NXG1

No-Clean Lead-Free Solder Paste

Supplemental Data Package

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kester

NXG1 Product Benefits

Kester's NXG1 lead-free no-clean solder paste represents a breakthrough in lead-free technology with a best-in-class combination of superior wetting behavior, shiny joints, excellent printing and the longest shelf life available. Backed by Kester's world renowned customer service, technical service expertise, and 110 plus years experience in soldering technology, NXG1 lead-free no-clean paste is the only product that satisfies all your assembly needs.

Key Characteristics:

Superior Solderability: Best-in-class solderability with the widest reflow process window available. A wide process window is the hallmark of a forgiving paste for drop-in performance. The NXG1 provides the smoothest and shininess joints of any lead-free paste on the market; the difference from SnPb to lead-free is virtually transparent. This characteristic will make the transition to lead-free easier on OEMs and contract manufacturers alike by making the change to lead-free appear seamless.

Ultra-low BGA Voiding: Low void performance is a must for most assemblies today reducing rework costs and improving first pass yields.

Reduced Ball-in-socket Defects: Designed specifically to reduce or fully eliminate the occurrence of ball-in-socket (also know as head-in-pillow and foot-in-mud) defects.

Excellent Printability: Consistent solder paste volume deposits regardless of idle time, stencil life and print speed. This is the most important characteristic of any solder paste, as print volume inconsistency is the top cause of defects in electronic assembly. Excellent print definition and bridging prevention due to its non-slumping chemistry. The solder brick maintains its shape without variation over time. This attribute avoids bridging especially in fine-pitch components, saving the customer from wasting time and money on rework.

Longest Shelf Life: NXG1 has the longest shelf life, at 8 months, of any lead-free no-clean paste on the market. A longer shelf life will help reduce scrap and waste while allowing for more manageable inventory.

Clear, Probeable Residues: The lightest colored residues of any paste in its class. Increased reflow temperatures required by lead-free assembly tend to char, darken and harden post-soldering residues. NXG1 offers best-in-class residue appearance and penetrability making AOI and manual inspection effortless.

1. Industry Classification

1.1 Flux Composition

The flux medium in NXG1 is a rosin based No Clean flux. The non-volatile portion of the material is classified as rosin type (symbol RO) per IPC J-STD-004A. A rosin flux is defined in paragraph 3.2.5 of J-STD-004A.

Results: **Type RO**

1.2 Copper Mirror

This test is designed to help define the level of activity of the flux and determine the corrosive properties of the material per IPC-TM-650, Test Method 2.3.32.

Conditions: Non-activated rosin flux used as the control, polished glass slide with a 50nm layer of copper that was vacuum deposited, and a drop of the test sample are the major materials needed for this test. The test begins by preparing and cleaning the copper mirror. As the copper mirror is placed on a flat surface with the copper foil side up one drop of the control flux and one drop of the test flux is placed on the slide. The test states that the flux droplets are not allowed to touch. Then the slide is placed in an environmental chamber (23°C +/- 2°C and 50 +/- 5% RH) for 24 hours. The slide is then removed and cleaned. The copper mirror is then evaluated.

If there is no removal or breakthrough of the copper foil then the flux is classified as "L".
If there is less than 50% breakthrough or complete removal of the copper along the perimeter of the drop then the flux is defined as "M".
If there is greater than 50% breakthrough or complete removal of the copper than the flux is placed in the "H" category.

Results: **L (no breakthrough)**

1.3 Silver Chromate Paper Test

This test is used to determine the presence of chlorides and bromides per IPC-TM-650, Test Method 2.3.33. The presence of free chlorides and bromides may indicate a material having ionic, corrosive, and conductive properties.

Conditions: One drop, approximately 0.05 ml, of test flux is needed along with 6 silver chromate test papers (51 mm x 51mm). The test flux is placed on each of the test papers. The material remains on the paper for a minimum of 15 seconds and then the test papers are cleaned to remove any residual organic materials. The test papers are allowed to dry before the visual examination is performed.

If there is a color change of the dark silver chromate paper to off-white or yellow-white indicates the presence of chlorides or bromides.

Results: **Pass (no chlorides or bromides detected)**

1.4 Corrosion Test

The corrosion test is conducted per J-STD-004A specifications, IPC-TM-650 method 2.6.15. This test is designed to determine the corrosive properties of the flux residues under extreme environmental conditions. The test conditions used are 40°C and 93 +/- 2% RH for 240 hours. Any initial color change that may develop when the test panel is heated during soldering is disregarded, but subsequent development of green-blue discolouration is regarded as corrosion.

Test Method:

The test panels used are copper coupons, each of size 51 mm x 51 mm x 0.50 mm. A circular depression of about 3.2mm deep is formed in the center of each test panel. One corner of each test panel is bent to facilitate subsequent handling with tongs.

Before performing the test, the test panels are first pre-treated. The panels are degreased with a suitable neutral organic solvent and then immersed in 5% sulfuric acid (by volume) at 65 +/- 5°C for 1 minute to remove the tarnish film. Then they are immersed in a solution of 25% m/v ammonium persulphate (0.5% v/v sulfuric acid) at 23 +/- 2°C for 1 minute to etch the surface uniformly. The panels are washed in running tap water for a maximum of 5 seconds followed by immersion in 5% sulfuric acid (by volume) at 23 +/- 2°C for 1 minute. They are then washed for 5 seconds in running tap water and rinsed thoroughly in deionized water. Finally they are rinsed with acetone and allowed to dry in clean air. The pre-treated test panels must be used as soon as possible or stored up to 1 hour in a closed container.

