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Overview

**Indium Corporation** is a premiere materials supplier to Global Industries:

- Electronics assembly
- Semiconductor
- Solar
- Thin-film
- Thermal management
- Specialty chemical
Indium Corporation – The Numbers

- 80 years of consistent growth
- >600 Employees
- 11 Factories
- High quality earnings
Indium Corporation’s Business

**Engineered Solders:**
solder preforms, wire, ribbon, fluxes, etc.

**NanoFoil®:**
Precisely controlled instantaneous heat for reaction initiation and joining applications.

**Solar Assembly Products:**
Tab/bus ribbon, rotary & planar targets, thermal evaporation materials, solders, fluxes, etc.

**Semiconductor Assembly Materials:**
Semiconductor grade fluxes, solder pastes, and other assembly materials.

**PCB Assembly Soldering Materials:**
Solder pastes, wave solder fluxes, bar solder, and rework materials.

**Medical Assembly Products:**
The assembly of medical devices uses a wide variety of alternative soldering processes.

**Thermal Interface Materials:**
Reflow and Non-Reflow TIMs.

**Indium Germanium, Gallium and Tin Metal:**
All grades of purity, sizes, shapes, and quantities.

**Salts and Chemicals:**
Full range of Indium, Gallium, Germanium and Tin chemical compounds.

**Solder Fortification™:**
Reliable first-pass solder joints.
Corporate Structure

- **Solder Products Business Unit:**
  - Electronics assembly materials
  - Semiconductor Packaging & Die-Attach Materials
  - Solder and selected brazing materials in over 200 alloys and more than 5,000 forms

- **Metals & Chemicals Business Unit:**
  - Indium, Germanium, Gallium, Tin metals and inorganic chemicals
  - ITO & other reclaim

- **Solar Products Business Unit:**
  - Fluxes
  - Metallization and solder pastes
  - CIG Rotary and Planar Targets
  - Tabbing and Bus ribbons
  - Alloy powders
  - Nanofoils for target bonding
Indium Corporation Worldwide: Manufacturing and Sales Offices
Agenda

- Solder Paste
  - Product Design – Technology Drivers
  - No Clean / Water Soluble
  - What the booklet says…and what it means
  - Voiding
  - Pb Free Alloy – Ag %
  - Halogen Free
  - Which product where...Pb Free
  - Which product where...Pb Containing
  - PCBa Complimentary Products
  - Which product where...Low Temperature Solders
  - Conformal Coating

- Advanced Materials
  - POP Materials

- Engineered Materials
Our FULL suite of products

- **Solder Preforms**
  - Washer
  - Rectangle
  - Square
  - Frame
  - Cylinder/Cut Wire
  - Disc
  - Cluster/Integrated

- **Solder Pastes**
  - Halogen-Free
  - No-Clean
  - Water Wash
  - Dispensing
  - Pb-Free

- **Solder Foil & Ribbon**
  - Indium
  - Gold
  - Pb-Free

- **Solder Spheres**
  - Precision
  - High Temperature
  - Pb-Free

- **Ingot & Shot**
  - Wave Solder
  - Fusible Alloys
  - Anodes/Plating Ingot
  - High-Purity Indium

- **Solder Fluxes**
  - Wave
  - TACFlux™
  - Flip-Chip Flux

- **Solder Wire**
  - Solid
  - Flux-Cored
  - Die-Attach

- **Polymers/Underfills**
  - No-Flow Underfill
  - Epoxy Flux

- **Metal Gaskets/Seals**
  - O-Rings
  - Flat Gaskets
  - Custom Shapes

- **Metal TIMs**
  - Metal Shims
  - Compressible Metals
  - Liquid Metals

- **Solar**
  - Metallization Pastes
  - Sputtering Targets
  - Evaporation Sources
  - In/Ga Chemicals
  - Alloy Powders
  - Tabbing Conductors
Product Design – Technology Drivers
Smaller components/tighter pitch

• High reliability
  – Server, telecommunication, automotive

• Very High Reliability
  – Military, Aerospace, Medical

• Miniaturization
  – Multi-Functionality
    • PDA, Cell Phone, IPOD
  – Board Real Estate is a Premium
  – Components Continue to “Shrink”

• High Density on Large Boards
  – 0201 on Servers
  – CSP on Motherboards
Solder Paste
No-Clean or Water Soluble

No-Clean Residue

Solder paste flux residue passes electrical surface insulation resistance tests.
- Can be left on in non life/safety critical applications
- Can be cleaned if application demands
- Application notes on this with Zestron/Kyzen
- Mostly Commercial Applications

Water Soluble

Solder paste flux residue MUST be removed
Shorter shelf life – Chemistry driven
Smaller process window
Mostly High Reliability – Military/Aerospace Applications
Solder Paste
What does a customer look for in a solder paste?

