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It is a widespread belief that, when compared to SMD passive components with SnPb terminations, SMD passive components with Pb-free terminations have a limited shelf life. While this belief is generally true, it does not mean the components are unsolderable and fall off the boards, and this study will provide proof of that claim. In the following study two different types of Pb-free finishes were tested: (a) 100% Matte Sn over Nickel and (b) SnAgCu over Cu. While there are many other potential Pb-free type finishes available, the two types used in this study were chosen because 100% Matte Sn over nickel is the predominant Pb-free termination coating being used, and SnAgCu was chosen because it matches the most common Pb-free SAC (96.5/3.0/0.5) alloy being used for Pb-free reflow soldering processes.

The tests performed in this study did not use steam conditioning (formerly known as steam aging) to process the termination finish of the components; rather, we utilized the components in a steam condition-free state, with the components stored at room temperature for an extended period. The components were split into two groups; half were left in the tape and the other half was removed. The parts left in the tape were simulating the typical storage condition for SMD components while the other half, which was removed from the tape, were simulating the storage condition of components being used in bulk cassette type packaging. It is understood that components size 1210 and over are not typically found in bulk cassettes but were used in this test to simulate worst case storage conditions for components of that size.

The intent of this study was **not** to study the formation or consistency of the solder fillets, nor were tests or checks performed for any type of Sn whisker growth or lack thereof. This test was performed simply to check the solderability and adhesion of SMD devices with Pb-free terminations to the land pads on a circuit board. It was also determined that companies wanted to know how well Pb-free terminations would react with the SnPb solder paste and with the Pb-free solder pastes, specifically SAC (96.5/3.0/0.5). The two tests involved in this study were (a) solderability per J-STD-002C and (b) adhesion per JISC-5202.

**TEST RESULTS #1 (Adhesion)**

**TEST ITEM:** Adhesion  
**SPEC:** JIS-C-5202  
**SAMPLE:** varies sizes and Passive products  
**STORAGE:** Office  
**COMP MFG DATE:** See Below  
**TERMINATION:** RoHS Compliant (in tape)  
**SOLDER PASTE:** Sn/Pb  
**TEST DATE:** Sep-05

		Sample #	Force to dislodge from Board (N)
<b>Component:</b>	0201 SMD thick film	1	not performed
<b>Termination:</b>	Matte Sn	2	not performed
<b>Age of Comp.</b>		3	not performed
		4	not performed
		5	not performed
		6	not performed
		7	not performed
		8	not performed
		9	not performed
		10	not performed
<b>Component:</b>	0402 SMD thick film	1	30
<b>Termination:</b>	Matte Sn	2	31
<b>Age of Comp.</b>	Jan-03	3	30
		4	30
		5	29
		6	29
		7	28
		8	30
		9	29
		10	30
<b>Component:</b>	0603 SMD Thick film	1	43
<b>Termination:</b>	Matte Sn	2	42
<b>Age of Comp.</b>	Jan-03	3	42
		4	41
		5	45
		6	42
		7	43
		8	42
		9	42
		10	43
<b>Component:</b>	0805 SMD thick film	1	49
<b>Termination:</b>	Matte Sn	2	51
<b>Age of Comp.</b>	Jan-03	3	54
		4	53
		5	51
		6	51
		7	50
		8	51
		9	51
		10	52

<b>Component:</b>	<b>1206 SMD thick film</b>	<b>1</b>	<b>60</b>
<b>Termination:</b>	<b>Matte Sn</b>	<b>2</b>	<b>59</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>59</b>
		<b>4</b>	<b>61</b>
		<b>5</b>	<b>62</b>
		<b>6</b>	<b>61</b>
		<b>7</b>	<b>62</b>
		<b>8</b>	<b>59</b>
		<b>9</b>	<b>63</b>
		<b>10</b>	<b>62</b>

<b>Component:</b>	<b>1210 SMD thick film</b>	<b>1</b>	<b>65</b>
<b>Termination:</b>	<b>Matte Sn</b>	<b>2</b>	<b>63</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>67</b>
		<b>4</b>	<b>64</b>
		<b>5</b>	<b>64</b>
		<b>6</b>	<b>67</b>
		<b>7</b>	<b>68</b>
		<b>8</b>	<b>63</b>
		<b>9</b>	<b>62</b>
		<b>10</b>	<b>67</b>