About 0.3 gram of solderpaste is weighed and placed in the center of depression of each test panel. The test panel is then lowered onto the surface of molten solder heated at about the temperature (T+50) +/- 5°C whereby T denotes the liquidous temperature of the lead-free alloy. The temperature is maintained for about 5 +/- 1 seconds. The test specimens are then examined carefully at 20x magnification for subsequent comparison after humidity comparison. One set of specimens is placed in a clean dust-free dessicator which is conditioned at 23 +/- 2°C and 50 +/- 5% RH for 240 hours. Another set of test specimens is suspended vertically in a humidity chamber controlled at 40 +/- 1°C and 93 +/- 2%RH for 240 hours (10 days).

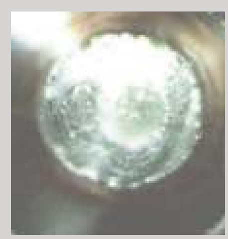
After the 240 hours period, the test specimens are removed from the chamber and examined at 20x magnification. They are compared with the reference test specimen for any evidence of copper corrosion.

Any initial change of colour that may develop when the test panel is heated during soldering can be disregarded. But subsequent development of green discolouration with observation of pitting of the copper panel is regarded as copper corrosion.

The evaluation standard is as follows:

Category	Condition
L	No evidence of copper corrosion
M	Minor corrosion observed
H	Major corrosion observed

Results:

<table>
<tr><th>Paste</th><th>Results</th></tr>
<tr><td>NXG1</td><td>No evidence of green corrosion

Kester NXG1 passes in the L category</td></tr>
</table>

1.5 Spot Test

The Spot Test is used to determine if any fluorides which are not detectable in the Silver Chromate Test per IPC-TM-650, Test Method 2.3.35.1.

Conditions: A solution of zirconium nitrate and sodium alizarin sulfate is made. One drop of each solution is placed on a white spot plate to form three purple lakes of solution. One drop of the test flux is then placed into each purple spot. A clean glass rod is used to combine the test flux and the solutions.

The test is positive for fluorides if there is a change in color from purple to yellow.

Results: **Pass (no fluorides detected)**

1.6 Halide Test

The halide content of NXG1 solder paste is determined by ion chromatography per IPC-TM-650 method 2.3.28.1.

Results: **No chloride and low levels of bromide is detected. Classifified as 1.**

2. Reliability

2.1 Surface Insulation Resistance per IPC

This test is to determine the degradation of electrical insulation resistance of printed circuit boards after exposure to the test flux. SIR testing is performed at elevated an elevated temperature and humidity (85°C +/- 2°C and 85% +/- 2% RH for 168 hours).

Conditions: IPC-B-24 test patterns are unpreserved bare copper comb patterns on bare FR-4 laminate with 0.4 mm lines and 0.5mm spacing. A standing bias potential of -50 volts DC is required as well as a meter capable of recording high resistance (10^{12} ohms) and a test voltage of 100 volts. The test coupons used are prepared with a 75% 2-propanol, 25% deionized water solution to remove all ionic contaminants. The test matrix for this type of flux is found below in Table 1.

Sample Set	Processed	Coupon Preparation	Post Cleaning	Number of Coupons
Sample	Yes	Precleaned	No	3
Control	No	Precleaned	NA	3

Table 1: IPC Surface Insulation Resistance Testing Matrix

Resistance measurements of the test specimens shall be taken at 24, 96, and 168 hours. The test coupons are examined under a 10x to 30x microscope within 24 hours of test completion. If dendrites are present and spans more than 25% of the original spacing then this constitutes a failure. The resistance values must also be greater than 1 x 10^{8} ohms. The test data results for this flux is found below in Table 2.

Results: **Pass**

Table 2: IPC Surface Insulation Resistance Results

	Blank	NXG1	Disposition
Day 4	5.1 E+09	4.0 E+09	Pass
Day 7	3.7 E+09	3.6 E+09	

2.2 Surface Insulation Resistance per Bellcore GR-78-CORE

This test is to determine the degradation of electrical insulation resistance of printed circuit boards after exposure to the test flux. SIR testing is performed at elevated an elevated temperature and humidity (35°C +/- 2°C and a minimum of 85% RH).

Conditions: The test patterns used were unpreserved bare copper comb pattern, IPC-B-25, on bare FR-4 laminate with 0.0125 inch spacing. Standing bias potential of -50 volts DC, a meter capable of recording high resistance (10^{13} ohms) as well as a test voltage of 100 volts is required. The test matrix for SIR testing for this flux is summarized in Table 3.

Table 3: Bellcore Surface Insulation Resistance Testing Matrix

Sample Set	Processed	Coupon Preparation	Post Cleaning	Number of Coupons
Sample	Yes	Precleaned	No	3
Control	No	Precleaned	NA	3

Resistance measurements of the test specimens shall be taken at 24 hours and at 4 days. The resistance values must also be greater than 2 x 10^{10} ohms for IPC-B-25 coupons and/or filament growth greater than 20% of the spacing is considered a failure. The test data results for this flux is found below in Table 4.