What do these terms mean?
Print Transfer
Volume of solder paste from stencil to the PCBs

- Determine the paste transfer efficiency for 1, 2, and 4 hour downtimes
- NO under-stencil wipe or solder paste kneading between prints or during the downtimes

Range of prints Speeds

Guidelines for Stencil Design

<table>
<thead>
<tr>
<th>Area Ratio For Square/Rectangular Apertures</th>
<th>Area Ratio For Circular Apertures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area Ratio = ( \frac{\text{Area Opening}}{\text{Area Walls}} )</td>
<td>Area Ratio = ( \frac{\text{Area Opening}}{\text{Area Walls}} )</td>
</tr>
<tr>
<td>Area Opening = ( L \times W )</td>
<td>Area Opening = ( \frac{\pi D^2}{4} )</td>
</tr>
<tr>
<td>Area Walls = ( 2t (L + W) )</td>
<td>Area Walls = ( \pi D t )</td>
</tr>
<tr>
<td>Area Ratio = ( \frac{2t (L + W)}{L \times W} )</td>
<td>Area Ratio = ( \frac{4t}{4t} )</td>
</tr>
</tbody>
</table>
8.9 Printing – Area Ratio = 0.62 (12 mil apertures) – Response to Pause
8.9 Print- Area Ratio = 0.5
8-mil Square & Circular Apertures

8 mil Square Aperture

8 mil Circular Aperture

[Graphs showing data for 8 mil Square Aperture and 8 mil Circular Aperture]
Print Transfer

~Variables that can affect the

• All in single instance...or combination...

1. Stencil Material
2. Board Support
3. Gasketing
4. Print Speed
5. Squeegee Pressure
6. Separation Speed
7. Print Alignment
8. ...

...
Head in Pillow
Non coalescence of BGA ball and solder paste

Causes failures of device at time zero AND in the field

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.
Head in Pillow
Non coalescence of BGA ball and solder paste

**eliminate 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

**Problem:**
- Properly placed ball in solder paste
- Heating creates warping
- Ball/paste separation
- Separate coalescence – defect formation

**Solved**

Temperature (°C)

0 50 100 150 200 250 300

Time (Min)

MP = ~217°
Ball Onto Paste Method to verify Oxidation Barrier

**Head-In-Pillow Test Method (Ball Onto Paste)**

- Ball prebaked @ 200°C for a given time
- Paste at soaking temp
- Ball placed onto molten solder dome at various intervals
- Paste get melted
- Well coalesced
- Head-in-pillow for paste with poor oxidation barrier

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Solder Ball Prebaked @ 200°C/25 min

Soaking Temperature of 200°C, soaking time VARIES @ (1, 2, 3, 4 min)
Paste stay @ Melting time (before ball drop) on VARIES

**Oxidation Barrier in the flux is the key to achieve good coalescence**
Graping Resistance
What is graping?

What is graping?
Solder powder oxide prevents proper coalescence. It looks like a bunch of grapes on top of the solder joint.

How does it happen?
1. Smaller paste deposits result in a higher relative surface area of exposed solder particles (and smaller particle sizes)
2. Higher temperatures and longer profiles required for Pb-free soldering
3. Premature flux spreading, leading to exposed particles that oxidize before peak temperature

approaches to eliminate graping:
- Appropriate flux chemistry reduces premature flux spread
- Unique oxidation barrier technology

Additional approaches to eliminate graping:
- Maximize aperture dimensions within known stencil design rules to insure the maximum deposited paste volume
- Use electro-form or electro-polished stencils
- 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
In Circuit Test (pin/probe testing)

- **In-circuit test (ICT)** is an example of where an electrical probe tests a populated printed circuit board (PCB).
- checking for shorts, opens, resistance, capacitance, and other basic quantities which will show whether the assembly was correctly fabricated.
- It may be performed with a bed of nails type test fixture and specialist test equipment, or with a fixtureless in-circuit test setup.