<b>Component:</b>	<b>2010 SMD thick film</b>	<b>1</b>	<b>125</b>
<b>Termination:</b>	<b>Matte Sn</b>	<b>2</b>	<b>125</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>150</b>
		<b>4</b>	<b>140</b>
		<b>5</b>	<b>150</b>
		<b>6</b>	<b>150</b>
		<b>7</b>	<b>130</b>
		<b>8</b>	<b>130</b>
		<b>9</b>	<b>155</b>
		<b>10</b>	<b>140</b>

<b>Component:</b>	<b>2512 SMD thick film</b>	<b>1</b>	<b>200</b>
<b>Termination:</b>	<b>Matte Sn</b>	<b>2</b>	<b>240</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>240</b>
		<b>4</b>	<b>240</b>
		<b>5</b>	<b>230</b>
		<b>6</b>	<b>230</b>
		<b>7</b>	<b>240</b>
		<b>8</b>	<b>240</b>
		<b>9</b>	<b>230</b>
		<b>10</b>	<b>210</b>

<b>Component:</b>	<b>1206 (metal plate)</b>	<b>1</b>	<b>150</b>
<b>Termination:</b>	<b>SnAgCu (96.5/3/0.5)</b>	<b>2</b>	<b>140</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>140</b>
		<b>4</b>	<b>130</b>
		<b>5</b>	<b>150</b>
		<b>6</b>	<b>150</b>
		<b>7</b>	<b>120</b>
		<b>8</b>	<b>150</b>
		<b>9</b>	<b>150</b>
		<b>10</b>	<b>130</b>

Component:	2512 (Metal Plate)	1	350
Termination:	SnAgCu (96.5/3/0.5)	2	350
Age of Comp.	Jan-03	3	350
		4	330
		5	350
		6	330
		7	340
		8	350
		9	350
		10	351

Component:	0402 SMD MLCC	1	22
Termination:	Matte Sn	2	25
Age of Comp.	Feb-95	3	25
		4	28
		5	24
		6	25
		7	23
		8	23
		9	24
		10	27

Component:	0603 SMD MLCC	1	27
Termination:	Matte Sn	2	27
Age of Comp.	Jan-94	3	28
		4	26
		5	29
		6	23
		7	25
		8	27
		9	28
		10	32

Component:	0805 SMD MLCC	1	38
Termination:	Matte Sn	2	39
Age of Comp.	Feb-94	3	39
		4	41
		5	45
		6	39
		7	39
		8	36
		9	38
		10	32

Component:	1206 SMD MLCC	1	43
Termination:	Matte Sn	2	46
Age of Comp.	Mar-93	3	45
		4	42
		5	46
		6	47
		7	48
		8	48
		9	50
		10	49

**TEST RESULTS #2 (Adhesion)**

**TEST ITEM:** Adhesion  
**SPEC:** JIS-C-5202  
**SAMPLE:** varies sizes and Passive products  
**STORAGE:** Office  
**COMP MFG DATE:** See Below  
**TERMINATION:** RoHS Compliant (in tape)  
**SOLDER PASTE:** SAC 305  
**TEST DATE:** Sep-05

		Sample #	Force to dislodge from Board (N)
Component:	0201 SMD thick film	1	not performed
Termination:	Matte Sn	2	not performed
Age of Comp.		3	not performed
		4	not performed
		5	not performed
		6	not performed
		7	not performed
		8	not performed
		9	not performed
		10	not performed
Component:	0402 SMD thick film	1	19
Termination:	Matte Sn	2	21
Age of Comp.	Jan-03	3	24
		4	20
		5	21
		6	22
		7	18
		8	26
		9	21
		10	22
Component:	0603 SMD Thick film	1	32
Termination:	Matte Sn	2	32
Age of Comp.	Jan-03	3	33
		4	30
		5	31
		6	33
		7	30
		8	29
		9	31
		10	33
Component:	0805 SMD thick film	1	45
Termination:	Matte Sn	2	44
Age of Comp.	Jan-03	3	46
		4	45
		5	45
		6	43
		7	43
		8	42
		9	44
		10	45