Results: **Pass**

Table 4: Bellcore Surface Insulation Resistance Results

	Blank	NXG1	Disposition
48 Hours	2.7 E+12	6.6 E+10	Pass
96 Hours	1.5 E+13	8.0 E+10	

2.3 Electromigration per Bellcore GR-78-CORE

This is a laboratory test used to characterize the chemical reactions of flux residues with an applied bias in an elevated temperature and humidity chamber. This test is used as a reliability predictor of flux residues.

Conditions: IPC-B-25 test coupons are prepared and the test flux is applied to the coupons. The IPC-B-25 boards are then processed in a wave solder machine with a solder pot temperature maintained at 260 +/- 6°C (500 +/- 10°F). The environmental chamber is maintained at 65 +/- 2°C and a minimum of 85% RH. A bias voltage of 10 volts and a test voltage of 100 volts are required. The sample set of boards is summarized below in Table 5.

Table 5: Bellcore Electromigration Test Matrix

Sample Set	Processed	Coupon Preparation	Post Cleaning	Number of Coupons
Sample	Yes	Precleaned	No	3
Control	No	Precleaned	NA	3

A material passes this test when the resistance data does not degrade by more than a decade and there is no evidence of electromigration (filament growth) that reduces the conductor spacing by more than 20%. This visual examination is performed with backlighting at 10x magnification. The test data results for this flux is found below in Table 6.

Results: **Pass**

Table 6: Bellcore Electromigration Results

	Blank	NXG1	Degradation	Disposition
96 Hours	1.3 E+10	2.3 E+08	None	Pass
500 Hours	6.7 E+09	4.5 E+08	None	

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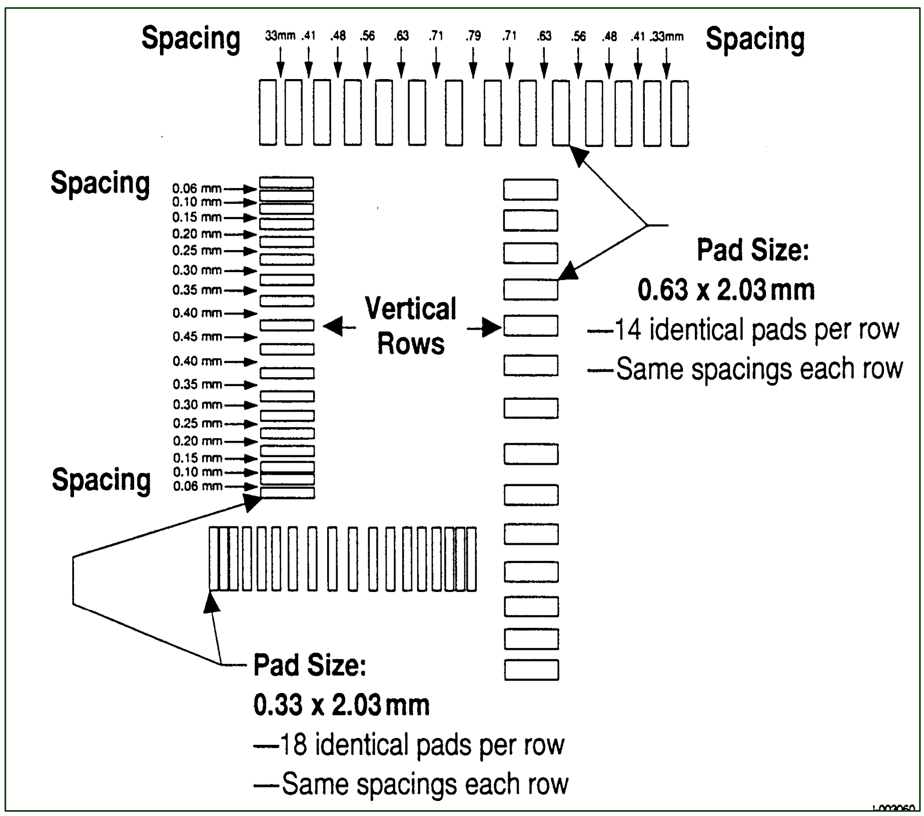
3. Printing

3.1 Slump

Under the slump test method per J-STD-005 specifications, Method 2.4.35, two sets of test specimens are prepared. A stainless steel stencil, IPC-A-21 of 8 mils (0.2 mm) thick is used as shown below. The spacing between the apertures varies from 0.06 mm to 0.45 mm with varying increments. The solder paste is manually printed on a ceramic plate using this stencil.

Fig 1: IPC-A-21 Stencil



Two test specimens are prepared. One set of test specimen shall be marked as #1 and the other specimen as #2 to test for cold and hot slump respectively.

For cold slump test, specimen #1 is placed for 50 to 70 minutes at 25 +/- 5°C and 50 +/- 10%RH. The slump behavior is examined by observing the minimum spacing across which the paste has not merged.

For hot slump test, specimen #2 is heated in a air-circulating convection oven at about 180°C for 1 minute after printing and cooled to ambient temperature and examined for slump. The minimum spacing across which the paste has not merged after the hot slump test is observed.

