561 Hillgrove Avenue • LaGrange, Illinois • 60525-5997 • U.S.A.
Phone: (708) 354-1040 • Fax: (708) 354-2820 • http://www.grayhill.com

Lead Free Process Compatibility Study

Grayhill DIP Switches

August 25, 2004
Revision A

Grayhill INC.
An ISO-9001 Company
561 Hillgrove Avenue • LaGrange, Illinois • 60525-5997 • U.S.A.
Phone: (708) 354-1040 • Fax: (708) 354-2820 • http://www.grayhill.com

TABLE OF CONTENTS

Grayhill INC.
An ISO-9001 Company
561 Hillgrove Avenue • LaGrange, Illinois • 60525-5997 • U.S.A.
Phone: (708) 354-1040 • Fax: (708) 354-2820 • http://www.grayhill.com

Lead Free Process Compatibility Study

1. Introduction. In order to comply with the European ROHS directive, a study was conducted to qualify pure matte tin plating as a replacement for tin/lead plating currently used on Grayhill DIP switches. The study also investigated the compatibility of Grayhill's DIP switches with the higher process temperatures required by lead-free solder processing. The focus of the testing was on solderability of pure matte tin plated terminals and process temperature testing to ensure device compatibility in both tin-lead and lead-free processes. Solderability testing was performed using both tin-lead and lead-free solder. Process temperature testing was performed using both a wave solder process on thru-hole mount switches and a reflow process on surface mount switches.

2. Solderability.

2.1. Intent. Solderability testing was performed to ensure process compatibility of pure matte tin plated switch terminals using both tin-lead and tin-silver-copper solders. Testing was performed using both thru-hole mount switches and surface mount switches.

2.2. Procedure. Solderability testing was performed per IPC/EIA/JEDEC J-STD-002B, Test Method A. The following two groups of DIP switches were used for the testing:

Switch Part Number and Terminal Plating	Number of Samples
76SB08 with 100% pure matte tin plating on the terminals, (lead-free)	40
94HAB08W with 100% pure matte tin plating on the terminals, (lead-free)	40

Twenty switches from each group were tested using tin-lead solder (63% tin, 37% lead) and the remaining twenty switches from each group were tested using lead-free solder (96% tin, 3.5% silver, 0.5% copper). The following procedure was used for the testing:

- Steam age, 8-hour duration
- Immerse in flux for 5 to 10 seconds
- Dry 5 to 20 seconds
- Immerse in molten solder for 5 seconds
- Remove flux (Isopropyl alcohol in ultrasonic tank)
- Inspect at 10X magnification

The solder bath was maintained at a temperature of 245° Celsius for the tin-lead solder and 260° Celsius for the lead-free solder. Type ROL1 flux was used for all the switches.

The 76SB08 switches are through-hole devices with leads coming straight down from the bottom of the device. These parts were dipped straight down into the solder bath.

The 94HAB08W switches are surface-mount with gull-wing leads. These parts were dipped at a 45-degree angle.

2.3. Results. The switches were examined under a microscope with a minimum magnification of 10X. The overall solderability was judged to be acceptable with greater than 95% of the soldered area covered and free of defects. All switches passed testing. The results are summarized in the table below.

Test Performed	Switch Part Number and Terminal Plating	Test Standard	Number of Samples	Number Pass	Number Fail
Solderability – Tin/Lead Solder	76SB08 with 100% pure matte tin plating on the terminals	IPC/EIA/JEDEC J-STD-002B	20	20	0
Solderability – Tin/Lead Solder	94HAB08W with 100% pure matte tin plating on the terminals	IPC/EIA/JEDEC J-STD-002B	20	20	0
Solderability – Lead Free Solder	76SB08 with 100% pure matte tin plating on the terminals	IPC/EIA/JEDEC J-STD-002B	20	20	0
Solderability – Lead Free Solder	94HAB08W with 100% pure matte tin plating on the terminals	IPC/EIA/JEDEC J-STD-002B	20	20	0

3. Process Temperature Compatibility

3.1. Intent. Process temperature compatibility testing was performed on both thru-hole switches and surface mount switches to ensure that they can withstand the higher process temperatures associated with lead-free soldering. Additional testing was done to verify the compatibility of the tape seals used on each on the switches.