<b>Component:</b>	<b>1206 SMD thick film</b>	<b>1</b>	<b>54</b>
<b>Termination:</b>	<b>Matte Sn</b>	<b>2</b>	<b>53</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>53</b>
		<b>4</b>	<b>51</b>
		<b>5</b>	<b>49</b>
		<b>6</b>	<b>56</b>
		<b>7</b>	<b>53</b>
		<b>8</b>	<b>54</b>
		<b>9</b>	<b>53</b>
		<b>10</b>	<b>52</b>

<b>Component:</b>	<b>1210 SMD thick film</b>	<b>1</b>	<b>56</b>
<b>Termination:</b>	<b>Matte Sn</b>	<b>2</b>	<b>54</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>53</b>
		<b>4</b>	<b>56</b>
		<b>5</b>	<b>54</b>
		<b>6</b>	<b>55</b>
		<b>7</b>	<b>56</b>
		<b>8</b>	<b>54</b>
		<b>9</b>	<b>52</b>
		<b>10</b>	<b>51</b>

<b>Component:</b>	<b>2010 SMD thick film</b>	<b>1</b>	<b>110</b>
<b>Termination:</b>	<b>Matte Sn</b>	<b>2</b>	<b>105</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>101</b>
		<b>4</b>	<b>112</b>
		<b>5</b>	<b>102</b>
		<b>6</b>	<b>109</b>
		<b>7</b>	<b>98</b>
		<b>8</b>	<b>91</b>
		<b>9</b>	<b>100</b>
		<b>10</b>	<b>102</b>

<b>Component:</b>	<b>2512 SMD thick film</b>	<b>1</b>	<b>150</b>
<b>Termination:</b>	<b>Matte Sn</b>	<b>2</b>	<b>130</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>165</b>
		<b>4</b>	<b>150</b>
		<b>5</b>	<b>150</b>
		<b>6</b>	<b>120</b>
		<b>7</b>	<b>130</b>
		<b>8</b>	<b>110</b>
		<b>9</b>	<b>150</b>
		<b>10</b>	<b>130</b>

<b>Component:</b>	<b>1206 (metal plate)</b>	<b>1</b>	<b>145</b>
<b>Termination:</b>	<b>SnAgCu (96.5/3/0.5)</b>	<b>2</b>	<b>148</b>
<b>Age of Comp.</b>	<b>Jan-03</b>	<b>3</b>	<b>152</b>
		<b>4</b>	<b>150</b>
		<b>5</b>	<b>149</b>
		<b>6</b>	<b>148</b>
		<b>7</b>	<b>140</b>
		<b>8</b>	<b>145</b>
		<b>9</b>	<b>140</b>
		<b>10</b>	<b>143</b>

Component:	2512 (Metal Plate)	1	340
Termination:	SnAgCu (96.5/3/0.5)	2	330
Age of Comp.	Jan-03	3	331
		4	320
		5	350
		6	330
		7	320
		8	330
		9	343
		10	345

Component:	0402 SMD MLCC	1	13
Termination:	Matte Sn	2	12
Age of Comp.	Feb-95	3	11
		4	15
		5	12
		6	13
		7	15
		8	10
		9	14
		10	11

Component:	0603 SMD MLCC	1	19
Termination:	Matte Sn	2	17
Age of Comp.	Jan-94	3	19
		4	15
		5	13
		6	19
		7	18
		8	16
		9	16
		10	13

Component:	0805 SMD MLCC	1	21
Termination:	Matte Sn	2	20
Age of Comp.	Feb-94	3	24
		4	18
		5	20
		6	17
		7	20
		8	19
		9	20
		10	27

Component:	1206 SMD MLCC	1	31
Termination:	Matte Sn	2	29
Age of Comp.	Mar-93	3	30
		4	34
		5	31
		6	32
		7	35
		8	33
		9	34
		10	31