If flux does not ‘collect’ on the probe...
Less false positives' on the test machine
Less machine maintenance = more productivity!!
**High Speed Printing mm/Sec**

<table>
<thead>
<tr>
<th>Domestic Electronics</th>
<th>Infotainment</th>
<th>Consumable Electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Washer Machine</td>
<td>• Automotive</td>
<td>• Mobile Electronics</td>
</tr>
<tr>
<td>• Vacuum Cleaner</td>
<td>• Defence</td>
<td>• LCD Television</td>
</tr>
<tr>
<td></td>
<td>• Leisure</td>
<td></td>
</tr>
</tbody>
</table>

- Great flux design – hugely demanding on the chemistry
- Requirements:
  - Volume of PCBs
    - > 150mm / Sec
    - Low pressure
    - Small Apertures

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Voiding
Many types in SMT

- BGA – Microvia sites for void propagation

- Under Flat Bottom Terminated Component (QFN)
  - Flux Development has been key to reduce voiding
  - Profile adjustment will help
Voiding Mechanisms/cure

**Excessive oxidation (Process)**
- Minimize heat input prior to reflow / minimize soaking zone, or use linear ramp-up from ambient to solder melting temperature to reduce oxidation.

**Excessively oxidized SMT components**
- Check MSL and storage conditions of components / change component lot.

**Moisture ingress from PCB**
- Bake out PCB prior to assembly.

**Flux remnant too high in viscosity**
- Cooler reflow profile to allow more solvents in flux remnant.
Voiding Reduction SAC Soak Profile

- Linear Ramp of 1-1.5°C/sec from ambient to 180°C – 190°C
- Soak from 180/190°C to 210°C for 120 – 150 sec
- Peak temp ~ 255°C for 60 sec TAL
- No change in cool down

Temperature (°C) vs. Elapsed Time (min.)

- Hot Soak (2 min.)
- Cool Soak (1.5 min.)
- 255°C Peak Temperature 60 sec. above Liquidus
- Ramp-to-Peak (RTP) Reflow Profile
Pb Free Alloy
Alloy Choice – Ag%
Pb Free Alloy
Alloy Choice – Low Ag

• 8.9 Flux Platform Compatible with Low-Ag Solders
  o SAC 105 (1% Ag)
  o SAC 0307 (0.3% Ag)

Yeah, but is it reliable???
Pb-Free Alloy

Low Ag – Poor Thermal Cycling (compared to SAC 305)

ATC -40/125 °C with approx. 15 minute dwells.

Decrease of Ag content from 4% to 1% decreases the thermal fatigue life (first failure) by a factor of about 2.

Figure 8. ATC test data from Terashima showing the direct relationship between Ag content and thermal fatigue life [15].
Pb – Free Alloy (Low Ag)

Drop Testing: SAC 105 Better than SAC 305; SAC w/ Dopants Better than SAC 105

Drop Test Results of As-Reflowed Samples (Min, Max, 2X-StDev)

SAC w/ Dopants (Mn & Ti) > SAC 305 – this alloy was developed by Indium Corp

SAC w/ Dopants (Mn & Ti) has good thermal cycling as well as good drop performance
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 “LO” per IPC J-STD-004 does not indicate that materials are halogen-free; this merely indicates that ionic halide content is less than 500ppm.

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...
No Clean Pb Free Solder Paste

