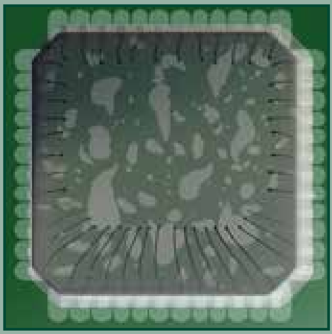
Indium8.9HFA

Halogen-Free No-Clean Solder Paste for Use with Pb-Free Alloys

- Best-in-class printing performance
- Superior halogen-free reflow performance
- Unique oxidation barrier eliminates common soldering defects
- Reliable solder joint formation

Circuit Board Assembly

Graping



QFN Voiding

Printing

Head-in-Pillow

INDIUM CORPORATION®

From One Engineer To Another®

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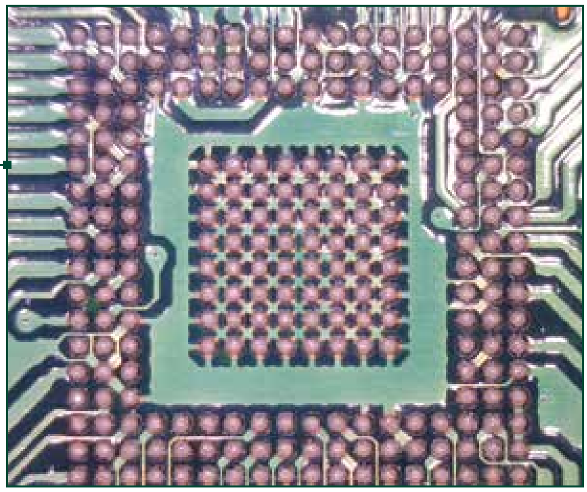


Indium8.9 Series

INDIUM8.9 SOLDER PASTE

Multi-faceted performance to bring the right balance of attributes, tailored to your process

Ideal for miniaturized components and fine-pitch assembly

- Designed especially for CSP, 0201, and 01005 components

First-class printing performance

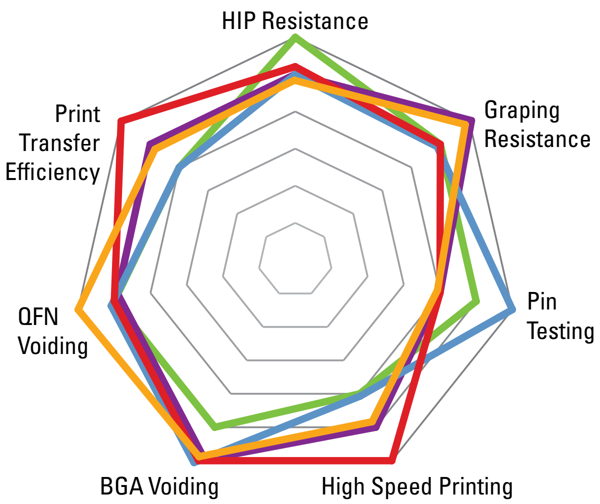
- Excellent print transfer through tiny apertures with area ratios <0.66
- Long stencil life and forgiving response-to-pause
- High component retention tack prevents components from shifting

Robust reflow performance

- Wide process window for flexible reflow profiling
- Optimal wetting to all common surface finishes

Resists voiding

- Low voiding (<5%) for BGAs with via-in-pad technology



Indium8.9HFA Delivers:

- Superior printing at high speeds → Decreased cycle times
- Ultra-low print pressures → Extended stencil life and reduced need for underside wipe
- Unsurpassed transfer efficiency for small apertures → Extends process window
- Excellent resistance to bridging for fine-pitch components → Best fine pitch performance
- Quick recovery after pauses → Forgiving to increasing mix on lines and change-overs
- Halogen-free performance that rivals traditional solder paste → Environmental conformance
- Unique oxidation barrier to ensure robust reflow performance → Eliminates common defects

HALOGEN FREE

www.Pb-Free.com

Pb-Free Alloys for use with Indium8.9HFA

Common Name	Composition	Solidus (°C)	Liquidus (°C)	Comments
SAC405	95.5Sn/4.0Ag/0.5Cu	217	218	High thermal reliability for applications in harsh environments
SAC387	96.5Sn/3.8/0.7Cu	217	219	Original iNEMI recommended SAC alloy
SAC305	96.6Sn/3.0Ag/0.5Cu	217	220	Solder products value council recommended SAC alloy
SAC105	98.5Sn/1.0Ag/0.5Cu	217	225	Low-cost alloy with reasonable drop test performance
SACM	Sn/Ag/Cu+Mn	217	225	Low-Ag alloy with enhanced performance compared to SAC305
SAC0307	99.0Sn/0.3Ag/0.7Cu	217	227	Low-Ag SAC alloy
Sn992	99.2Sn/0.5Cu+Bi+Co	227		No-Ag alloy with enhanced properties suitable for SMT applications

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Solder Printing Basics

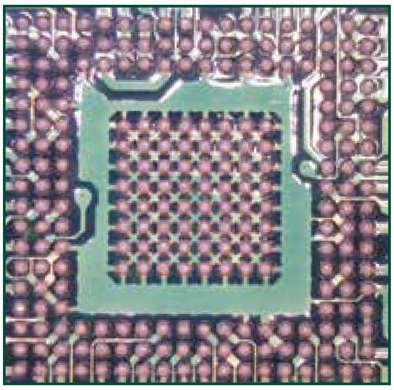
Best Practices for Solder Paste Storage and Handling

1. Paste is packaged for overnight shipping and should arrive at room temperature (<25°C)
2. Upon arrival, remove paste containers from cooler and store in <10°C
3. Prior to use, remove paste containers from storage and allow to equilibrate to room temperature before opening (typically 2-3 hours) DO NOT USE A HEAT SOURCE

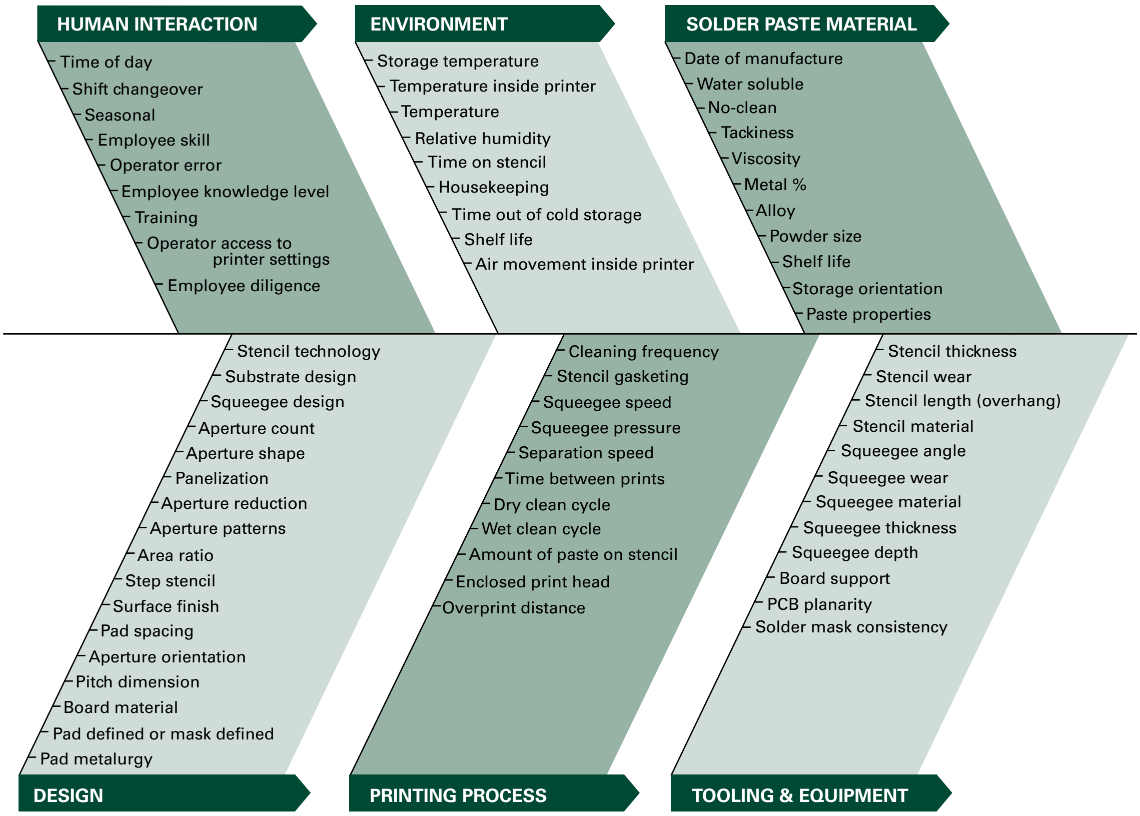
Note: Paste containers opened while still cold can absorb water from condensation, affecting the integrity of the paste; likewise, exposing paste to temperatures above 25°C can cause degradation.