TEST RESULTS #3 (Solderability)

TEST ITEM: Solderability  
 SPEC: J-STD-002  
 SAMPLE: various sizes resistive Passive products  
 STORAGE: Office  
 Part Mfg Date: Jul-02  
 TERMINATION: RoHS Compliant  
 SOLDER PASTE: Sn/Pb  
 LIMIT: 95%

		Time of Test												
		Jan-03		Jul-03		Jan-04		Jul-04		Jan-05		Jul-05		
		out of tape	in tape	out of tape	in tape	out of tape	in tape	out of tape	in tape	out of tape	in tape	out of tape	in tape	
Component:	0201 SMD thick film	1	100	99	98	99	99	100	99	100	99	98	98	98
Termination:	Matte Sn	2	100	100	100	99	100	99	100	99	99	97	99	99
Age of Comp.	Jan-03	3	100	99	98	100	100	99	100	99	99	98	98	98
		4	98	100	99	99	99	100	98	100	99	100	98	99
		5	100	100	100	99	98	98	99	100	98	99	98	99
		6	99	98	100	100	100	99	99	99	100	97	98	98
		7	100	98	99	98	100	100	98	99	98	98	97	99
		8	100	99	100	99	100	99	98	100	98	99	98	99
		9	99	99	99	100	99	99	98	98	99	100	97	98
		10	98	100	98	99	99	99	98	98	99	99	98	98
Component:	0402 SMD thick film	1	100	100	100	100	100	99	99	99	98	100	97	99
Termination:	Matte Sn	2	100	99	100	100	99	100	99	99	98	100	98	98
Age of Comp.	Jan-03	3	100	99	100	100	100	98	98	100	98	98	97	98
		4	89	100	99	98	99	99	98	100	99	99	98	99
		5	98	99	99	100	100	98	99	100	99	99	98	99
		6	99	100	99	100	99	100	99	98	98	100	97	100
		7	100	98	99	100	100	99	99	99	99	100	97	98
		8	99	99	100	98	99	99	98	98	99	98	97	98
		9	99	100	100	99	100	100	98	100	99	98	98	99
		10	99	98	99	98	99	100	98	100	98	99	98	98
Component:	0603 SMD Thick film	1	100	100	100	100	99	100	99	100	99	99	97	98
Termination:	Matte Sn	2	100	100	100	100	100	100	98	100	98	100	96	99
Age of Comp.	Jan-03	3	99	100	99	100	100	98	99	100	98	99	98	99
		4	98	99	100	98	100	100	99	100	98	98	97	99
		5	99	100	98	99	98	99	99	99	99	100	97	98
		6	100	98	99	100	98	100	99	99	98	99	98	98
		7	100	100	100	99	99	99	99	100	98	100	98	99
		8	99	98	100	100	100	99	99	100	98	100	97	99
		9	100	99	99	99	98	100	99	99	98	100	97	100
		10	99	100	100	100	100	100	99	100	99	98	97	99
Component:	0805 SMD thick film	1	98	99	99	99	100	100	99	100	99	99	97	99
Termination:	Matte Sn	2	100	100	99	99	100	100	99	99	98	99	98	99
Age of Comp.	Jan-03	3	99	100	100	100	100	100	99	98	98	98	97	98
		4	100	99	100	100	99	100	99	100	98	100	98	98
		5	99	100	100	100	98	98	98	100	99	99	98	98
		6	99	99	99	100	98	99	99	98	98	100	96	98
		7	100	100	99	99	98	99	99	99	99	100	97	100
		8	100	98	100	100	99	98	99	100	98	100	96	99
		9	99	98	98	99	100	98	99	98	98	100	96	99
		10	100	100	100	98	100	100	98	100	98	99	98	98
Component:	1206 SMD thick film	1	99	99	100	100	99	100	99	100	99	100	98	99
Termination:	Matte Sn	2	100	98	99	100	100	98	98	99	98	99	97	99
Age of Comp.	Jan-03	3	100	99	99	98	100	100	99	100	99	98	98	99
		4	100	100	98	100	99	99	99	98	98	99	97	98
		5	98	100	100	100	99	100	99	100	98	100	97	99
		6	100	100	100	99	98	99	98	99	98	100	96	99
		7	99	100	100	99	98	100	99	100	98	100	96	100
		8	100	99	100	100	100	100	98	100	99	98	98	99
		9	99	99	99	98	100	99	99	100	98	100	96	98
		10	98	100	99	100	99	99	99	99	98	99	96	99