Pb-Free Assembly Materials
<table>
<thead>
<tr>
<th>Process</th>
<th>Metal Load (T3)</th>
<th>Metal Load (T4)</th>
<th>Flux Class</th>
<th>Halogen-Free (JEITA ET-7304)</th>
<th>Malcom Viscosity (poise)</th>
<th>Typical Tackiness (grams)</th>
<th>Ideal Print Speeds (mm/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indium8.9</strong></td>
<td>No-clean</td>
<td>88.50</td>
<td>88.25</td>
<td>ROL1</td>
<td>No</td>
<td>2000</td>
<td>50</td>
</tr>
<tr>
<td><strong>Indium8.9E</strong></td>
<td>No-clean</td>
<td>88.75</td>
<td>88.50</td>
<td>ROL1</td>
<td>No</td>
<td>1500</td>
<td>35</td>
</tr>
<tr>
<td><strong>Indium8.9HF-1</strong></td>
<td>No-clean</td>
<td>89.00</td>
<td>88.50</td>
<td>ROL0</td>
<td>Yes</td>
<td>1300</td>
<td>40</td>
</tr>
<tr>
<td><strong>Indium8.9HFA</strong></td>
<td>No-clean</td>
<td>88.50</td>
<td>88.00</td>
<td>ROL0</td>
<td>Yes</td>
<td>1300</td>
<td>50</td>
</tr>
<tr>
<td><strong>Indium9.0A</strong></td>
<td>No-clean</td>
<td>88.75</td>
<td>88.50</td>
<td>ROL1</td>
<td>No</td>
<td>1500</td>
<td>35</td>
</tr>
<tr>
<td><strong>Indium5.8LS</strong></td>
<td>No-clean</td>
<td>88.50</td>
<td>88.25</td>
<td>ROL0</td>
<td>Yes</td>
<td>1300</td>
<td>40</td>
</tr>
<tr>
<td><strong>Indium8.9HF</strong></td>
<td>No-clean</td>
<td>89.00</td>
<td>88.50</td>
<td>ROL0</td>
<td>Yes</td>
<td>1700</td>
<td>35</td>
</tr>
<tr>
<td><strong>Indium3.2</strong></td>
<td>Water-wash</td>
<td>88.50</td>
<td>88.00</td>
<td>ORM1</td>
<td>No</td>
<td>1750</td>
<td>50</td>
</tr>
<tr>
<td><strong>Indium3.2HF</strong></td>
<td>Water-wash</td>
<td>89.00</td>
<td>88.50</td>
<td>ORH0</td>
<td>Yes</td>
<td>2100</td>
<td>50</td>
</tr>
</tbody>
</table>

Circled Product = First Choices for General SMT
Feature = Which Paste
Pb Free solder paste Quick look up

What properties are most important to you?

- Eliminating head-in-pillow ➤ Indium8.9
- Eliminating grapig ➤ Indium8.9E
- In-circuit probe testing ➤ Indium8.9HF-1
- Superior printing for miniaturization ➤ Indium8.9HFA
- QFN voiding ➤ Indium9.0A

![Radar chart comparing properties of solder pastes](chart.png)
“The Pb-Free solder paste that performs like SnPb!”
“All of the performance characteristics you have come to expect in a SnPb solder paste.”

**UNIQUE FEATURES:**

**Defect Elimination**
- Eliminates head-in-pillow defects. Improves first-pass yields and reduces field failures when mounting BGA devices
- Low voiding. Less than 5% voiding for BGAs with via-in-pad technology, even when using a variety of profiles

**Printing**
- Designed for CSP, 0201, and 01005 technologies
- Excellent response-to-pause

**Reflow Capability**
- Accommodates high peak temperatures and long soak profiles
- Excellent wetting to all common finishes at high and low peak reflow temperatures

**In-Circuit Probe Testing**
- Clear, probe-testable flux residue

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<table>
<thead>
<tr>
<th>Alloy</th>
<th>Metal Load</th>
<th>IPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>96.5Sn/3.0Ag/0.5Cu (SAC305)</td>
<td>88.25% (Type 4)</td>
<td>800420</td>
</tr>
<tr>
<td>96.5Sn/3.0Ag/0.5Cu (SAC305)</td>
<td>88.5% (Type 3)</td>
<td>800449</td>
</tr>
</tbody>
</table>
8.9HF1 vs 8.9HFA Summary

**Indium 8.9HF-1**

- A high performance, halogen-free solder paste, designed for best-in-class probe-testability, delivering cost savings and the highest finished goods reliability.
- Unique features:
  - In-circuit probe testing:
    - Provides best-in-class probe-testability with few false rejects from in-circuit testing.
    - Extremely thermally stable; maintains soft, pliable residue, even after reflow.
  - Flux residue from Indium 8.9HF-1 does not collect on testing pins.