Results: **NXG1 has excellent slump resistance per J-STD-005**

Table 7 : Slump Results

NXG1 (1 hour at 25C +/- 5C and 50% +/- 5% RH)					
Stencil IPC-A-21 (0.2mm / ~8mil hick)					
Pad Size 0.63mm x 2.03mm			Pad Size 0.33mm x 2.03mm		
Pass: 0.56mm or greater			Pass: 0.56mm or greater		
Spacing mm	Horizontal	Vertical	Spacing mm	Horizontal	Vertical
0.79	Pass	Pass	0.45	Pass	Pass
0.71	Pass	Pass	0.40	Pass	Pass
0.63	Pass	Pass	0.35	Pass	Pass
0.56	Pass	Pass	0.30	Pass	Pass
0.48	Pass	Pass	0.25	Pass	Pass
0.41	Pass	Pass	0.20	Pass	Pass
0.33	Pass	Pass	0.15	Pass	Pass
-	-	-	0.10	Pass	Pass
-	-	-	0.06	Pass	Pass
Results: Pass at room temperature (no bridging at 0.33mm or greater)			Results: Pass at room temperature (no bridging at 0.10mm or greater)		

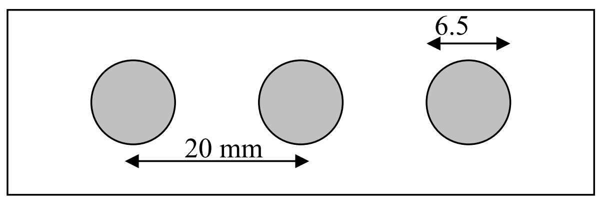
NXG1 (10 minutes @ 180C +/- 5C and 35% +/- 5% RH)					
Stencil IPC-A-21 (0.2mm / ~8mil hick)					
Pad Size 0.63mm x 2.03mm			Pad Size 0.33mm x 2.03mm		
Pass: 0.63mm or greater			Pass: 0.30mm or greater		
Spacing mm	Horizontal	Vertical	Spacing mm	Horizontal	Vertical
0.79	Pass	Pass	0.45	Pass	Pass
0.71	Pass	Pass	0.40	Pass	Pass
0.63	Pass	Pass	0.35	Pass	Pass
0.56	Pass	Pass	0.30	Pass	Pass
0.48	Pass	Pass	0.25	Pass	Pass
0.41	Pass	Pass	0.20	Pass	Pass
0.33	Pass	Pass	0.15	Pass	Pass
-	-	-	0.10	Pass	Pass
Results: Pass at room temperature (no bridging at 0.33mm or greater)			Results: Pass at room temperature (no bridging at 0.20mm or greater)		

3.2 Static Tack Test

Kester NXG1 is tested to IPC-TM-650, Method 2.4.44, which is the industry's standard tack test. The testing was conducted over a 24-hour period to verify the consistency of tack over time.

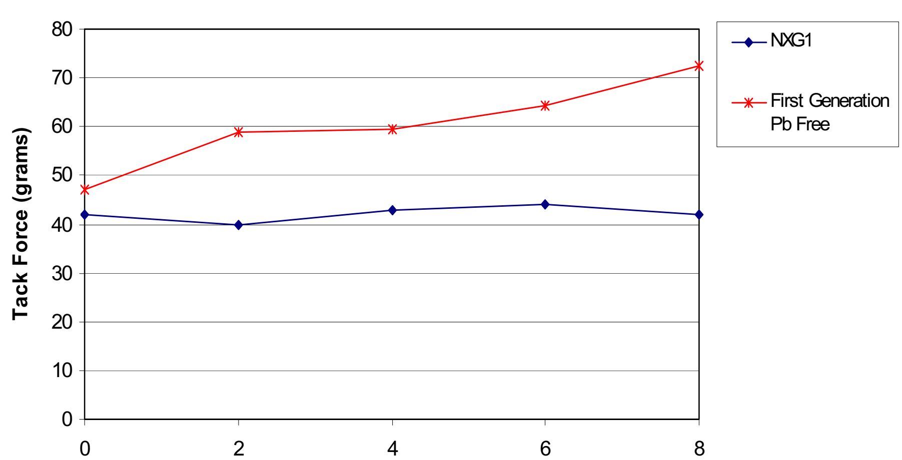
The tackiness test is conducted by using the Chatillon Tackiness Tester. Solder paste deposits of 0.65 cm in diameter and 0.25 mm thick are printed onto a glass slide. The test probe is brought into contact with the printed paste specimens at a rate of 2.5 +/- 0.5 mm/min and a force of 300 +/- 30 grams. Within 5 seconds following the application of this force, the probe is withdrawn from the specimens at a rate of 2.5 +/- 0.5 mm/min and the peak force required to break the contact is recorded. This force is known as the tackiness of the paste. The tack force is measured at different time intervals after the solder paste specimens are left at room temperature.

Fig 2: Test glass slide



Results: NXG1-HF remained very stable over the course of the test. This data indicates a stable tack value after boards are printed. This data is particularly applicable to production environments where printed boards are left waiting for components. A stable tack value indicates that NXG1-HF will not present problems with a loss of tack if printed paste is left in the open environment. This data may vary depending on paste thickness, volume, component placement pressure and process conditions.

Figure 3: StaticTack



3.3 Printing Flexibility

Kester NXG1 (SAC, Type 3 powder, 11.25% flux) was tested utilizing an MPM UP1500 fully automated stencil printer. Testing was conducted under typical production temperature and humidity conditions (72°F and 49% RH). NXG1 was printed at speeds from 30 to 200 mm/sec (1 to 8 in/sec) to determine the maximum print speed of the paste. The squeegee pressure was increased accordingly as print speed increased. The paste was observed at each print speed for rolling behavior, squeegee sticking and print definition.