Measurable Attributes of Good Paste Performance and Print Quality

- Transfer efficiency
  - Small apertures
  - Varying shapes and area ratios
  - Fine pitch
- Response-to-Pause
  - Print speed variation
- Slump
  - Under hot and cold conditions
- Reflow performance
  - Oxidation resistance



Factors that Cause Variation in Transfer Efficiency



Stencil Printing Process

Stencil Design:

Electroformed and laser cut/electropolished stencils produce the best printing characteristics among stencil types. Stencil aperture design is a crucial step in optimizing the print process. The following are a few general recommendations:

- Discrete components — A 10-20% reduction of stencil aperture has significantly reduced or eliminated the occurrence of mid-chip solder beads. The “home plate” design is a common method for achieving this reduction.
- Fine pitch components — A surface area reduction is recommended for apertures of 20 mil pitch and finer. This reduction will help minimize solder balling and bridging that can lead to electrical shorts. The amount of reduction necessary is process dependent (5-15% is common).
- For optimum transfer efficiency and release of the solder paste from the stencil apertures, industry standard aperture and aspect ratios should be adhered to.

Best Practices for Stencil Printing

- Board support is of paramount importance for consistent stencil printing
- Use enough paste so that a generous bead is able to roll freely when the squeegee moves (typically a dime to quarter in diameter, make sure paste only touches the squeegee blade)
- Set squeegee pressure just high enough to ensure a clean swipe of the squeegee with no paste left on the stencil after the pass (for indium pastes, typically 5 kg is sufficient for a 10” blade)
- Paste is a thixotropic material meaning it thins under pressure, so it only reaches optimal performance after a couple of prints (number varies depending on paste)
- Proper “gasketing” is very important, meaning alignment of apertures with pads, levelness of board surface, and solder mask definition should not detract from contact between the surface of the board and the stencil
- Wiping the underside of the stencil intermittently to remove any excess paste is often necessary, typically dry wipe with advancing paper and a vac cycle is sufficient
- Calculating area ratios and staying within typical stencil guidelines will give best first pass yields
- Typically higher area ratios will allow for better transfer efficiency

Calculating Area Ratios

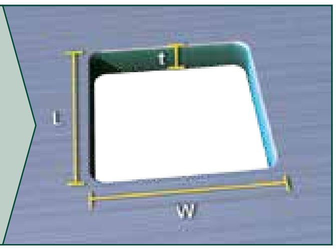
Area Ratio For Square/ Rectangular Apertures

$$\text{Area Ratio} = \frac{\text{Area Opening}}{\text{Area Walls}}$$

$$\text{Area Opening} = L \times W$$

$$\text{Area Walls} = 2t\,(L + W)$$

$$\text{Area Ratio} = \frac{L \times W}{2t\,(L + W)}$$



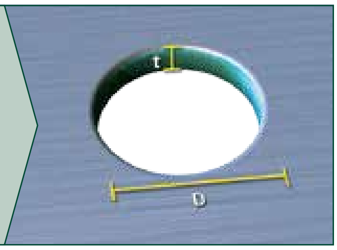
Area Ratio For Circular Apertures

$$\text{Area Ratio} = \frac{\text{Area Opening}}{\text{Area Walls}}$$

$$\text{Area Opening} = \frac{\pi D^2}{4}$$

$$\text{Area Walls} = \pi D t$$

$$\text{Area Ratio} = \frac{D}{4t}$$



Metric Aperture Ratio Chart (microns)

Aperture Size (µm)		50	100	150	160	170	180	190	200	250	300	350	400
Aperture Size (mils)		1.97	3.94	5.91	6.30	6.69	7.09	7.48	7.87	9.84	11.81	13.78	15.75
Stencil Thickness (mils)	5	0.10	0.20	0.30	0.31	0.33	0.35	0.37	0.39	0.49	0.59	0.69	0.79
	4	0.12	0.25	0.37	0.39	0.42	0.44	0.47	0.49	0.62	0.74	0.86	0.98
	3	0.16	0.33	0.49	0.52	0.56	0.59	0.62	0.66	0.82	0.98	1.15	1.31

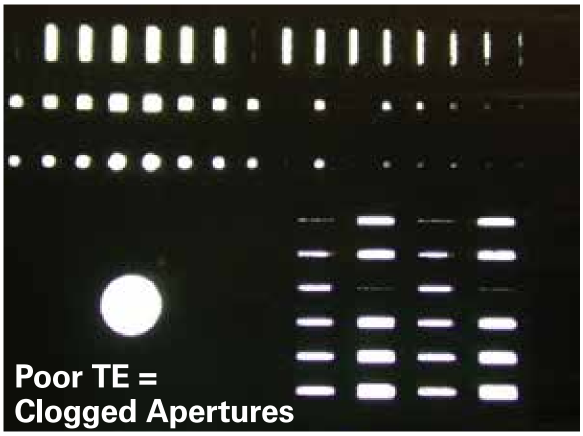
Green: Typically within process window
Yellow: Marginal or attainable with newer generation products
Red: Not typically within the process window

Continuous Print Testing

Continuous Print Procedure

Print 30 boards, minimal pressure, no wipe, 100mm/s

$$\text{Transfer Efficiency} = \frac{\textit{Measured Solder Volume per Aperture}}{\textit{Theoretical Maximum Aperture Volume}}$$

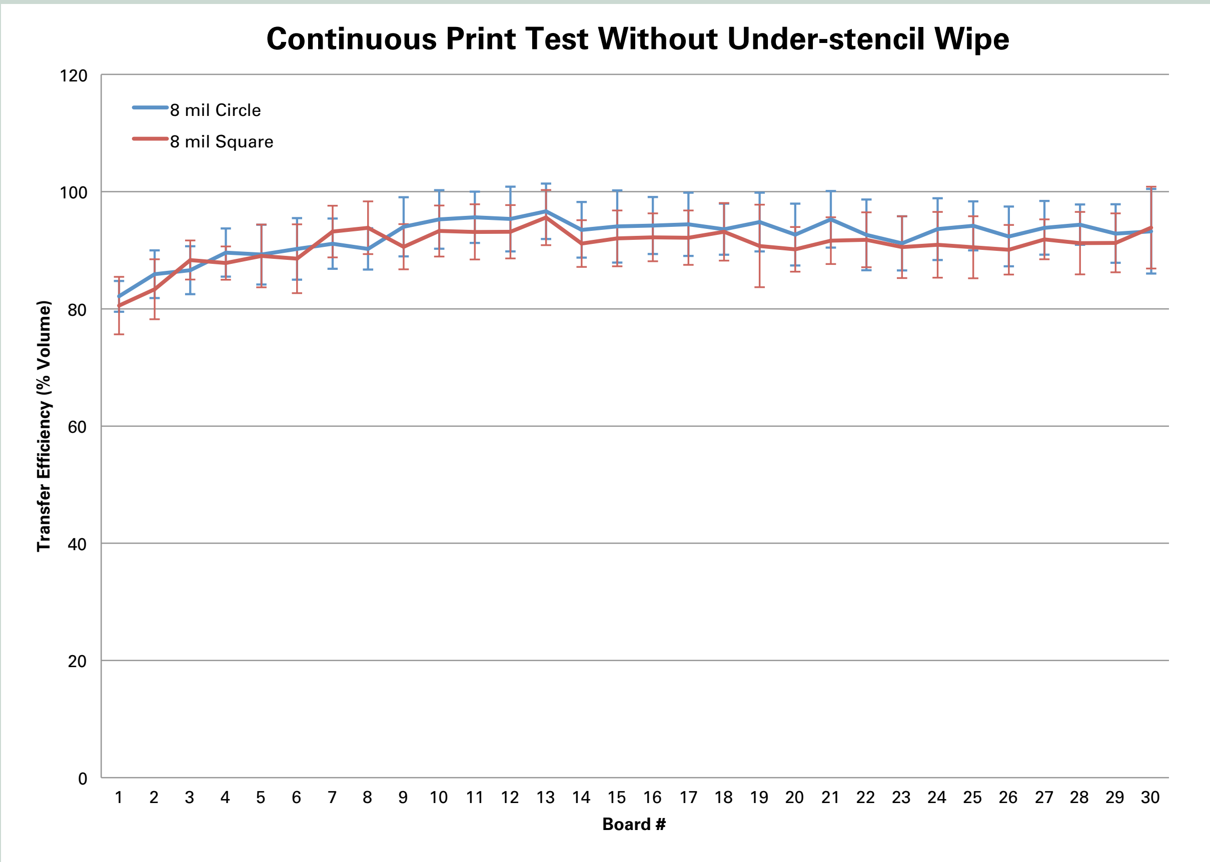


Test Results for Indium8.9HFA (Type 4 powder):

- Data was analyzed for a variety of apertures to ensure reasonable variation for any possible print defects
- 8 mil apertures are reported here because AR=0.5 is a small area ratio and good indicator of paste printing integrity
- >80% initial transfer efficiency: **no need to discard first startup board**
- Error bars show actual standard deviations, which remain stable throughout the 30 boards
- Transfer efficiencies stay **consistent, with no insufficients**

Benefits:

- Less frequent wiping can significantly decrease cycle time
- Overall, reduces the potential for process interruptions
- Robust printing process window to accommodate everyday process variation



