wetting, but it is a minor effect in this case, most likely because of the "wettability" of the PWB. The effects of RT, AG, and PDT are very minor.

Summary of the average values for each combination of Pad and RA is shown graphically in Figure 14. The table contrasts the average values in CPT testing versus PWB soldering. The data demonstrates a difference in the side-wetting performance between CPT test method versus PWB soldering, particularly for the narrow pad/aperture openings (IPC, CUST) in air. When N2 is used, the wetting performance is essentially the same for either method, CPT or PWB soldering.

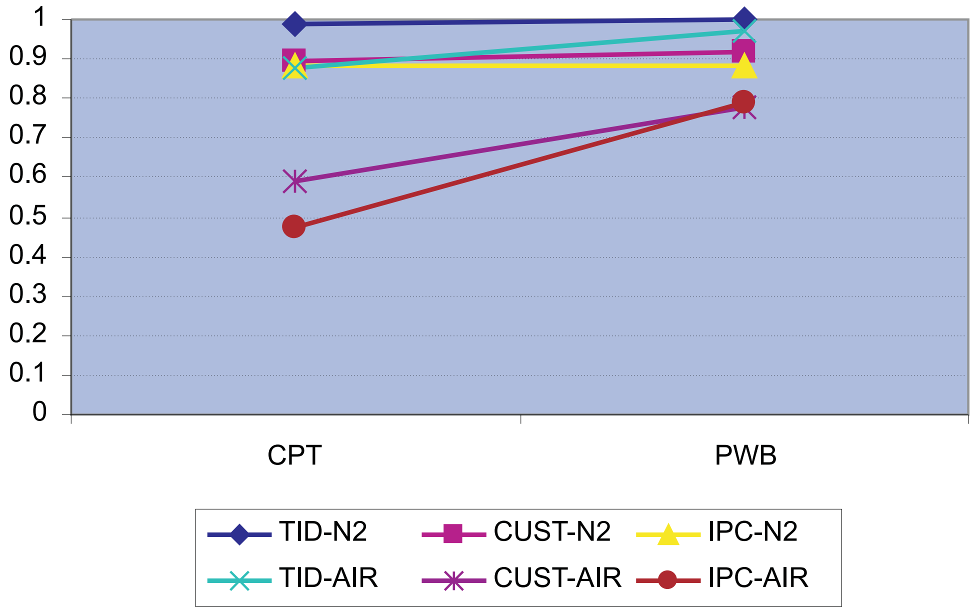



**Figure 14. Comparison of Side-Wetting Performance in CPT Method Versus PWB Soldering**

## 3.3 Lead Pull Variation in PWB Soldering

ANOVA results for component lead pull after PWB soldering of TI versus Competitor 1 are shown in Table 9.

**Table 9. ANOVA Results for Lead Pull After PWB Soldering, TI Versus Competitor 1**

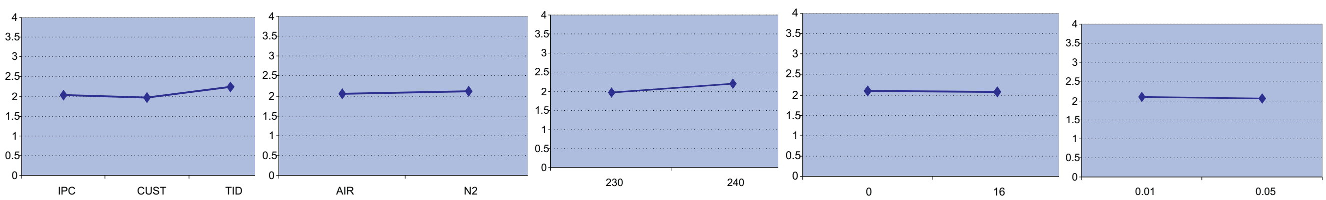
| Rank | Source | Df | SS | F Ratio | Prob > F | % Contribution |
|---|---|---|---|---|---|---|
| 1 | RT | 1 | 2.5438 | 21.264 | <0.0001 | 48.44 |
| 2 | Pad (CUST and IPC-TID) | 1 | 2.1901 | 18.307 | <0.0001 | 41.7 |
| 3 | Pad (IPC-CUST)*RT | 1 | 0.405 | 3.386 | 0.0674 | 7.71 |
| 4 | Pad (IPC-CUST) | 1 | 0.1128 | 0.943 | 0.3328 | 2.15 |
| | Total | | 5.2517 | | | 100 |