Results: NXG1 was evaluated up to 200 mm/sec of print speed without demonstrating any degradation in the areas of rolling behavior, sticking to the squeegee and print definition. NXG1 is rated for the maximum print speed that the printer equipment is capable of, which is 200 mm/sec (8 in/sec).

Test Condition Notes:
Test Vehicle Identifier: KS0003 Test Board (see Figure 4)
Stencil Type: Laser Cut / Electro-Polished
Stencil Thickness: 5 mil
Printer Type: MPM Ultraprint 1500
Squeegee Pressure: 12 – 18 lbs/ linear inch
Squeegee Length: 12”
Squeegee Material: Stainless Steel
Squeegee Angle: 45°
Aperture Reduction or Ratio: 1:1
Temperature and Humidity of the Test Environment: 23°C / 73°F and 55%RH

Figure 4 KS0003 Test Board

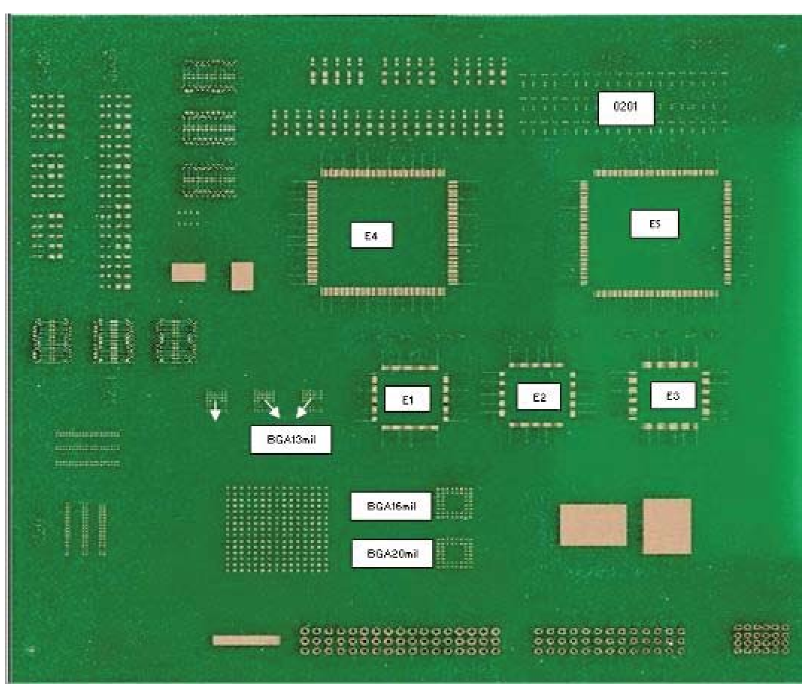
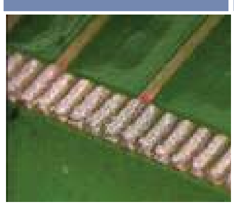
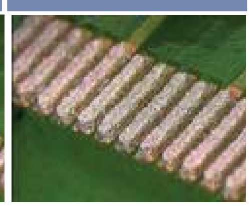
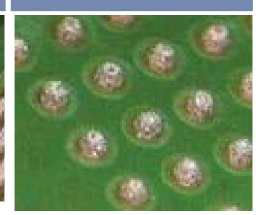


Table 8: Test Board Details

	Details for Test Board Opening			
Units = mils	E1-16mil	E4-20mil	E5-20mil	20mil BGA
Length	37.7	77.6	57.6	Dia = 19.7
Width	8.3	10.3	10.1	NA
Stencil Thickness	5	5	5	5
Aspect Ratio	1.66	2.07	2.02	.099

Table 9: Print Test Photos

	16mil QFP	20mil QFP	13mil BGA	20mil BGA
8” per Sec				

3.4 Shear Sensitivity (Thixotropic Index and Non-Recovery Rate of Viscosity)

Kester NXG1 (SAC, Type 4 powder, 11.5% flux) was tested on a Malcolm viscometer. The procedure is intended to determine the loss in viscosity over time under high amounts of shear. Readings are taken from the viscometer in the following order: 10 rpm, 3 rpm, 4 rpm, 5 rpm, 10 rpm, 20 rpm, 30 rpm and 10 rpm. The second and third readings at 10 rpm are compared for the purpose of this test. The first 10-rpm reading is considered a baseline "warm-up" viscosity. The subsequent 10-rpm readings are compared to each other to verify a stable viscosity after a high amount of shear. The second value is typically very near the initial value because very little shearing has occurred. (Having a high degree of consistency between the first and second 10-rpm readings is expected for most solder pastes.) The percent change between the second and third 10-rpm readings is recorded as the "Percent non-recovery of viscosity". The optimal percent non-recovery is 0%, or complete recovery of viscosity characteristics. Good paste formulations tend to be <5% in this test. Percent non-recovery over 5% indicates that the paste tends to shear thin substantially with a continuous applied stress.

Results: **1.8% non-recovery rate of viscosity. Detailed data is presented in Tables 8 and 9.**

<u>Data Explanation:</u>

The percent non-recovery of viscosity value is the amount of viscosity lost between the second and third viscosity readings at 10 RPM. It should be emphasized that this loss in viscosity represents the decrease in viscosity during a 6-minute period of consistent shear.