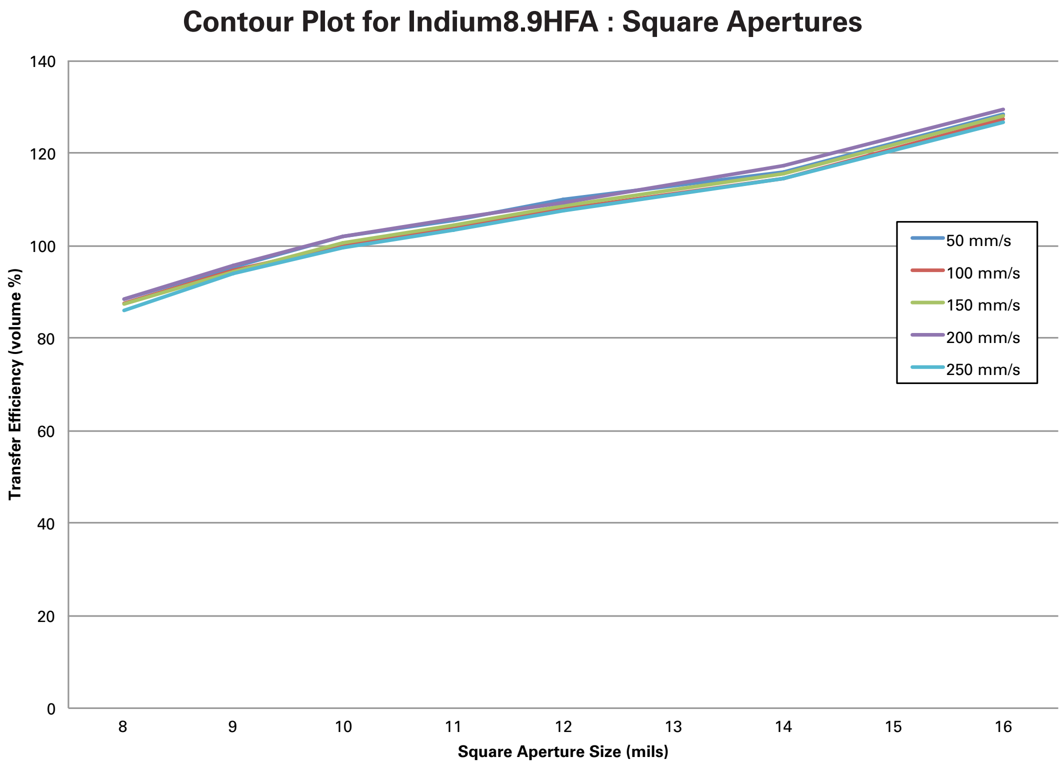
Stencil Printing Speed and Aperture Sizes

Contour Plots:

- Show relationship between transfer efficiency and printing process
- For traditional materials, show transfer efficiency decreases with high print speeds or small apertures
- Clearly illustrate the process window for a material by highlighting its limitations

Test Results for Indium8.9HFA:

- No insufficients for all aperture sizes and all speeds
- Most robust results, showing high quality printing for 8-16 mil apertures and 50-250mm/s print speeds
- Wide process window will accommodate many designs and processes



Aperture Ratio Chart (mils)											
Aperture Size (mils)	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Aperture Size (µm)	**152.40**	**177.80**	**203.20**	**228.60**	**254.00**	**279.40**	**304.80**	**330.20**	**355.60**	**381.00**	**406.40**
Stencil Thickness 4 mil	0.38	0.44	0.50	0.56	0.63	0.69	0.75	0.81	0.88	0.94	1.00

Green: Typically within process window
Yellow: Marginal or attainable with newer generation products
Red: Not typically within the process window

Response-to-Pause Testing

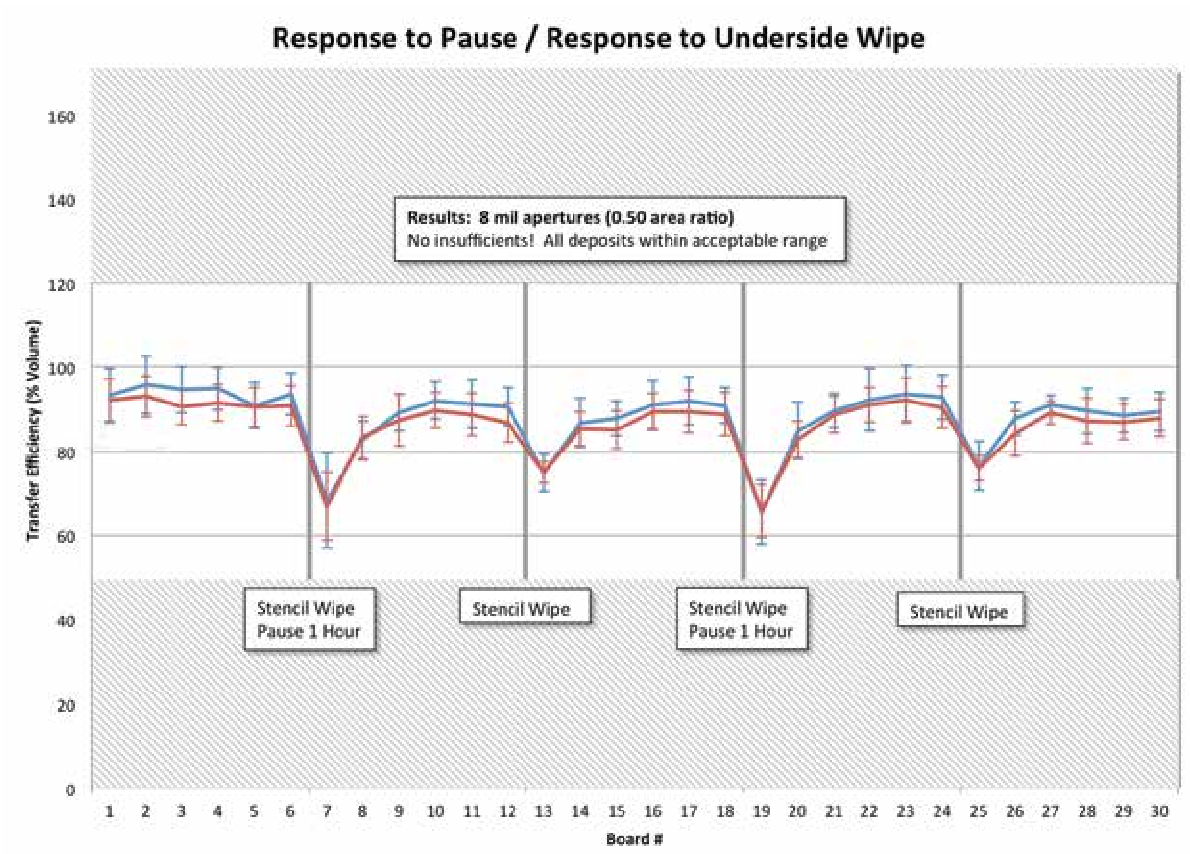
Why is response-to-pause important?

- Pauses and interruptions are common on SMT lines due to change-overs and maintenance
- Testing will show how much these pauses potentially change the printing process
- Procedure compares any drop in transfer efficiency for a pause, to that of an under-stencil wipe cycle
- During testing, all apertures are monitored for changes in transfer efficiency
- 8 mil apertures are chosen because they have consistently shown the most potential for failure

Note: It is best practice to always perform a wipe cycle before a pause!

Test Results for Indium8.9HFA:

- No deposits (for all aperture sizes) with less than 50% transfer efficiency = no skips or insufficients (also no excessives more than 120%)
- 8 mil deposits shown because they have the highest potential for failure (smallest area ratio)
- Maintaining high quality transfer even after wipe or pause -> no need to wash or discard boards
- Builds confidence that interruptions will minimally impact process robustness



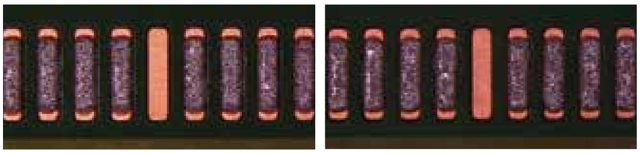
Slump Resistance

What causes hot slump and bridging?

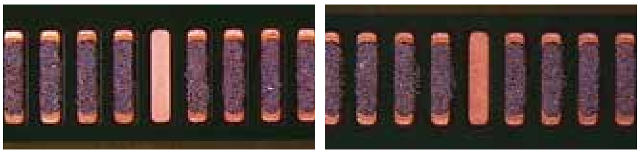
- Viscosity drops with increased temperature
- Solder deposits "slump" and risk connecting to adjacent deposits

Slump Resistance

- Tests the propensity of solder deposits to retain their shape and size over time after printing
- Prevents bridging and flux starvation



Before: Initial (room temperature immediately after printing)



After: After 15 min at 150°C

Optimizing Reflow

Section #1 – Preheat:

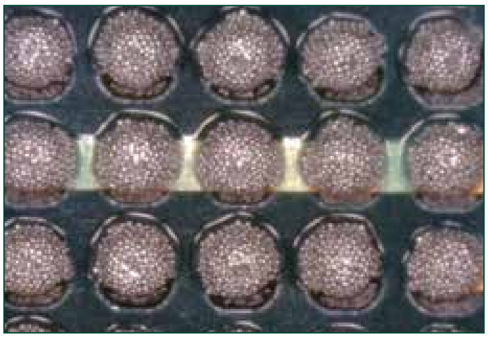
- **Slow Ramp Rate** – Minimizes paste slump and flux spattering. Fewer shorts, solder balls, and solder beads.
- **Fast Ramp Rate** – Minimizes additional oxidation on parts and boards. May help soldering of highly oxidized components.