**Indium 8.9HFA**

- Superior printing capabilities – great for high speed printing and small apertures.
- Unique features:
  - Printing:
    - Offers unprecedented print transfer efficiency through small apertures at high print speeds.
    - Eliminates clogged apertures.
    - Excellent wetting on a variety of surfaces.
    - Eliminates hot and cold slump.

**Shared Characteristics:**

- Halogen-free
- Unique oxidation barrier technology:
  - No more head-in-pillow defects.
  - Strong oxidation barrier eliminates graping.
  - Low voiding (<5%) for many profiles when soldering BGAs with via-in-pad technology.
- Robust reflow capability:
  - Wide processing window accommodates various board sizes, throughput requirements, and minimizes potential defects.
  - Excellent soldering performance even with high temperatures and long reflow profiles.

**In-Circuit Testing (ICT) of Pb-Free Paste Residues**

<table>
<thead>
<tr>
<th>Typical paste</th>
<th>ICT fail with marginal resistance (per 1,000 boards)</th>
<th>ICT fail with high resistance (per 1,000 boards)</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Indium 8.9HF-1</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

**Indium 8.9HFA 0.4mm pitch CSP**

**Consistent Print Volumes**

**Print Transfer Efficiency**

- Indium 8.9HF-1
- Indium 8.9HFA

**HIP Resistance**

- Grappling Resistance
- Pin Testing
- BGA Voiding
- High Speed Printing
Halogen Free Solder Paste

- No-Clean Pb-Free Solder Paste
  - Indium 5.8LS
  - Indium 8.9HF1
  - Indium 8.9HFA

- Water Soluble Pb-Free Solder Paste
  - Indium 3.2HF

- No Clean Sn/Pb Solder Paste
  - Indium NC-SMQ92J

- Water Soluble Sn/Pb Solder Paste
  - Indium 6.3
3.2 Water Soluble Pb-Free

FEAT URES OF INDIUM 3.2

Printing
- Consistent fine-pitch print performance and transfer efficiency
- Excellent response-to-pause
- Tackiness sufficient for high-speed and high-mix SMT assembly
- Outstanding slump resistance

Defect elimination
- Superb wetting performance on a variety of substrates
- Low voiding
- Humidity resistance

Robust reflow capability
- Wide reflow window
- Effective in air or nitrogen environments

Cleaning
- Minimal foaming during cleaning
- Easily cleaned in warm, pressurized DI water
- Enhanced cleaning achieved with hot water or commercially available saponifiers

Wetting Comparison on Various Common Substrates
- Bare Cu
- OSP
- ENIG
- Immersion Ag

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PCBa – Pb Free
Complimentary product to paste

<table>
<thead>
<tr>
<th>Solder Paste</th>
<th>Flux Cored Wire</th>
<th>Tacky Rework Flux</th>
<th>Liquid Flux</th>
<th>PIP+ Preforms</th>
<th>Wave Flux</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.9</td>
<td>CW-807</td>
<td>TAC20B</td>
<td>FP-500</td>
<td>SAC 0603/0402</td>
<td>WF-9945, WF-7745</td>
</tr>
<tr>
<td>8.9HFA, 8.9HF1, 8.9HF</td>
<td>CW-802</td>
<td>TAC20B</td>
<td>FP-500</td>
<td>SAC 0603/0402</td>
<td>WF-9942, WF-7742</td>
</tr>
</tbody>
</table>

Our No-Clean Tacky & Liquid Rework fluxes Pass SIR Unactivated

| 3.2          | CW-301         | TAC25            | FP-300     | SAC 0603/0402 | 1081     |
PCBa complimentary product to paste