Reflow temperature and Pad have the most contribution to any variance in lead pull after PWB mount. However, as can be seen in the following effects plots, the actual variance is small. Other factors (RA, PDT, and AG) have no contribution.

The average effects table for individual factors is shown in Table 10.

**Table 10. Average Effects Table for Lead Pull After PWB Soldering, TI Versus Competitor 1**

| Pad | | RA | | RT | | AG | | PDT | |
|---|---|---|---|---|---|---|---|---|---|
| IPC | 2.033 | Air | 2.042 | 230 | 1.964 | 0 | 2.083 | 0.01 | 2.1 |
| CUST | 1.973 | N2 | 2.116 | 240 | 2.194 | 16 | 2.074 | 0.05 | 2.057 |
| TID | 2.23 | | | | | | | | |




Pad RA RT AG PDT

The effects table and effects plots for lead pull show very little variance from any variable in this experiment. Basically, all lead pull data are in the same range.

## 3.4 Summary/Conclusions for TI Versus Competitor 1

In both CPT and PWB soldering, RA and Pad contribute strongest to component lead side-wetting height. The other factors had negligible or no contribution. N2 provided the highest side wetting of leads and for Pad, the wider the pad/stencil aperture opening, the higher the lead side wetting. For lead pull after PWB mount, RT and Pad had the greatest contribution to variance. However, the effects table shows there is very little variation in the lead pull data across all groups.

# 4 Results: TI Versus Competitor 2

## *4.1 Lead Side-Wetting Height after CPT Testing*

Analysis of Variance (ANOVA) results for CPT lead side-wetting height of TI versus Competitor 2 are shown in Table 11.

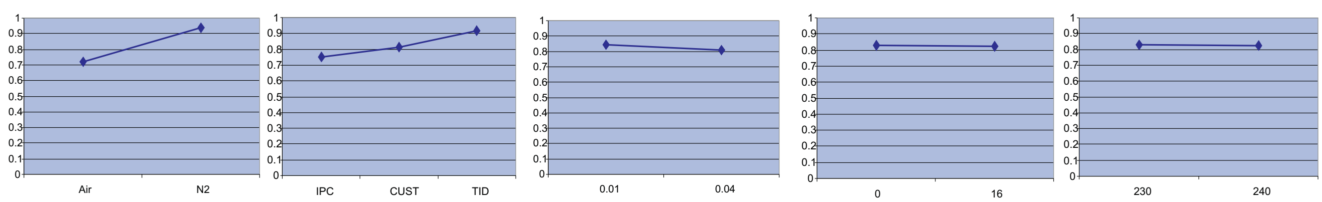
**Table 11. ANOVA Results for CPT Side Wetting, TI Versus Competitor 2**

| Rank | Source | Df | SS | F Ratio | Prob > F | % Contribution |
|---|---|---|---|---|---|---|
| 1 | RA | 1 | 4.6376042 | 146.65 | <0.0001 | 61.53 |
| 2 | Pad (IPC and CUST-TID) | 1 | 1.622513 | 51.307 | <0.0001 | 21.53 |
| 3 | Pad (IPC and CUST-TID)*RA | 1 | 0.5365755 | 16.968 | <0.0001 | 7.12 |
| | Pad (IPC-CUST)*RT | 1 | 0.2691016 | 8.51 | 0.0037 | 3.57 |
| | Pad (IPC-CUST) | 1 | 0.2562891 | 8.104 | 0.0047 | 3.4 |
| | PDT | 1 | 0.1426042 | 4.509 | 0.034 | 1.89 |
| | Pad(IPC-CUST)*PDT | 1 | 0.0722266 | 2.284 | 0.1316 | 0.96 |
| | Total | | 7.5369142 | | | 100 |

RA and Pad have the strongest contribution to lead side-wetting height in the CPT. Other factors (PDT, RT, and AG) all have lesser or no contribution. The average effects table for the individual factors is shown in Table 12.