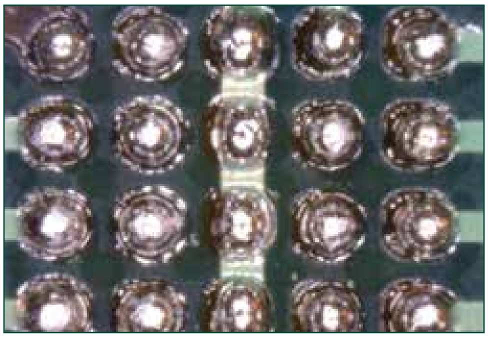
Section #2 – Soak:

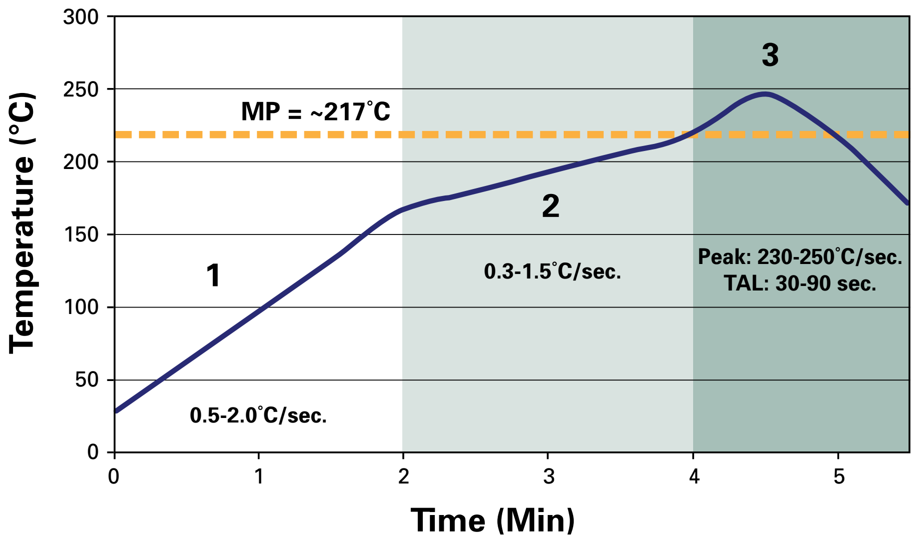
- **Short Soak Time** – Minimizes oxidation and provides best opportunity for good wetting and shiny solder joints.
- **Long Soak Time** – Minimizes tombstoning and voiding. Could negatively impact wetting.

Section #3 – Time Above Liquidus (TAL)/Peak:

- **Short TAL/Low Peak** – Minimizes voiding and thermal damage to components/substrates.
- **Long TAL/High Peak** – Improves solder coalescence but could result in dewetting if too long/high.







Defect Elimination: Head-in-Pillow

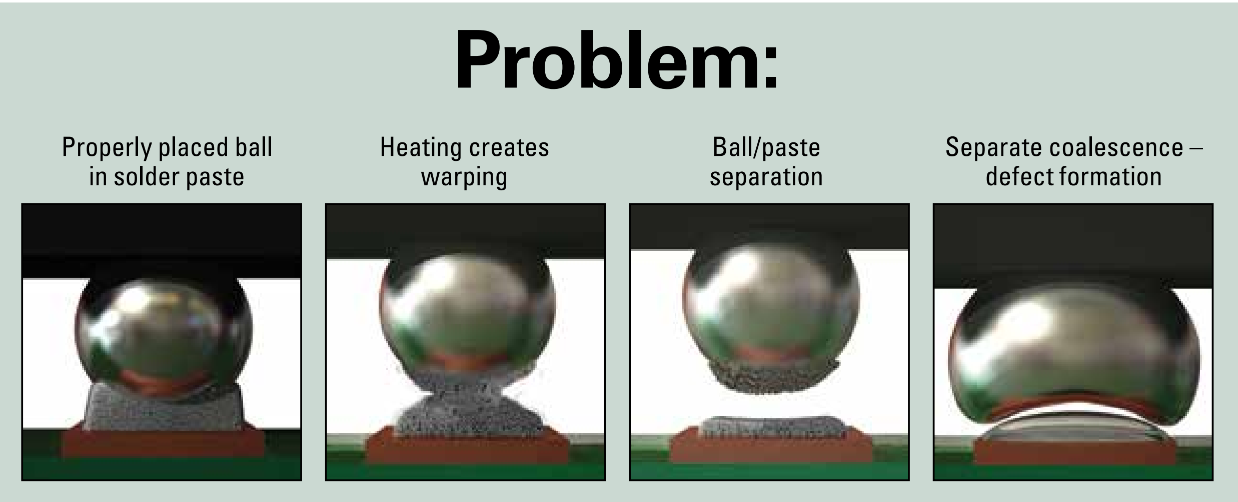
How does it happen?

1. Component warps during preheat and soak of profile
2. Paste and ball separate prior to melting
3. Paste and ball melt separately and solidify separately
4. Oxide layer forms on surface of molten solder
5. Component warps back during cool down but has already solidified, or oxide layer is too thick for paste and ball to coalesce

How Indium8.9HFA eliminates head-in-pillow

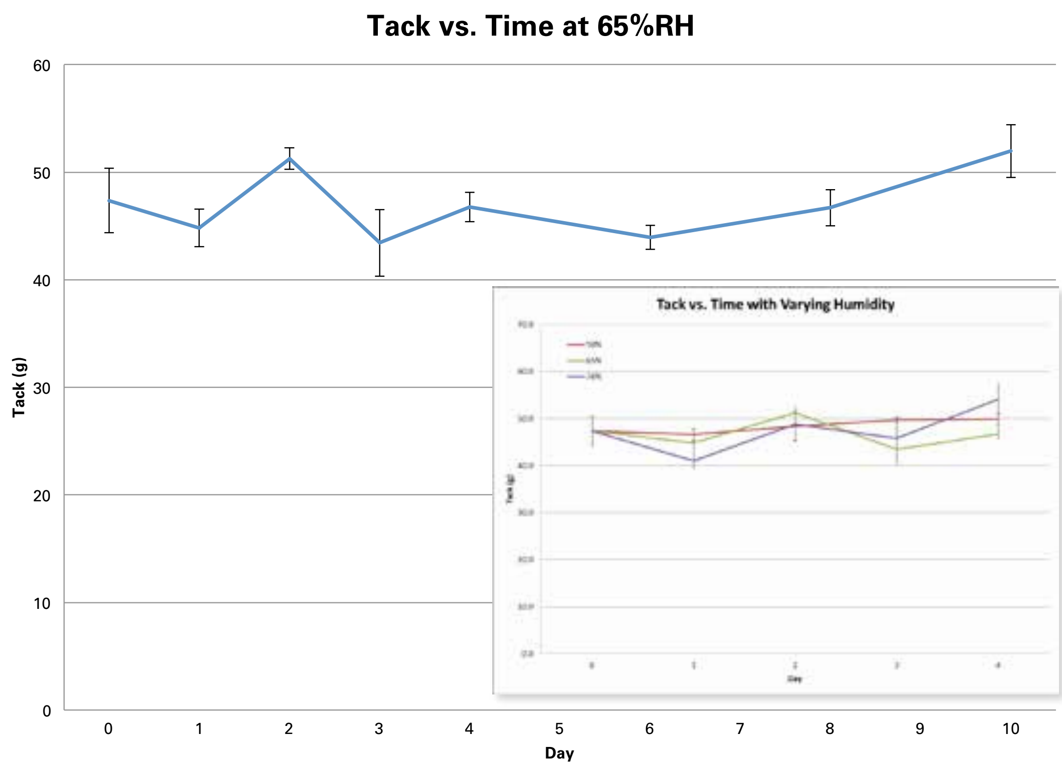
- Excellent wetting properties help to join paste and ball upon reflow
- Strong oxidation barrier promotes coalescence
- High tackiness prevents the ball and paste from separating

Head-in-Pillow Defect Formation



Indium8.9HFA Tackiness Test

Tack Versus Time



Defect Elimination: Graping

Oxidation barrier technology, which helps with HIP, also prevents graping on small paste deposits.

Graping happens because:

- Small paste deposits with fine solder particles have a much lower ratio of flux-to-surface area of oxide
- High reflow temperatures and long soak profiles promote more oxidation
- Flux spreading can leave some areas starved for flux
- Oxide is not cleaned from the surface, particles fail to coalesce properly

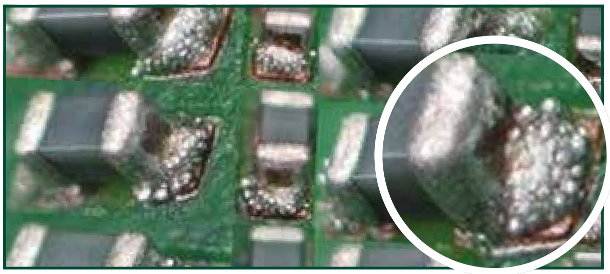
Be careful – graping is often misdiagnosed as cold solder.