Component:	1210 SMD thick film	1	100	100	100	99	100	100	99	100	99	99	97	99
Termination:	Matte Sn	2	100	100	99	100	100	99	98	100	99	100	97	99
Age of Comp.	Jan-03	3	98	100	99	100	99	100	99	99	99	100	98	100
		4	100	98	100	100	100	99	99	100	98	100	98	100
		5	100	99	99	100	99	99	99	99	98	99	98	99
		6	99	100	100	99	99	100	98	99	98	99	96	99
		7	99	100	98	98	100	100	98	99	98	99	96	99
		8	100	98	98	99	99	98	98	98	99	98	96	98
		9	98	99	100	100	98	100	99	100	98	100	97	99
		10	100	100	100	98	100	99	99	99	98	100	96	99
Component:	2010 SMD thick film	1	99	99	99	99	100	99	98	100	98	100	97	100
Termination:	Matte Sn	2	100	99	99	100	100	100	99	99	98	100	97	99
Age of Comp.	Jan-03	3	100	100	100	100	100	99	99	100	99	100	98	99
		4	99	100	100	99	100	100	99	99	99	100	96	98
		5	100	100	100	99	99	99	98	100	98	100	97	98
		6	99	99	100	100	99	100	99	99	98	99	97	99
		7	98	99	99	100	98	100	99	100	98	99	97	99
		8	99	100	100	99	100	100	99	99	98	100	96	99
		9	99	98	99	99	100	99	98	100	98	99	96	98
		10	100	100	98	100	98	100	98	98	98	98	97	99
Component:	2512 SMD thick film	1	100	100	100	99	100	100	99	100	99	99	97	98
Termination:	Matte Sn	2	100	100	100	99	100	100	98	100	99	100	96	99
Age of Comp.	Jan-03	3	99	100	100	100	100	100	99	100	98	98	96	98
		4	100	99	99	98	99	99	99	100	98	100	97	98
		5	99	100	99	99	99	100	99	99	98	99	97	98
		6	99	100	100	99	99	99	98	99	98	100	98	99
		7	98	99	100	99	100	100	98	98	98	99	98	100
		8	99	99	98	100	100	98	98	100	98	100	97	98
		9	100	99	99	99	100	100	99	100	99	99	98	98
		10	99	99	100	100	99	99	98	99	98	100	97	99
Component:	1206 (metal plate)	1	100	99	98	99	99	100	99	100	99	98	98	99
Termination:	SnAgCu (96.5/3/0.5)	2	100	100	100	99	99	100	99	100	99	99	98	99
Age of Comp.	Jan-03	3	100	99	99	100	100	100	99	99	99	99	98	99
		4	98	100	99	99	99	100	98	100	99	100	98	100
		5	100	100	100	98	99	98	99	100	98	99	98	99
		6	99	s	100	100	100	99	99	99	99	100	99	100
		7	100	98	99	98	100	100	98	99	98	99	98	100
		8	100	100	99	99	100	99	99	100	98	99	98	99
		9	99	99	99	100	99	99	98	98	99	100	99	99
		10	99	100	98	99	99	99	99	98	99	99	98	99
Component:	2512 (Metal Plate)	1	99	99	99	99	100	99	98	100	98	100	98	99
Termination:	SnAgCu (96.5/3/0.5)	2	100	99	99	100	100	100	99	99	98	100	98	100
Age of Comp.	Jan-03	3	100	100	100	100	100	99	99	100	99	99	99	99
		4	99	100	100	99	100	100	99	99	99	100	98	100
		5	100	100	100	99	99	99	98	100	98	100	98	99
		6	99	99	100	100	99	100	99	99	98	99	98	99
		7	98	99	99	100	98	100	99	100	98	99	99	100
		8	99	100	100	99	100	100	99	99	98	100	99	99
		9	99	98	99	99	100	99	98	100	98	99	98	98
		10	100	100	98	100	98	100	98	98	98	99	98	99