**Table 12. Average Effects Table for CPT Side Wetting, TI Versus Competitor 2**

| RA | | Pad | | PDT | | AG | | RT | |
|---|---|---|---|---|---|---|---|---|---|
| AIR | 0.718 | IPC | 0.75 | 0.01 | 0.847 | 0 | 0.829 | 230 | 0.829 |
| N2 | 0.938 | CUST | 0.813 | 0.05 | 0.808 | 16 | 0.826 | 240 | 0.826 |
| | | TID | 0.92 | | | | | | |




RA Pad PDT AG RT

The effects table and effect plots show that RA and Pad have a strong effect. N2 provides higher lead side wetting. For the factor of Pad, the wider the pad opening the higher the lead side wetting. Thinner Pd showed slightly higher side wetting. AG and RT had no effect.

### 4.2 PWB Lead Side-Wetting Height

ANOVA results for PWB lead side-wetting height of TI versus Competitor 2 are shown in Table 13.

**Table 13. ANOVA Results for PWB Lead Side Wetting, TI Versus Competitor 2**

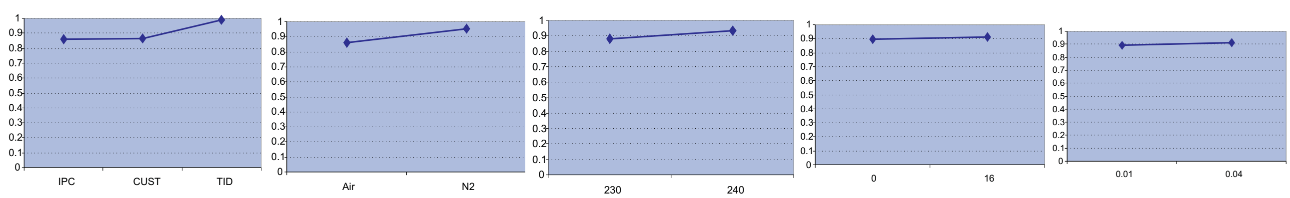
| Rank | Source | Df | SS | F Ratio | Prob > F | % Contribution |
|---|---|---|---|---|---|---|
| 1 | Pad (IPC and CUST-TID) | 1 | 1.3167187 | 83.324 | <0.0001 | 48.16 |
| 2 | RA | 1 | 0.8251042 | 52.214 | <0.0001 | 30.18 |
| 3 | RT | 1 | 0.2604167 | 16.48 | <0.0001 | 9.52 |
| 4 | Pad (IPC and CUST-TID)*RA | 1 | 0.2200521 | 13.925 | 0.0002 | 8.05 |
| | PDT | 1 | 0.0816667 | 5.168 | 0.0236 | 2.99 |
| | RT*PDT | 1 | 0.0301042 | 1.905 | 0.1683 | 1.1 |
| | Total | | 2.7340626 | | | 100 |

Again, Pad and RA have the strongest contribution to lead side-wetting height in board mount. Other factors (PDT, RT, and AG) show less or no contribution.

The average effects table for the individual factors is shown in Table 14.

**Table 14. Average Effects Table for PWB Lead Side Wetting, TI Versus Competitor 2**

| Pad | | RA | | RT | | AG | | PDT | |
|---|---|---|---|---|---|---|---|---|---|
| IPC | 0.859 | Air | 0.858 | 230 | 0.879 | 0 | 0.898 | 0.01 | 0.89 |
| CUST | 0.867 | N2 | 0.951 | 240 | 0.931 | 16 | 0.912 | 0.05 | 0.919 |
| TID | 0.988 | | | | | | | | |




Pad RA RT AG PDT

The effects table and effects plots show that Pad and RA have minor effect. Once again for the Pad factor, the wider pad opening provides higher side wetting. For RA, N2 provides higher side wetting. For RT, effect is minor and 240°C provides higher wetting. AG and PDT have virtually no effect on side-wetting height in PWB soldering.