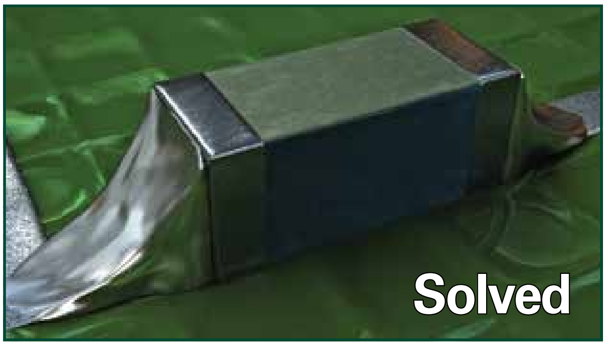
Solutions:

- Better oxidation suppression
- Less flux spreading
- Optimized reflow profile

Additional approaches to eliminate graping:

- Maximize aperture dimensions within known stencil design rules to ensure the maximum deposited paste volume
- Optimize aperture profile to enable maximum paste release (e.g., trapezoid aperture)
- Set the highest possible separation speed to maximize paste release
- Consider changes to reflow profile to minimize soak time

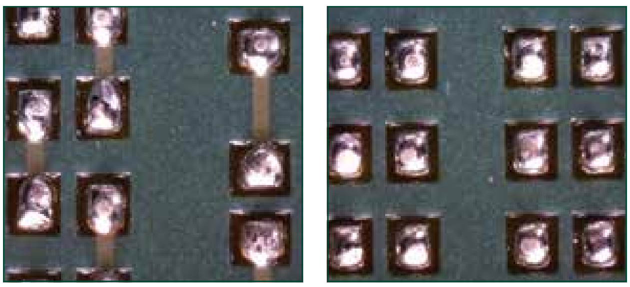




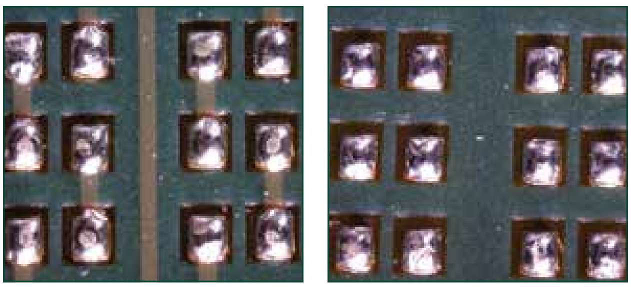
Causes of Graping

Reflow	Printing	Materials	Processes
Ramp rate	Stencil thickness	Solder paste oxidation resistance	Contaminated incoming air
Soak time	Aperture size	Powder size	Time between print and reflow
Peak temperature	Transfer efficiency	PCB surface finish and solderability	Aperture clogging
Air flow rate in reflow oven		Component finish and solderability	Paste time on stencil
			Poor paste handling or storage

Indium8.9HFA coalescence with typical reflow profile



Indium8.9HFA coalescence with harsh reflow profile



Solutions for QFN Voiding

How Indium8.9HFA reduces voiding under QFNs:

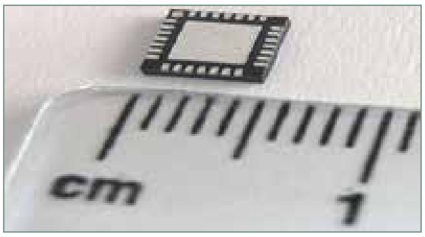
- Reduces size of single largest void, and fewer total voids
- Increased activity effectively removes oxide from small solder particles
- Optimized composition of volatile flux components cleans surfaces, while reducing gas entrapment
- Wide processing window allows for reflow optimization to further enhance low voiding performance

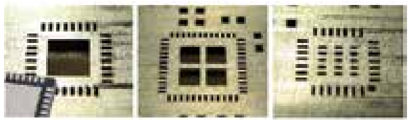
Reduce QFN Voiding Through Stencil Design

Instead of Printing One Large Square at the Center of QFNs:

- With greater paste volume, voiding increases, so aperture designs that limit paste volume will reduce voiding
- Break up this square into smaller apertures
- Spaces between printed areas leave paths for volatiles to escape
- Larger aperture separations will further reduce voiding

For additional information refer to paper: *"Influence of Reflow Profile and Pb-free Solder Paste in Minimizing Voids for QFN Assembly"* by T. Jensen, E. Briggs, et al.



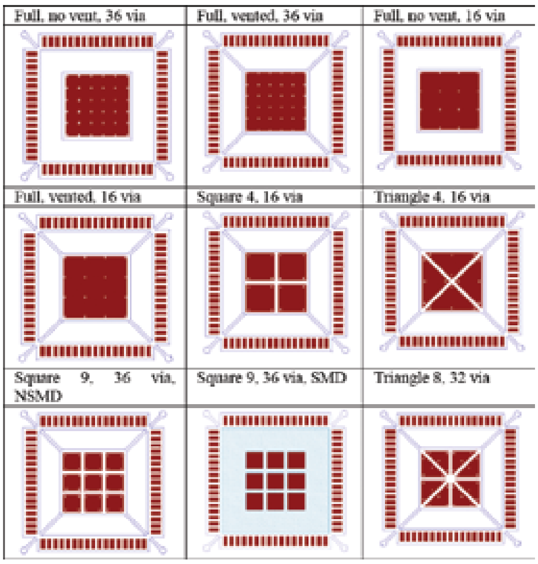


Modified stencil design for thermal pad

Thermal Pad Design to Reduce Voiding Under QFNs

- Breaking up the design for the thermal pad under a QFN can increase the amount of venting channels for volatiles
- Highly recommended white paper on many facets of the QFN Assembly Process

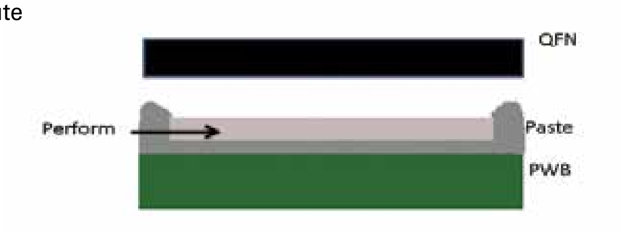
For further results refer to paper: *"Thermal Pad Design and Process for Voiding Control at QFN Assembly"* by D. Herron, Dr. Y. Liu, and Dr. N.C. Lee.



Further Minimizing QFN Voiding Using Solder Preforms

Using a square solder preform with paste adds the solder volume needed without adding additional volatiles, which will contribute to voiding underneath the QFN. Crucial considerations for this method:

- Stencil design
- Preform geometry
- Placement parameters (in respect to thermal pad)
- Preform flux coating
- Reflow profile



For additional information, refer to paper: *"Minimizing Voiding in QFN Packages Using Solder Preforms"* by S. Homer and R. Lasky, PhD, PE, or **askus@indium.com** for technical assistance on implementing this method.

Featured Pb-Free Alloys

Choosing an Alloy

1. Final assembly operating conditions (temperature & stresses):
   - To eliminate thermal failure (melting of joint), the alloy softening point (solidus) should be 40°– 50°C above operating temperature.
   - Mechanical stresses induced by temperature fluctuations must be matched by alloy compliance (thermal fatigue resistance).
   - Hostile environments, such as salt or swamp conditions, may require corrosion resistant alloys.
2. Surface metallization (alloy compatibility):
   - The alloy must wet to surfaces while not scavenging (dissolving) excessive surface metal or forming brittle intermetallics.
   - Typical surface metal is gold (Au) over nickel (Ni). Recommended gold thickness is generally between 8 – 15 micro inches (2,000 – 4,000 angstroms). If Au thickness is greater than 8 – 15 micro inches, a non Sn-bearing alloy may be needed to avoid brittle AuSn intermetallics.
3. Assembly conditions and methods:
   - Most alloys will form a solder joint best at temperatures 20°– 40°C above the alloy's liquidus point. Consequently, the peak temperature limitations of components must be considered.
   - Heating methods could impact the alloy choice. For example, a fluxless process with no reducing atmosphere may require an alloy that has low oxide formation, such as 80Au20Sn.
4. Fabrication capabilities:
   - All alloys cannot be formed into all shapes and sizes. For example, 58Bi42Sn is an excellent low temperature alloy, but its brittle nature makes the formation of fine wire difficult.
   - Key variables that impact fabrication: brittleness (low malleability and ductility); oxide formation rate; melting temperature; segregation; and softness.
5. Cost:
   - Alloy elemental composition can be an issue. For instance Au, Ag, and In alloys can be expensive.
   - Costs will vary due to fabrication difficulties and the quantity ordered.