3.2. Thru-hole switches.

3.2.1. Wave Solder Temperature Processing.

3.2.1.1. Procedure. Twenty switches were put through a wave solder simulation using a solder pot set at 280° C. The terminals of the switches were dipped vertically into the molten solder for 5 seconds. No preheat was used for this test. Grayhill part number 76SB08 was used for the testing per the following procedure:

- Measure initial contact resistance.
- Dip switch terminals into molten solder at 280° C for 5 seconds
- Measure contact resistance after solder dip.

3.2.1.2. Results. Contact resistance remained within specification and there was no significant change between the initial and the final measurements as a result of the solder dip process. A visual inspection revealed no physical damage or deformation of the switch. All switches passed testing. The results are summarized in the table below.

Test Performed	Test Standard	Number of Samples	Number Pass	Number Fail
Contact Resistance before and after Solder Dip	Contact Resistance must be less than 50mΩ	20	20	0

3.2.2. Tape Seal Integrity after Wave Solder.

3.2.2.1. Procedure. Thirty-five switches were first processed through a wave-solder operation. Grayhill part number 76SB02S was used for the testing. The following temperature profile was used for the wave solder operation:

- 300° C preheat
- 260° C solder bath

To verify the integrity of the tape seal the switches were leak tested after the temperature processing. Leak testing was performed per MIL-STD-202, Method 112E, Test Condition D. The following procedure was use for the testing:

- Fill leak test tank with FC40 liquid.
- Raise temperature of FC40 to 125° C.
- Submerge test samples for a period of 20 seconds.
- Look for a steady stream of bubbles released by test samples.
- Test passes if no stream of bubbles seen during 20 seconds.

3.2.2.2. Results. All switches passed leak testing. The results are summarized in the table below.

Test Performed	Test Standard	Number of Samples	Number Pass	Number Fail
Leak Test after Wave Solder	MIL-STD-202, Method 112E, Test Condition D	35	35	0

3.3. Surface mount switches.

3.3.1. Reflow Temperature Processing.

3.3.1.1. Procedure. To insure the integrity of Grayhill's 90 and 94 series switches after lead-free reflow soldering processing, 20 switches from each series were tested per IPC/JEDEC J-STD-020B "Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices". The switches were tested to Level-1 classification, or unlimited floor life. Grayhill part numbers 90HBW07P and 94HAB08W were used for the testing per the following procedure:

561 Hillgrove Avenue • LaGrange, Illinois • 60525-5997 • U.S.A.
Phone: (708) 354-1040 • Fax: (708) 354-2820 • http://www.grayhill.com

- Initial electrical test of the switches including contact resistance, dielectric strength and insulation resistance.
- Bake for 24 hours at 125° C.
- Soak for 168 hours at 85° C and 85% relative humidity.
- Reflow, three cycles, five minutes between cycles, at 245° C per table 5.2 of J-STD-020B, using the lead-free profile for a large body component, (package thickness greater than 2.5 mm or package volume greater than 350 mm^3).
- Final electrical test of the switches including contact resistance, dielectric strength and insulation resistance. Visual inspection under magnification.

An additional test was done to verify that the switches could withstand a reflow process with a 260° C peak temperature for 60 seconds. Ten 76, 90 and 94 series switches were subjected to the reflow profile shown in figure 1 below. Grayhill part numbers 76HPSB08GW, 90HBW08P and 94HAB08 were used for the testing per the following procedure:

- Measure initial contact resistance.
- Process switches through one reflow operation as defined by the profile shown in Figure 1 below.
- Measure contact resistance after reflow.