A solder paste with <5% loss of viscosity is considered excellent. This paste would continue to remain very stable on the stencil during a consistent, high-volume printing operation.

A solder paste with between 5 and 10% loss of viscosity should be considered marginal in terms of stencil stability. This paste may result in increased slumping and bridging as the stencil life is extended to more than 4 hours.

A solder paste that loses >10% of its viscosity during the test should be expected to shear thin excessively. Such a paste would become very "thin" on the stencil. This will ultimately result in severe slumping and a massive increase in bridging defects. This paste may work well in short production runs (or evaluations), but will fall apart under consistent printing applications.

Table 8: NXG1 Thixotropic Index and Non-Recovery Rate of Viscosity

	V_{10A}	V_3	V_4	V_5	V_{10B}	V_{20}	V_{30}	V_{10C}
Spindle Speed (RPM)	10	3	4	5	10	20	30	10
Time to Measure (Min)	3	6	3	3	3	1	1	1
Viscosity (Poise)	1820	3601	3053	2689	1803	1275	1044	1836

TI (Thixotropy Index) = log (V_3) - log (V_{30})
R (Non-recovery Rate of Viscosity) = (V_{10B}-V_{10C}) / V_{10B} X 100

	TI/SSF	R
NXG1	0.54	1.8%

Table 9: Previous Generation No-clean Lead-free Thixotropic Index and Non-Recovery Rate of Viscosity

	V_{10A}	V_3	V_4	V_5	V_{10B}	V_{20}	V_{30}	V_{10C}
Spindle Speed (RPM)	10	3	4	5	10	20	30	10
Time to Measure (Min)	3	6	3	3	3	1	1	1
Viscosity (Poise)	1840	3920	3380	2910	1890	1100	840	1640

TI (Thixotropy Index) = log (V_3) - log (V_{30})
R (Non-recovery Rate of Viscosity) = (V_{10B}-V_{10C}) / V_{10B} X 100

	TI/SSF	R
Previous Generation NC Pb-free Paste	0.67	13.2%

3.5 Wiping Frequency

NXG1 has been printed onto 20 mil pads without requiring wiping of the bottom side stencil for 20 consecutive prints. Wiping is required when bridging of deposits, changes in volume of solder paste deposits or when excessive bleed-out of the flux from the deposit is observed.

3.6 Flux Percent Recommendation

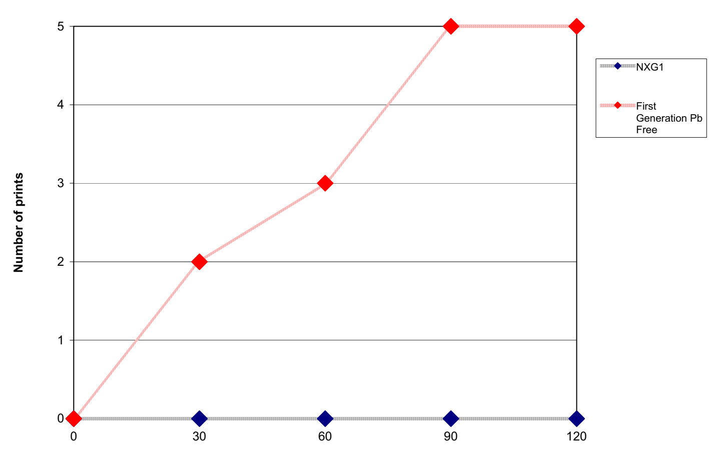
The recommended flux percentage for stencil/screen printing applications is 11.25% flux by weight (88.75% metals by weight) for SnAgCu alloys of mesh -325+500. The recommended flux percentage for stencil/screen printing applications is 11.5% flux by weight (88.5% metals by weight) for SnAgCu alloys of mesh -400+500.

3.7 Relax/Recovery (Dwell Time)

Kester NXG1 (SAC, Type 3 powder, 11.25% flux) was tested utilizing an MPM fully automated stencil printer. Testing was conducted under typical production temperature and humidity conditions (75°F and 54% RH). The NXG1 was subjected to print breaks ("relaxations") of varying lengths to see how the product would respond to printer downtime. Solder paste deposits were examined visually after downtimes of 15 to 60 minutes. For the purpose of this test, a "pass" is considered a solder paste deposition of at least 95% on a 20-mil QFP pad area.

<u>Results:</u> The NXG1 solder paste was capable of a 60 minute "relaxation" without causing any print related problems. This indicates that the stencil printer can be left idle for at least 60 minutes without requiring any kneading before printing the first board. The chart below (Figure 5) compares the relax & recovery characteristics of NXG1 to a traditional RMA product and a competitive no-clean formulation. NXG1 clearly opens the process window in the area of printer downtimes.