Pb-Free Alloys for Solder Paste

Common Name	Composition	Solidus (°C)	Liquidus (°C)	Comments
InSn	52.0In/48.0Sn	118 (eutectic)		Lowest melting point practical solder
Indalloy227	77.2Sn/20.0In/2.8Ag	175	187	Not for use over 100°C due to 118°C SnIn eutectic
SnInCe	87.0Sn/13.0In+Ce	190	205	Best-in-class thermal cycling performance due to high ductility; addresses high CTE mismatches
Indalloy254	86.9Sn/10In/3.1Ag	204	205	No SnIn eutectic problems; potential uses for flip-chip assembly
SnBiAg	91.8Sn/4.8Bi/3.4Ag	211	213	Board and component metallizations must be Pb-free
SAC405	95.5Sn/4.0Ag/0.5Cu	217	218	Petzow (German) prior art reference makes this alloy patent-free
SAC387	96.5Sn/3.8/0.7Cu	217	219	Original iNEMI recommended SAC alloy
SAC305	96.6Sn/3.0Ag/0.5Cu	217	220	Recommended SAC alloy by the Solder Products Value Council
SAC105	98.5Sn/1.0Ag/0.5Cu	217	225	Low-cost alloy with reasonable drop test performance
SACM	Sn/Ag/Cu+Mn	217	225	Drop test performance as good as SnPb
SAC0307	99.0Sn/0.3Ag/0.7Cu	217	227	Low-cost SAC alloy
SnCu	99.3Sn/0.7Cu	227 (eutectic)		Inexpensive; possible use in wave soldering
Sn992	99.2Sn/0.5Cu+Bi+Co	227		High-performance and low-cost solder alloy
"J" alloy	65.0Sn/25.0Ag/10.0Sb	223 (eutectic)		Die-attach solder alloy; very brittle
Indalloy133	95.0Sn/5.0Sb	235	240	High-temperature Pb-free alloy
Indalloy259	90.0Sn/10.0Sb	250	272	High-temperature Pb-free alloy

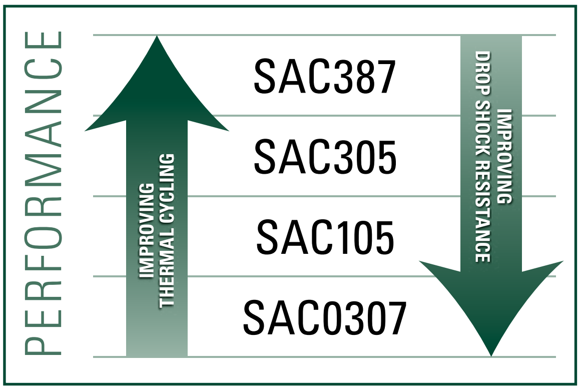
Indium Corporation offers hundreds of other alloy choices. Visit our website at www.indium.com/alloysolderchart.php for more information.

Sn992
Low-cost, Pb-free

- Performance and appearance comparable to SAC305
- No Ag for future cost stability
- Cobalt enhances wetting and shininess

SACM
Low-Ag, High-performance

- Enhanced reliability compared to traditional SAC alloys
- Doped with manganese to strengthen thermal reliability
- High resistance to drop shock



Halogen-Free Overview

Minimize Environmental Impact

Upon incineration, some organic halogenated compounds are known to release toxic dioxins and furans into the environment.

Sources of Halogens in Electronics

- **PCB Laminate Materials**
  - Halogen-free alternatives are more expensive to manufacture and may be more sensitive in high reliability applications
- **Components**
  - Halogen-free components are being developed, but can be challenging in complex IC's
- **PVC (primarily in cables)**
  - Halogen-free alternatives are often more brittle and more costly
- **Soldering Materials**
  - Halogen-free materials could suffer in soldering performance (HIP, graping, and long profiles)

Halogen-Free vs. Halide-Free

HALOGEN-FREE

- It does not contain Cl,
  - Br, F, I, At (most concern for chlorinated and brominated flame retardants)
- Concern is environmental
  - Uncontrolled incineration
  - Dioxin formation
- Issues:
  - Do the halogen-free PCB's impact end product reliability?

HALIDE-FREE

- Should be halide ion free as it is defined in electronics as not containing ionic halides
- Concern is reliability
  - Corrosion
  - Dendritic growth
- Activators in flux
- Issues:
  - Is halide-free actually more reliable than halide-contained?
  - How do you test fluxes for halide content?

Halogen-Free Implementation Challenges

- **Activity and Oxidation Barrier**
  - Activators remove oxides and rosins/resins protect from oxidation
  - More activator could leave less room for oxidation barrier (narrower reflow window)
    - Graping phenomenon
    - High peak temperature challenges
- **Potential Reliability Challenges**
  - Targeting equal performance could mean higher activator...greater SIR & ECM risk
- **F and I Usage Concerns**
  - Could meet halogen-free for Cl and Br, but have high levels of other halogens
- **Hole-Fill on Thick Boards**
  - Already a challenge with Pb-free; eliminating halogens makes this more challenging
  - Higher solids content materials possible
- **Testing Halogen Content of the Wave Flux Residue**
  - Fluxes with low solids do not have much residue
  - 0.5 to 1.0g of residue needed to run oxygen bomb test

FACT

Ion Chromatography and Titration Do Not Guarantee Halogen-Free

Both ion chromatography and titration only reveal the presence of ionic halide content in materials, although additional halogen content can be present covalently bonded within the formulation. These covalently bonded halogens may be restricted by legislation and may pose an environmental risk during the recycling process.

The designation of "L0" per IPC J-STD-004 does not indicate that materials are halogen-free; this merely indicates that ionic halide content is less than 500ppm.

METHOD

Oxygen Bomb Combustion Followed by Ion Chromatography (EN14582)

Most of the electronics manufacturing industry agrees that the best method for determining the halogen content of a flux or solder paste is through the use of an oxygen bomb combustion followed by ion chromatography (IC) testing.

This test method involves subjecting a sample of flux to an oxygen bomb combustion in which all of the organic material is burned off at very high temperatures. The remaining ash consists of the halogens and other inorganic materials. That ash is then run through ion chromatography to determine the true halogen content. Any covalently bonded halogens would have those bonds broken through the oxygen bomb process.

Halogen-Free Product Suite

Ensuring that Indium Products are Halogen-Free:

- Products tested with EN14582 test method
  - *Oxygen bomb combustion followed by ion chromatography*
  - *Assures that halogens will not be released by reflow or recycling*

Halogen-free, No-clean for Pb-free Alloys

Product Line	Product Name	Comments
Solder Paste	Indium8.9HFA	Superior printing performance - unique oxygen barrier technology eliminates common defects
Wave Flux (VOC-free)	WF-7745	Probe-testable formulation - prevents green discoloration in copper corrosion test - spray application
Wave Flux (alcohol based)	WF-9945	Perfomance comparable to halogen-containing fluxes, without halogens - spray or foaming application
Flux-cored Wire (low halogen)	CW-807	<900ppm halogen - mild smell and low smoke formula - clear residue
TACFlux	020B	Residual flux passes SIR without heating
TACFlux	089HF	
Flux Pen	NC-771	Residual flux passes SIR without heating

TACFluxes 020B and 089HF

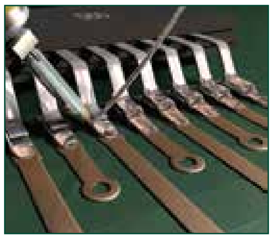
- Performs well in traditional touch-up repair as well as BGA/CSP rework
- Halogen content of residue:
  - Br < 50ppm
  - Cl < 50ppm
- Low risk: passes SIR unreflowed (020B)

NC-771 Flux Pen

- Low risk: passes SIR unreflowed
- Halogen content of residue:
  - Br < 50ppm
  - Cl < 50ppm

CW-807 Flux-Cored Wire

- Superior wetting speeds
- User friendly: low odor and smoke
- ROL0
- Meets halogen-free requirements per EN14582 oxygen bomb testing

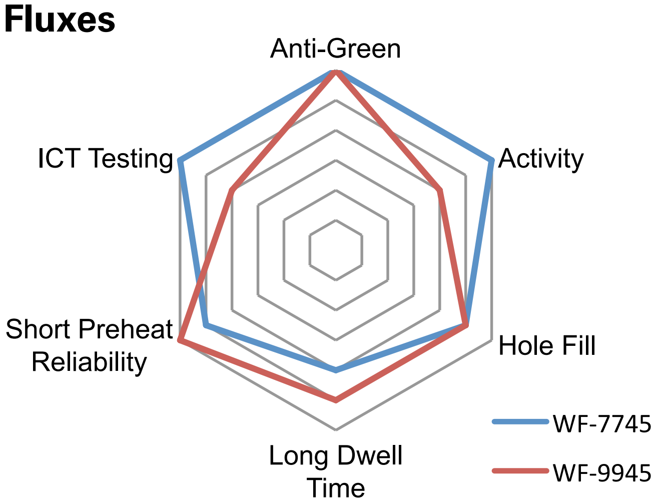


Indium8.9HFA

- Halogen content of residue (EN14582):
  - Br <50ppm
  - Cl <50ppm

WF-7745 and WF-9945 Wave Solder Fluxes

- **WF-7745**
  - Superior hole-fill
  - No green copper discoloration as typical with VOC-free fluxes
  - Halogen content of residue:
    - Br < 50ppm
    - Cl < 50ppm
- **WF-9945**
  - Superior hole-fill
  - Sn/Pb and Pb-free compatible
  - Halogen content of residue:
    - Br < 50ppm
    - Cl < 50ppm



	No-Clean	VOC-Free	Halogen-Free	Halide Free	Rosin Containing	Solids Content	Acid Value (%)	Foaming Application	Spray Application
WF-7745	●	●	●	●		4.22	39.3		●
WF-9945	●		●	●	●	5.77	14.4	●	●

IPC/J-STD-004B Product Level Testing

Copper Mirror (Test #2.3.32)

Objective: The purpose of this test is to determine the corrosive (free-halide) properties of a flux.