### TACFlux Products

<table>
<thead>
<tr>
<th>No-Clean</th>
<th>Typical Tackiness (g)</th>
<th>Typical Viscosity (kcps)</th>
<th>Max Temp (°C)</th>
<th>Reflow Residue (%)</th>
<th>Reliability J-Std-004</th>
<th>Halide-Containing</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>007</td>
<td>190</td>
<td>570</td>
<td>310</td>
<td>47</td>
<td>Pass</td>
<td>Y</td>
<td>RMA</td>
</tr>
<tr>
<td>010</td>
<td>232</td>
<td>67</td>
<td>450</td>
<td>4</td>
<td>Pass</td>
<td>N</td>
<td>Ultra-low residue, good for use with underfill; inert atmosphere required at high temperatures</td>
</tr>
<tr>
<td>020</td>
<td>175</td>
<td>470</td>
<td>250</td>
<td>45</td>
<td>Pass</td>
<td>N</td>
<td>Flux residue ideal for in-circuit testing since it will not clog crown probes</td>
</tr>
<tr>
<td>020B</td>
<td>250</td>
<td>800</td>
<td>260</td>
<td>45</td>
<td>Pass</td>
<td>N</td>
<td>Halogen-free; passes SIR without reflow; suitable for use with Pb-free and Pb-containing alloys</td>
</tr>
<tr>
<td>055</td>
<td>215</td>
<td>16</td>
<td>200</td>
<td>45</td>
<td>Pass</td>
<td>N</td>
<td>Halogen-free; ideal for use with low temperature BiSn and BiSnAg alloys</td>
</tr>
<tr>
<td>089</td>
<td>146</td>
<td>17</td>
<td>260</td>
<td>35</td>
<td>Pass</td>
<td>Y</td>
<td>Formulated for use with SAC solders; residue is clear and good for in-circuit testing</td>
</tr>
<tr>
<td>089HF</td>
<td>120</td>
<td>10</td>
<td>260</td>
<td>35</td>
<td>Pass</td>
<td>N</td>
<td>Halogen-free; formulated for use with SAC solders</td>
</tr>
</tbody>
</table>

**Water-Soluble**
Easily cleaned with DI water with spray pressure and elevated temperature

<table>
<thead>
<tr>
<th>Water-Soluble</th>
<th>Typical Tackiness (g)</th>
<th>Typical Viscosity (kcps)</th>
<th>Max Temp (°C)</th>
<th>Reflow Residue (%)</th>
<th>Reliability J-Std-004</th>
<th>Halide-Containing</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>025</td>
<td>550</td>
<td>850</td>
<td>370</td>
<td>47</td>
<td>Pass</td>
<td>N</td>
<td>Compatible with a wide variety of alloys</td>
</tr>
</tbody>
</table>

### Flux-Cored Wire

<table>
<thead>
<tr>
<th>Application</th>
<th>Recommended Flux %</th>
<th>Flux Classification</th>
<th>Halogen-Free</th>
<th>Contains Rosin</th>
<th>Low Odor</th>
<th>Solders Oxidized Copper</th>
<th>Solders Nickel</th>
<th>Solders Brass</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW-807</td>
<td>No-clean</td>
<td>1.25</td>
<td>ROL1</td>
<td>Yes</td>
<td>Yes</td>
<td>Best</td>
<td>Better</td>
<td>Good</td>
</tr>
<tr>
<td>CW-802</td>
<td>No-clean</td>
<td>1.25</td>
<td>ROL0</td>
<td>Yes</td>
<td>Yes</td>
<td>Best</td>
<td>Better</td>
<td>Good</td>
</tr>
<tr>
<td>CW-501</td>
<td>No-clean</td>
<td>2.00</td>
<td>ROL1</td>
<td>No</td>
<td>No</td>
<td>Good</td>
<td>Better</td>
<td>Good</td>
</tr>
<tr>
<td>CW-201</td>
<td>Solvent clean</td>
<td>2.00</td>
<td>ROM1</td>
<td>No</td>
<td>Yes</td>
<td>Better</td>
<td>Best</td>
<td>Best</td>
</tr>
<tr>
<td>CW-301</td>
<td>Water-soluble</td>
<td>3.00</td>
<td>ORH1</td>
<td>No</td>
<td>No</td>
<td>Better</td>
<td>Best</td>
<td>Best</td>
</tr>
</tbody>
</table>

### Liquid Rework Fluxes

- **No-Clean**
  - FP-500
  - NC-771
  - Passes SIR without heating

- **Water-Soluble**
  - FP-300
SnPb Series of Products
92 Series
NC-SMQ 92J

Probe-testable residue
Extended open time
No-Clean
Halide-Free

Strong initial tack strength and long-term stability
High humidity resistance
Air or N₂ Atmosphere
Fine Pitch Capability
SnPb Series of Products
92 Series
NC-SMQ 92H