Figure 5: Relax/Recovery Data for NXG1



3.8 Printing Parameters

Squeegee Blade	:	80 to 90 durometers Rubber or Stainless Steel
Squeegee Speed	:	Capable to a maximum speed of 200mm/sec
Stencil Material	:	Brass, Stainless Steel, Nickel Plated, Molybdenum
Snap off	:	0 ~ 0.5 mm (dependent upon board design and machine capability) Although on-contact (zero snap-off) is nor mally recommended for fine-pitch applica tion, it is still advisable to provide proper snap-off distance so that the stencil or PCB can be separated from the substrate smoothly and gradually to ensure good sol der deposits.
Operating conditions	:	Optimal ranges are 21-25°C (70-77°C) and 35–65%RH

3.9 Printing Tips

a) Place sufficient amount of solder paste on the stencil. Add fresh paste to replenish the consumed amount. It is important to mini mize the quantity of paste left on the stencil to ensure continuous printing.

b) After a certain period of continuous printing, it is important to thor oughly clean the bottom or both the top and bottom sides of the stencil to ensure smooth printing. Any smearing of paste on the bottom side of the stencil to the board can result in solderballs.

c) It is recommended to clean both the top and bottom side of the stencil before break.

d) Used paste on the stencil is not advisable to be scooped back into the original jar to prevent mixture and contamination of fresh paste. It should be placed in a separate empty jar for reuse if necessary.

e) In cases where only half of the solder paste in the jar is used, the plastic insert should be returned until it comes into contact with the surface of the unused solder paste, recap, retape and stored in a cool area when not in use, preferably into the refrigerator to mini mize exposure of the solder paste.

4. Reflow

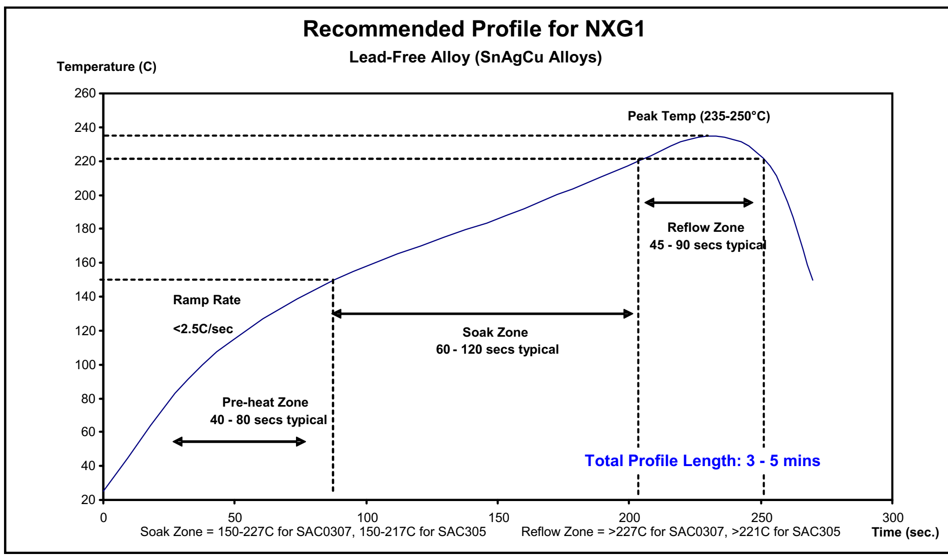
4.1 Reflow Profile Recommendation

The recommended reflow profile that has exhibited excellent wetting is located in Figure 6.

4.2 Reflow Environment

NXG1 was designed for excellent wetting and spreading performance in air reflow environments. When the reflow environment is inerted with nitrogen wetting is enhanced.

Figure 6: Recommended Reflow Profile for SnAgCu Alloy



- A gentle linear ramp-up profile is preferred to reflow low to medium thermal mass assemblies.
- Lower peak temperatures may require longer dwell time for better joint cosmetics.
- Fast cooling is typically recommended as it encourages finer grain growth and hence better solder interconnect joints. This will depend on thermal shock and component sensitivity. Refer to component suppliers' guide lines and specifications.
- Above information is a guideline. Since NXG1 is a highly active sol der paste, it can solder effectively over a wide range of profiles. It is possible that the optimal settings for a given assembly may vary from the above profiles based on your circuit board design, board thickness, components used, reflow oven equipment and mix of defects.

4.3 Ball-in-socket Defects

Ball-in-socket defects (also known as head-in-pillow or pillowhead) can be some of the most difficult defects to determine the root cause and eliminate from your SMT process. This type of defect is often passed through QC at the production facility, because the partial contact between the solder and the BGA sphere can produce enough continuity to pass on initial inspection, but the lack of a real metallurgical connection will cause this joint to fail quickly in the field. As defects go, this type can be particularly difficult for this reason.

There is a lot of discussion in industry about the causes and potential remedies for ball-in-socket defects. Although component warpage is often the leading cause of the defect, how can such a defect be tweaked out with process parameters? And can the right paste help with the prevention of this defect?

Generally, the ball-in-socket defect cannot form unless the ball comes loose from the paste at some point during the process. Some ways that this can occur include:

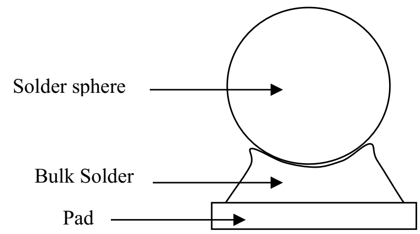
1) Component warps during reflow, forcing some of the balls around the perimeter of the BGA to come dislodged from the paste
2) Uneven heating across the BGA produces uneven wetting, resulting in something similar to a tombstone defect. The BGA solders on one side first, and with enough force to pull the BGA spheres out of the paste on the opposing side.