Procedure: Flux is applied to a copper-coated glass slide and sits in a controlled environment for 24 hours. The flux is cleaned and the copper inspected for corrosion.

Results: Pass (No Color Change)

Oxygen Bomb with Ion Chromatography Halogen Testing (EN14582)

Objective: The purpose of this test is to isolate and quantify any halogen, ionic or covalently bonded, that is present in flux residues once assembly is complete.

Procedure: A sample is combusted in oxygen at very high temperatures, burning off any organic materials. The remaining ash will contain halogens and other inorganic substances which can be characterized by ion chromatography to determine the halogen content.

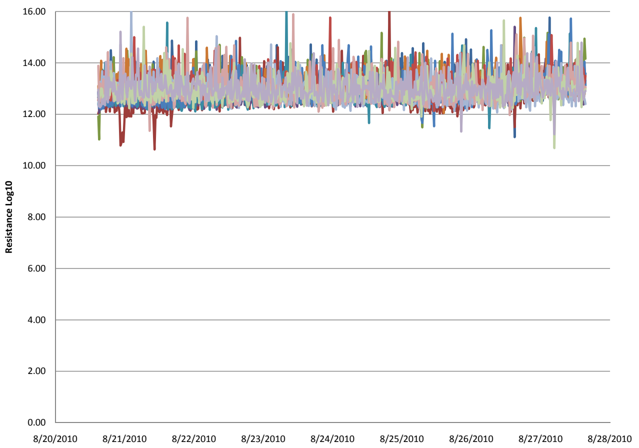
Results: Br = 0.0020% (20 ppm)
Cl = 0.0050% (50 ppm)

Surface Insulation Resistance (Test #2.6.3.7)

Objective: The purpose of this test is to determine the Surface Insulation Resistance (SIR) of the flux residue after paste reflow.

Procedure: Paste is stenciled onto the test board and reflowed. The un-cleaned board is then sent to outside laboratory for testing.

Results: Pass



Silver Chromate (Test #2.3.33)

Objective: The purpose of this test is to determine the corrosive (free-halide) properties of a flux.

Procedure: Flux is applied to Silver Chromate-impregnated paper, and inspected for color change.

Results: Pass (No Color Change)

Qualitative Corrosion (Test #2.6.15)

Objective: The purpose of this test is to determine the corrosive properties of the flux residues under extreme environmental conditions.

Procedure: Solder paste is reflowed onto a sheet of copper and exposed to 40°C and 93% RH for 10 days. Coupon is then investigated for any signs of Cu corrosion.

Results: Pass (No Color Change)

Electrochemical Migration (Test #2.6.14.1)

Objective: The purpose of this test is to determine the Electrochemical Migration and SIR of the flux residue after paste reflow.

Procedure: Paste is stenciled onto the test board and reflowed. Un-cleaned board is then sent to outside laboratory for testing.

Results: Pass

Electrochemical Migration Resistance, IPC-TM-650 Method 2.6.14.1 Results

Test Sample	Initial	96 Hour	500 Hour	Final
1	13.54	10.31	10.42	11.98
2	14.39	10.45	10.46	12.40
3	13.38	10.50	10.76	11.73
4	13.83	10.50	10.76	12.27
5	14.31	10.17	10.07	12.40
6	13.91	10.07	10.15	12.54
7	13.37	10.02	10.38	12.57
8	13.29	9.74	10.02	11.78
9	14.41	10.12	10.35	12.26
10	13.77	10.02	10.13	12.40
11	13.27	10.07	9.70	11.74
12	13.92	10.12	10.15	12.32
Control	**Initial**	**96 Hour**	**500 Hour**	**Final**
1	14.02	11.47	11.08	11.88
2	11.83	10.82	11.23	12.80
3	11.85	10.07	11.19	12.73
4	14.27	11.44	10.43	12.33
5	11.03	9.30	10.86	12.86
6	14.68	11.52	10.81	12.43
7	13.27	11.63	10.82	12.43
8	13.23	11.40	10.86	12.35
9	15.22	11.34	11.49	13.55
10	12.86	10.14	11.91	13.36
11	13.20	10.65	11.57	13.19
12	12.87	9.82	11.29	13.62

Note: Results are reported in log10.

IPC/J-STD-005 Test Results

Metal Content (Test #2.2.20)

Objective: The purpose of this test is to determine the weight percent of metal in the solder paste. The percentage should not deviate more than +/- 1% from the solder paste specification.

Procedure: A known weight of solder paste is reflowed in a glass beaker. A "button" of solder is formed from the coalescence of the solder. The "button" is cleaned and weighed. The ratio of "button" weight to original solder paste weight is the metal percent.

Sample Results

Lot	Metal % (Type 4 Powder)
Sample 1	87.68
Sample 2	88.27
Sample 3	88.03
Sample 4	87.95
Sample 5	87.82

Viscosity (Test #2.4.34.2)

Objective: The purpose of this test is to determine the viscosity of a specific lot of solder paste. Viscosity testing is a fundamental test that ensures consistent performance from lot-to-lot.

Procedure: Approximately 500g of solder paste is stabilized at 25 +/- 1°C and the viscosity is measured using a Malcom spiral pump viscometer at 5rpm's. The results are measured and compared to the nominal value. Solder paste lots with values outside the expected variation (USL and LSL) need to be investigated for possible performance related issues.

Sample Results

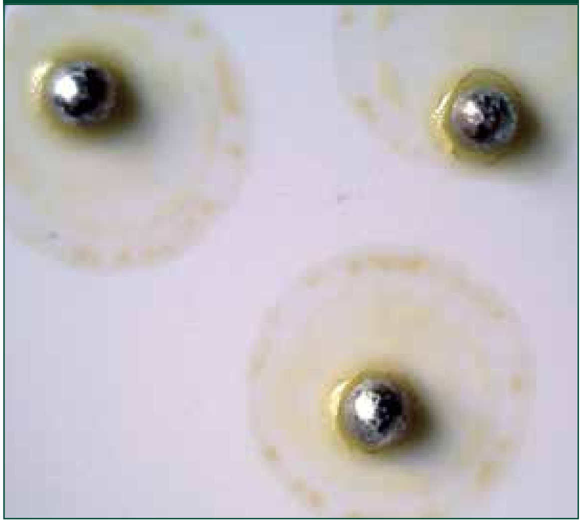
Lot	Malcom Viscosity
Sample 1	1134
Sample 2	1237
Sample 3	1277
Sample 4	1296

Solder Ball (Test #2.4.43)

Objective: The purpose of this test is to validate soldering performance of a specific lot of solder paste. Solder ball testing is a fundamental test that ensures consistent performance for lot-to-lot.

Procedure: Three small deposits of solder paste are printed onto a ceramic coupon and reflowed at a temperature of approximately 240°C (for Sn/Ag/Cu alloys). The coupon is then inspected to ensure complete coalescence of the solder paste, and that there are no extraneous solder balls in the flux pool. Results are compared to images in the J-STD-005 to determine whether it passes or fails.

Typical Result and Image: Pass, Preferred



IPC/J-STD-005 Test Results

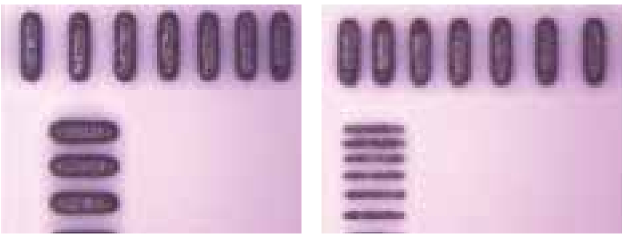
Slump (Test #2.4.35)

Objective: The purpose of this test is to determine the potential for slumping with a given solder paste.

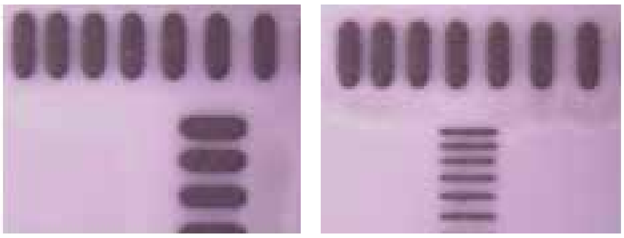
Procedure: For cold slump, solder paste is printed using an IPC-A-20 stencil on an alumina substrate and examined for maximum spacing bridged. Samples are stored at 47% relative humidity at room temperature (approx. 25 +/- 5°C) for 20 minutes. Samples are then re-examined for maximum spacing bridged. For hot slump, samples are again printed with an IPC-A-20 stencil on an alumina substrate and examined for maximum spacing bridged. Samples are then heated to 180°C for 15 minutes and allowed to cool. Samples are re-examined immediately, and again after 2-hours and 4-hours, for maximum spacing bridged.