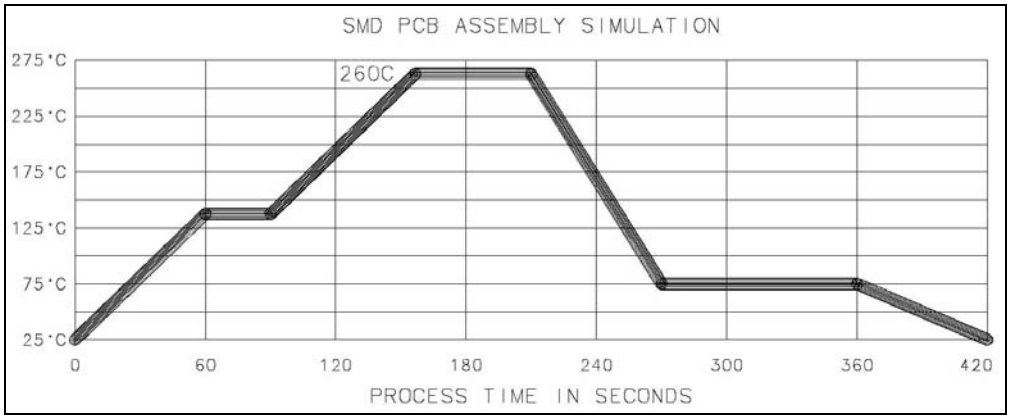

Figure 1

3.3.1.2. Results. All switches passed final electrical testing including contact resistance, dielectric strength and insulation resistance. A visual inspection showed no signs or any damage or deformation to the switch. All switches passed testing per IPC/JEDEC J-STD-020B, Level 1. The results are summarized in the table below.

Switch Series	Test Performed	Test Standard	Number of Samples	Number Pass	Number Fail
90	Moisture Sensitivity Level Using Lead-Free Reflow Temperature Profile	IPC/JEDEC J-STD-020B, Level 1	20	20	0
94	Moisture Sensitivity Level Using Lead-Free Reflow Temperature Profile	IPC/JEDEC J-STD-020B, Level 1	20	20	0

Contact resistance remained within specification and there was no significant change between the initial and the final measurements as a result of the reflow testing. All switches passed testing. The results are summarized in the table below.

Switch Series	Test Performed	Number of Samples	Number Pass	Number Fail
76	Contact Resistance Before and After Reflow at 260° C for 60 Seconds	10	10	0
90	Contact Resistance Before and After Reflow at 260° C for 60 Seconds	10	10	0
94	Contact Resistance Before and After Reflow at 260° C for 60 Seconds	10	10	0

3.3.2. Tape Seal Integrity after Solder Reflow.

3.3.2.1. Procedure. All switches were subjected to one solder reflow operation for lead-free devices as per J-STD-020B. To verify the integrity of the tape seal the switches were leak tested after the temperature processing. Leak testing was performed per MIL-STD-202, Method 112E, Test Condition D. Grayhill part number 90HBW07P was used for the testing per the following procedure:

- Fill leak test tank with FC40 liquid.
- Raise temperature of FC40 to 125° C.
- Submerge test samples for a period of 20 seconds.
- Look for a steady stream of bubbles released by test samples.
- Test passes if no stream of bubbles seen during 20 seconds.

3.3.2.2. Results. All switches passed leak testing. The results are summarized in the table below.

Test Performed	Test Standard	Number of Samples	Number Pass	Number Fail
Leak Test after Solder Reflow	MIL-STD-202, Method 112E, Test Condition D	15	15	0

4. Conclusion. Through this series of testing, backward and forward compatibility of Grayhill's pure matte tin terminal plating with both tin-lead and lead-free processes has been proven. The switches have also been proven to be compatible with the higher temperatures required by Grayhill's customers as they transition to lead-free soldering.