Option #1 above is a real issue, and would generally produce ball-in-socket defects randomly around the perimeter of the BGA. If the leading edge has ball-in-socket defects on one board and the next board has the same type of defects on the trailing edge, it is logical to assume that warping can be the culprit.

Option #2 is also a very common cause of ball-in-socket defects, and can be diagnosed by carefully charting the locations of the defects around the BGA. In general, ball-in-socket defects caused by this mechanism will occur repeatedly on the same side or corner of the BGA – after all, the uneven heating across the component should occur fairly similarly on all boards in the run. This type of defect mechanism can be remedied by tweaking the reflow profile to drive more even heating as the assembly approaches the liquidus temperature.

In both of these cases, the real issue at hand is that the BGA ball comes dislodged from the paste due to some sort of component tilting. When the ball is not lodged in the solder paste, the ball itself is prone to oxidation (particularly without any of the solder paste flux helping to reduce the oxides), and an oxide layer forms on the BGA sphere. Additionally, the solder paste, now without a large heat sink attached to it, will melt sooner than it would have otherwise, resulting in a lowered solder height (again, solder paste is only 50% solder by volume) and the flux will spill away from the solder and onto the board's solder mask. When the wetting action of the component forces the ball to merge with the molten solder, the combination of the oxide layer on the ball and the lack of flux on the surface of the molten solder results in what we now call a ball-in-socket defect.

Figure 7: Ball-in-socket Defect



So how can solder paste help with this? Well, the description above makes one assumption that may or may not have been obvious as you read the last paragraph. It was noted that "the flux will spill away from the solder and onto the board's solder mask." Well, this is indeed what most pastes do during the reflow process – the solder coalesces and the flux spreads out onto the board and somewhat away from the solder. But what if it didn't? What if the flux was less mobile, and not spreading away from the molten solder during that critical stage of the reflow profile? The result of this would be a coalesced molten solder bump with paste flux enveloping the bump, ready to "catch" the oxidized BGA ball when it is attempting to merge with the molten solder. The presence of flux on the surface can make all the difference between fighting with ball-in-socket defects and never worrying about them again.

So, it is possible that the right paste can help prevent ball-in-socket defects. Several major companies have proven that a change in paste can turn on and turn off this type of defect. And the main characteristic in the paste that drives this is the location of the flux in the few seconds just after the solder goes liquidus.

Kester NXG1 has been designed to prevent ball-in-socket defects.

4.4 Solderball Test

The solder ball test is conducted per J-STD-005 Method 2.4.43. The aim of this test is to determine the reflow property of a solder paste.

Two test specimens are prepared by printing three solder paste deposits of 0.65 cm in diameter and 0.25 mm thick onto a glass slide using a stencil (same as Tackiness Test). The printed deposits should be uniform in thickness with no solder particles between them.

One set of test specimen is reflowed within 15 +/- 5 minutes after printing. The other test specimen is stored at 25 +/- 3°C and 50 +/- 10% RH for 4 hours +/- 15 minutes after printing and then reflowed. Both specimens are reflowed on a hot plate that is heated at a temperature of 25 +/- 3°C above the liquidous temperature of the solder alloy. As soon as the solder has melted, the specimens are withdrawn from the hot plate. The reflow shall occur within 20 seconds after the specimen is placed in contact with the hot plate.

The reflowed specimens are inspected under 10x to 20x magnification. The solder ball size and number are compared with the solder ball test standards stated in J-STD-005 specifications.

Paste	Result
NXG1	Preferred

4.5 Residue Characteristics - Appearance

The NXG1 residue is categorized as colorless to light amber. The NXG1 also creates less post soldering residues than any lead-free solder paste on the market leaving finished assemblies looking pristine.

NXG1 Residues

The NXG1 residues are also easy to penetrate for in circuit testing. The residues do not accumulate on pin probe tips to help eliminate false failures and to reduce maintenance and down time.

NXG1	Typical Pb-free No-clean Solder Paste
	
Pin probe tip has not accumulated residue.*	Residue accumulated on pin probe tip.*
***Test Response:** Residue on pin probe tip after 100 probe cycles	

5. Shelf Life

5.1 Storage and Shelf Life

Refrigeration is the recommended optimum storage condition for solder paste to maintain consistent viscosity, reflow characteristics and overall performance. NXG1 should be stabilized at room temperature prior to printing. NXG1 should be kept at standard refrigeration temperatures., The shelf life for NXG1 solder paste is 8 months from date of manufacture when held under 0-10°C (32-50°F) refrigeration and unopened.

6. Summary

6.1 Product Performance Highlights

Kester's NXG1 Lead-free No-clean Solder Paste:

- Excellent wetting on a variety of metallizations
- Long stencil life and tack time (process dependent)
- Print speed up to 200mm/sec (8 inch/sec)
- Ultra low BGA voiding
- Excellent release from stencil
- Capable of 120 minutes break time in printing without any kneading
- Smooth shiny joints after reflow
- FLEX-LOY technology
- Clear, probeable residues
- 8 month shelf life
- Reflowable in air or nitrogen
- Classified as ROL1 per J-STD-004A

7. Licensing Agreements

7.1 Licenses

Kester is licensed to manufacture, use, and sell any solder product covered by U.S. Patent Number 5,527,628 that is assigned to ISURF.

Kester is also licensed to manufacture and sell solder compositions patented by Senju/Matsushita with Japanese Patent JP3027441.