- Compatibility with common conformal coatings
- Clear, benign residue
- Superior stencil life >12Hr
- Exceptional wetting in air reflow
- No-Clean
- Halide-Free
- Outstanding print characteristic
- Underside Stencil Wipe: Once every 10-25 prints
Low Temperature Solder Pastes

- Alloy Choices
  - Indium Based
    - Alloy considerations
  - Bismuth Based
    - Alloy considerations

- Complimentary Products
  - Tacfluxes
Indium Based Alloys

52In 48Sn (indalloy 1E) • Melting 118C

97In 3Ag (indalloy 290) • Melting 143C

100In (indalloy 4) • Melting 157C

INDIUM NC-SMQ80
In Based Solder Pastes NC-SMQ80

- No-clean residue
- Exceptional wetting in air reflow
- Halide-free
- 6 months at storage temperatures of -20° to +5°C.

Reduces leaching/scavenging of precious metals
Indium Alloy Consideration

- Avoid solders that contain In when soldering to Cu.
  - Indium and copper diffuse into one another forming a brittle inter metallic.
  - Nickel passivation (~4um) is enough to stop the metals diffusing
- Indium-containing solder is good for operating temperatures <125°C.
- Avoid solders that contain In when soldering to Sn or Sn/Pb.
  - It is possible for localized pockets of the InSn eutectic to form, which melts at 118°C.
Bismuth Based Alloys
Indium 5.7LT

Temperature

46Bi 34Sn 20Pb
(Indalloy 42)
Melting 96C

58Bi 42Sn
(Indalloy 281)
Melting 138C

57Bi 42Sn 1Ag
(Indalloy 282)
Melting 140C

Indium 5.7LT
Bismuth alloy considerations

- **Avoid Pb**
  - Bi and Pb will create a lower melting alloy

- **Indalloy 281**
  - Good low temp solder for electronics assembly or where Cd and Pb are to be avoided. Also good for thermo-electric applications.

- **Indalloy 282**
  - Bismuth based alloy - Ag used to give a better strength to the solder joint - Ag helps avoid Ag scavenging from the PCB (Where Ag is included).

- **Drop shock**
  - Not so good performance
Bi Based Solder Paste
Indium 5.7LT

- Pb-Free solution
- Formulated for use with the eutectic 58Bi/42Sn & 57Bi/42Sn/1Ag alloys
- Low activation temperature
- Low temperature

- Clear residue
- Exceptional wetting in an air reflow
- Halogen-free
- 6 months shelf life
Low Temperature solders
Complimentary Products

- **Solder wire**
  - Solid core
  - Name your dimensions

- **Solder Ribbon**
  - Name your dimensions...

- **TacFluxes**
  - Bi based alloys
    - 021 or 055
  - In based alloys
    - 012
Packaging – Tacky Fluxes

For hand dispensing of tacky fluxes, a thumb plunger can be used – *this is not airless pack*

For applications that use machine dispense, low-med-volume - Syringe with Wiper piston (to prevent flux bleed-out); Air-Free/Airless Pack – Best Effort (to minimize bubbles in flux)

For applications that use high volumes with machine dispense, call us – we have proprietary techniques to eliminate / minimize air bubbles (flux volume dependent)
Conformal Coating Defined

- Conformal Coating: “A type of protective coating for use on PCB assemblies. The conformal coating is intended to provide protection from moisture and contamination and provide electrical insulation”

- Types
  - Acrylic
  - Epoxy
  - Polyurethane
  - Silicon
  - Combinations of above
Definition of “Compatibility”

- There are **not any industry standard test methods** specifically aimed or written with regards to conformal coating **and** flux residue compatibility.

- Prospective users must satisfy themselves as to reliability of their finished assemblies.