Result: Pass Solder Paste Slump Test (IPC-TM-650 2.4.35)

Cold Slump



Hot Slump

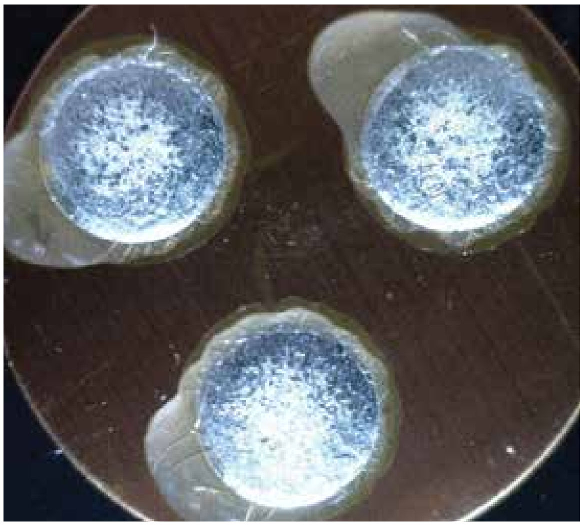


Wetting (Test #2.4.45)

Objective: The purpose of this test is to ensure that the solder paste has sufficient capability to wet to a copper substrate.

Procedure: Solder paste is printed onto a clean copper coupon and reflowed using the manufacturers recommended reflow profile. The coupon is then inspected to ensure uniform wetting and no evidence of de-wetting or non-wetting.

Results and Image: Pass



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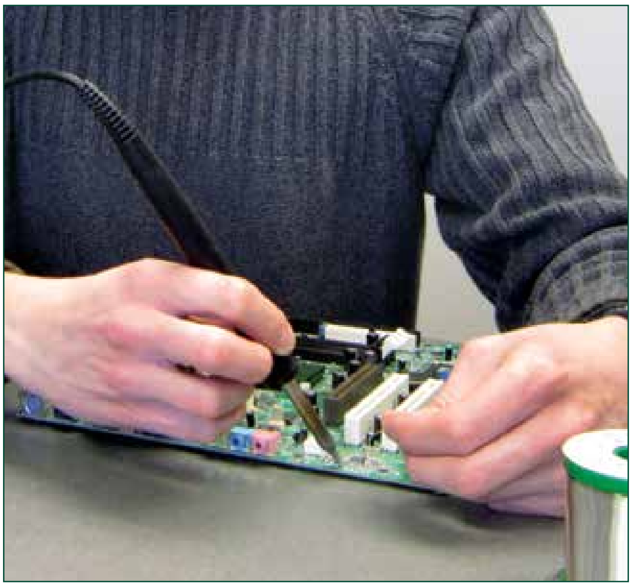

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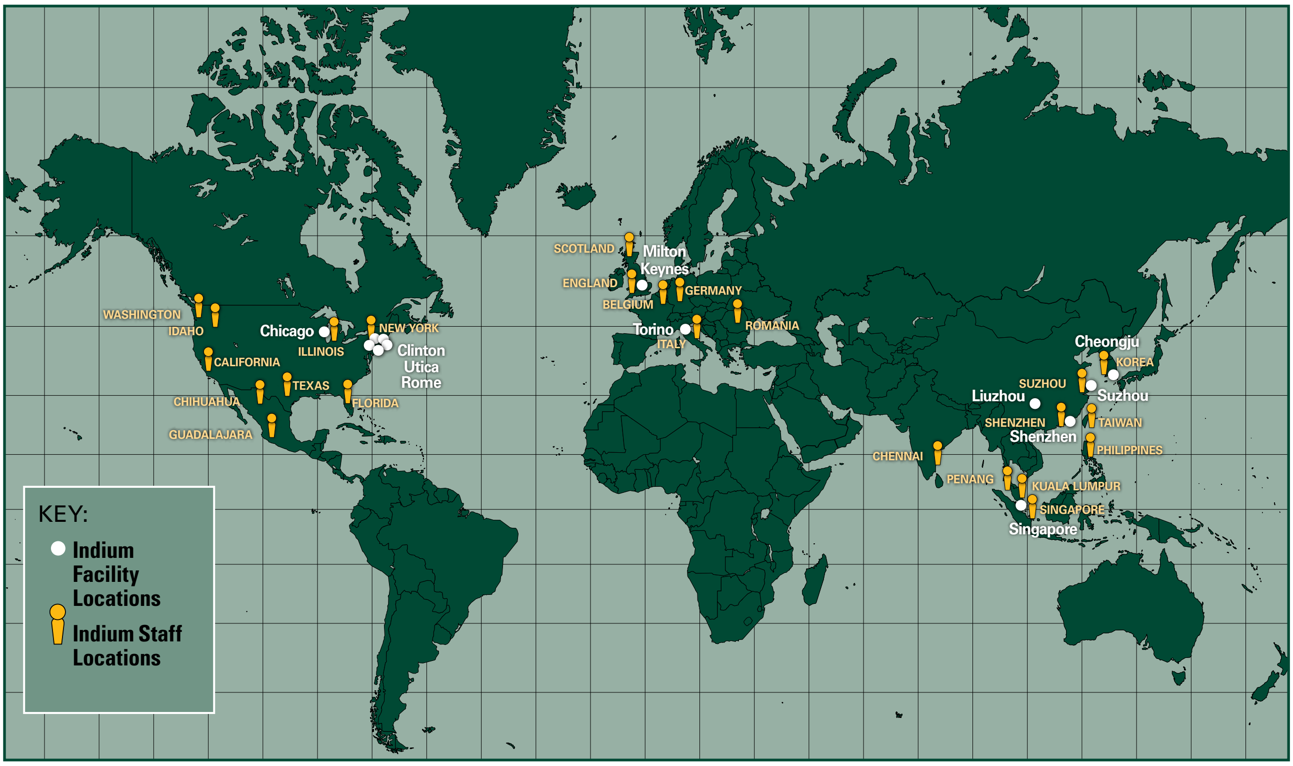
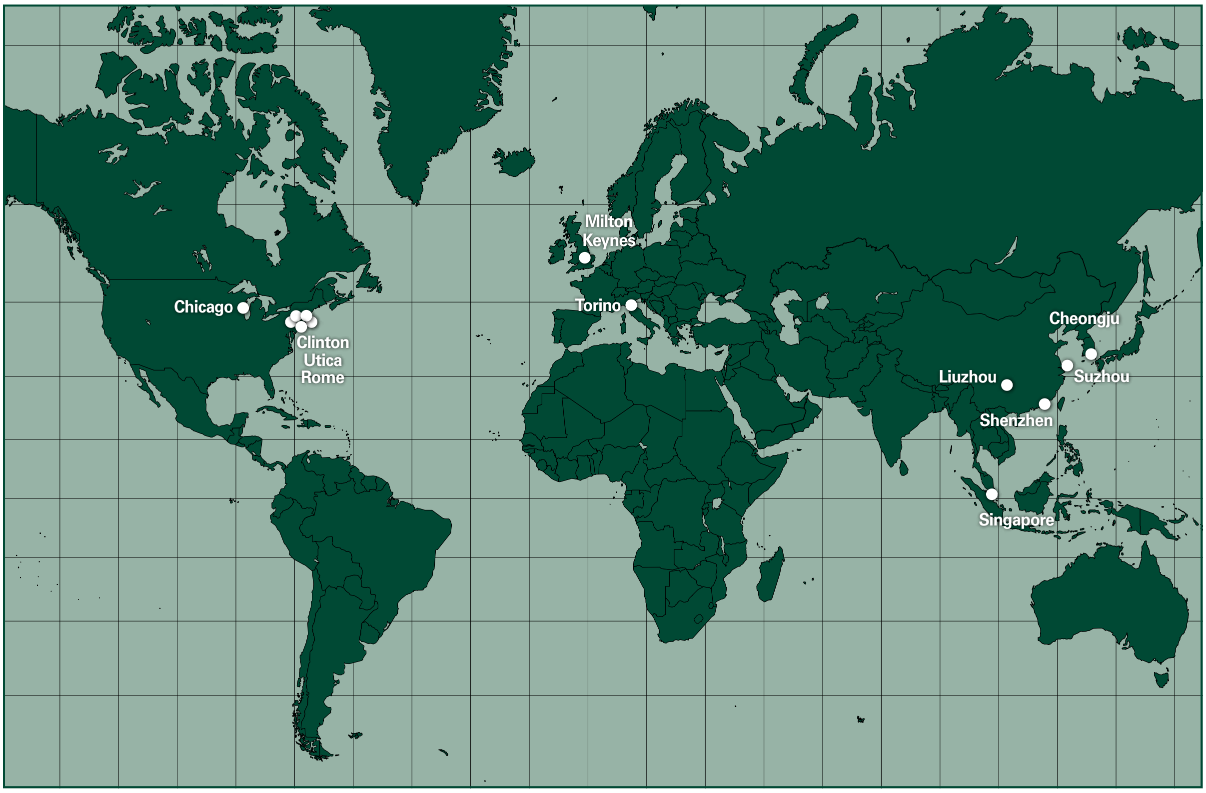


Locations Worldwide



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