TEST RESULTS #4 (Solderability)

TEST ITEM: Solderability  
 SPEC: J-STD-002  
 SAMPLE: various sizes resistive Passive products  
 STORAGE: Office  
 Part Mfg Date Jul-02  
 TERMINATION: RoHS Compliant  
 SOLDER PASTE: SAC305  
 LIMIT: 95%

		sample #	Jul-05	
			out of tape	in tape
Component:	0201 SMD thick film	1		
Termination:	Matte Sn	2	95	98
Age of Comp.	Jan-03	3	95	98
		4	96	98
		5	95	97
		6	95	99
		7	95	99
		8	96	99
		9	94	97
		10	95	99
			94	98
Component:	0402 SMD thick film	1		
Termination:	Matte Sn	2	94	97
Age of Comp.	Jan-03	3	94	96
		4	95	96
		5	94	97
		6	95	97
		7	96	97
		8	95	97
		9	94	98
		10	93	98
			95	98
Component:	0603 SMD Thick film	1		
Termination:	Matte Sn	2	93	97
Age of Comp.	Jan-03	3	94	97
		4	93	97
		5	96	98
		6	95	98
		7	94	98
		8	95	99
		9	94	98
		10	95	97
			94	97
Component:	0805 SMD thick film	1		
Termination:	Matte Sn	2	96	98
Age of Comp.	Jan-03	3	94	98
		4	94	97
		5	95	97
		6	95	97
		7	93	98
		8	96	97
		9	95	98
		10	95	97
			94	98
Component:	1206 SMD thick film	1		
Termination:	Matte Sn	2	94	97
Age of Comp.	Jan-03	3	95	97
		4	95	98
		5	94	98
		6	94	98
		7	94	97
		8	95	98
		9	95	96
		10	94	97
			96	97

Component:	1210 SMD thick film	1		
Termination:	Matte Sn	2	93	96
Age of Comp.	Jan-03	3	94	97
		4	95	98
		5	93	98
		6	93	97
		7	95	98
		8	94	96
		9	96	98
		10	93	96
			94	96
Component:	2010 SMD thick film	1		
Termination:	Matte Sn	2	93	98
Age of Comp.	Jan-03	3	92	97
		4	93	99
		5	94	99
		6	93	96
		7	92	99
		8	93	99
		9	92	97
		10	94	99
			94	99
Component:	2512 SMD thick film	1		
Termination:	Matte Sn	2	92	97
Age of Comp.	Jan-03	3	92	98
		4	93	97
		5	91	98
		6	92	98
		7	93	96
		8	92	97
		9	91	96
		10	92	96
			92	98
Component:	1206 (metal plate)	1		
Termination:	SnAgCu (96.5/3/0.6)	2	97	99
Age of Comp.	Jan-03	3	98	99
		4	98	100
		5	98	100
		6	97	100
		7	99	99
		8	98	100
		9	99	100
		10	99	99
			99	100
Component:	2512 (Metal Plate)	1		
Termination:	SnAgCu (96.5/3/0.6)	2	97	100
Age of Comp.	Jan-03	3	98	99
		4	99	99
		5	99	100
		6	99	100
		7	98	99
		8	98	100
		9	98	100
		10	99	100
			99	98



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#### CONCLUSION:

It was previously believed that the solderability of components with Pb-free terminations was limited to less than one year of shelf storage life. The documented test results indicate that Pb-free terminated components can easily be stored for more than two years, whether the components are left in their packaging or not, providing components are stored per the suppliers' recommended storage conditions. In fact, the testing has conclusively shown that components, which have been stored for over 11 years in tape, have the capability to be soldered and adhere to the soldering pads of the circuit board, regardless of whether a SnPb or Pb-free soldering paste is being utilized.

The lack of testing for the 0201 and 01005 size components should not be construed to indicate that these components have any solderability issues. Testing was not performed on the smaller case sizes due to the lack of board availability.