Summary of the average values for each combination of Pad and RA is shown graphically in Figure 15. The table contrasts the average values in CPT testing versus PWB soldering. The data demonstrates a difference in the side-wetting performance between CPT test method versus PWB soldering, particularly for the narrow pad/aperture openings (IPC, CUST) in air. When N2 is used, the wetting performance is essentially the same for either method, CPT or PWB soldering.

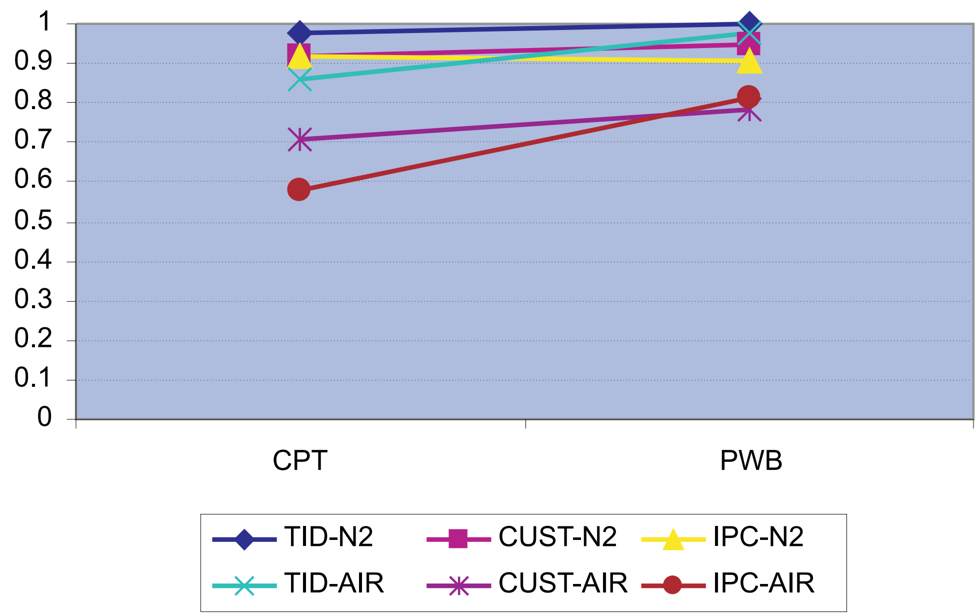



**Figure 15. Comparison of Side-Wetting Performance in CPT Method Versus PWB Soldering**

ANOVA results for component lead pull after PWB soldering of TI versus Competitor 2 are shown in Table 15.

**Table 15. ANOVA Results for Lead Pull After PWB Soldering, TI Versus Competitor 2**

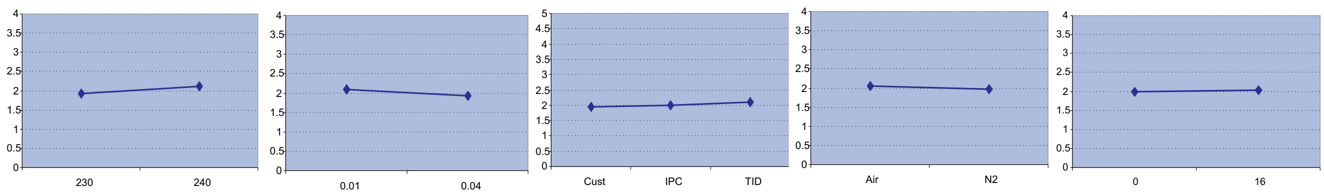
| Rank | Source | Df | SS | F Ratio | Prob > F | % Contribution |
|---|---|---|---|---|---|---|
| 1 | RT | 1 | 1.6875 | 12.676 | 0.0005 | 28.27 |
| 2 | PDT | 1 | 1.4352 | 10.781 | 0.0012 | 24.04 |
| 3 | Pad (CUST and IPC-TID)*RA | 1 | 1.0732 | 8.061 | 0.005 | 17.98 |
| 4 | Pad (CUST and IPC-TID) | 1 | 0.7975 | 5.991 | 0.0153 | 13.36 |
| | RA*PDT | 1 | 0.6075 | 4.563 | 0.034 | 10.18 |
| | RA | 1 | 0.3008 | 2.26 | 0.1345 | 5.04 |
| | RT*PDT | 1 | 0.0675 | 0.507 | 0.4773 | 1.13 |
| | Total | | 5.9692 | | | 100 |

The variation seen in lead pull after PWB mount is spread across the main factors of RT, PDT, and RA. The other factors (Pad and AG) show no contribution to variation.

The average effects table for the factors is shown in Table 16.

**Table 16. Average Effects Table for Lead Pull After PWB Soldering, TI Versus Competitor 2**

| RT | | PDT | | Pad | | RA | | AG | |
|---|---|---|---|---|---|---|---|---|---|
| 230 | 1.92 | 0.01 | 2.1 | IPC | 1.995 | Air | 2.053 | 0 | 1.994 |
| 240 | 2.107 | 0.04 | 1.927 | CUST | 1.941 | N2 | 1.974 | 16 | 2.033 |
| | | | | TID | 2.105 | | | | |




RT PDT Pad RA AG

The effect of the main factors is very small for lead pull response. RT has a slight effect, with 240°C being best case. PDT has a slight effect, with 0.01 being best case setting. Pad also has a slight effect, with TID being best case. RA and AG have no effect. In general, for lead pull after PWB soldering, the variation in the data is very small, confirming that the effect of these variables is also small.

## *4.3 Summary/Conclusions for TI Versus Competitor 2*

In both CPT and PWB soldering, RA and Pad contribute strongest to component lead side-wetting height. The other factors had negligible or no contribution. N2 provided the highest side wetting of leads and for Pad, the wider the pad/stencil aperture opening, the higher the lead side wetting. For lead pull after PWB mount, RT and Pad had the greatest contribution to variance. However, the effects table shows there is very little variation in the lead pull data across all groups.

## *4.4 Industry Standard Wetting Requirements*

Investigation of industry standards and consult with IPC staff determined that there is no toe fillet height or side joint height requirement in Table 8-5, section 8.2.5 of IPC-A-610D. “Climb” of the solder up the side of the lead or toe is not required. Comments from industry experts indicate that 70-80% of strength of the solder connection is from the heel fillet. The tables and dimensions in IPC-A-610D are identical to those in J-STD-001D. Stated simply, the industry standard for board soldered gull wing units has no requirement for component lead side wetting.

## 5 Summary/Conclusions

NiPdAu finished leads from three different companies were evaluated for CPT and PWB solderability. Reflow atmosphere and pad size gave the strongest contribution to component lead side wetting. Other factors had little or no contribution. Nitrogen atmosphere provided the highest side wetting and for pad size, the widest pad/stencil aperture opening showed the highest side wetting. For lead pull after PWB mount, the variance in the data was spread across reflow temperature, palladium thickness, and reflow atmosphere, however, the effects table shows very little variation in the lead pull data across all groups.

### *5.1 Conclusions*

- Of the factors tested, reflow atmosphere and pad/aperture size have the greatest contribution to component lead side-wetting height.
- Nitrogen gives higher lead side wetting than air.
- The larger the pad/aperture width, the higher the lead side wetting.
- Reflow temperature, palladium thickness, and precondition had very little impact on lead side-wetting height performance.
- The data demonstrates a difference in the side-wetting performance between CPT test method versus PWB soldering, particularly for narrow pad/aperture openings in air. When N2 is used the wetting performance is essentially the same for either method, CPT or PWB soldering.
- For lead pull, variance in the data was relatively small. Variation in the input factor tested had little impact on lead pull results. In other words, the mechanical strength of the solder joints is relatively independent of changes in the inputs. side-wetting height may change but mechanical strength is the same.
- Lead pull force is little affected by side-wetting height.

## 6 Acknowledgements

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