- Some methods may include...
Industry Test Methods

- **IPC-CC-830B**
  - Conformal Coatings

- **IPC Test Methods**
  - SIR Conformal Coating
  - SIR Solder Paste Flux Residue
  - Peel/Adhesion Test Methods
  - Conformal Coating

- **Other Industry Test Methods exist**
  - Industry specific requirements
Industry Partners

- **Humiseal**
  - UK based
- **Lackwerke Peters**
  - Germany based
- **Other Companies are available...**
  - Dow Corning
  - Electrolube
Design of Experiment

• In Conjunction with HumiSeal and Peters
• Testing Compatibility between No-Clean Flux Residues and Conformal Coating
• A matrix of products has been established based on best picks from companies.
Design of Experiment Matrix - Materials

• 6 Solder Pastes
  • SnPb
    – NC-SMQ92H / 8.9HF SnPb
  • SAC305
    – 5.1AT / 5.8LS / 8.9 / 8.9HF

• 5 Conformal Coatings
  • Humiseal
    – 1R32A-2 / UV40-250
  • Peters
    – SL 1301 / SL 1307 / 1600 E

• 30 potential pairings!!
Summary of Findings

• After...
  – Global Applications Engineering co-operation
  – Over 100 test coupons prepared & processed
  – 168 hours under test conditions

• We have identified pairings
  – Acrylic/Acrylate conformal coating formulations work best
Summary of Findings

- **Indium and Humiseal**

Humiseal 1R32A-2 85C/85RH 50V 7days

<table>
<thead>
<tr>
<th>Solder paste variant</th>
<th>Log Ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>92H</td>
<td>9.69</td>
</tr>
<tr>
<td>5.8LS</td>
<td>9.74</td>
</tr>
<tr>
<td>5.1AT</td>
<td>9.4</td>
</tr>
<tr>
<td>8.9</td>
<td>8.54</td>
</tr>
<tr>
<td>8.9HF SAC</td>
<td>9.62</td>
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<tr>
<td>8.9HFSn63</td>
<td>9.17</td>
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</tbody>
</table>

- IPC Pass/Fail Log Ohm
  > 8.00
Summary of Findings

- Indium and Peters

Peters 1307 85C/85RH 50 V 3days

<table>
<thead>
<tr>
<th>Solder paste variant</th>
<th>Log Ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>92H</td>
<td>9.73</td>
</tr>
<tr>
<td>5.8LS</td>
<td>9.91</td>
</tr>
<tr>
<td>5.1AT</td>
<td>9.05</td>
</tr>
<tr>
<td>8.9</td>
<td>9.32</td>
</tr>
<tr>
<td>8.9HF SAC</td>
<td>9.54</td>
</tr>
<tr>
<td>8.9HFSn63</td>
<td>9.12</td>
</tr>
</tbody>
</table>

- IPC Pass/Fail Log Ohm
  > 8.00
Summary of Findings

- **Results show no incompatibility under the conditions of test.**
- The product combinations are therefore good candidates for use on finished assemblies, but prospective users must satisfy themselves as to reliability of their finished assemblies taking into account actual service conditions and levels of workmanship required to ensure integrity of a coating on fully assembled circuit boards.
Advanced Technology
Package-on-Package (PoP) Assembly Materials
Introduction

Package-on-Package (PoP) and System-in-Package (SiP) are an exciting new technology that allows standard SMT assembly techniques to be used to manufacture combinations of different integrated circuits. For example, different types of memory may be used in combination to provide both DRAM and Flash in the same package for use in a cell phone.
Advanced Technology PoP

PoP Technology Basics
As devices shrink in size and expand in functionality, the capability to sequentially stack packages is becoming crucial. For instance, it is often useful to stack a PBGA memory chip on top of a logic package. Indium Corporation provides a variety of products to optimize your PoP process.

Material Requirements for Performance
- Appropriate for application by dipping
- Stable viscosity over time in dipping machinery with continuous smoothing
- Homogeneous – particle/crystal/bubble-free
- No cleaning of residue required
- Good wetting to a variety of pad metallizations and alloys
- Air reflow – stable for multiple refows

Effect of I/O Count and Paste Type on Amount of Paste Retained on Sphere During Dipping

- 8.9 (SMT)
- 9.86HF
- 5.79

PoP pastes – optimized for dipping applications
Advanced Technology
PoP

PoP Paste vs. PoP Flux

Choose PoP Flux if:
- Packages are small and rigid
- Warpage is not likely and thermal expansion is uniform for packages and substrate
- Solder contained in package solder balls is sufficient for strong joints

Choose PoP Paste if:
- Packages are prone to warping
- Printed PCBAs are being used as they are not typically as rigid
- “Crocodiling” is evident – top package is only reflowing to form joints along one side
- Head-in-pillow defects are a concern
- Additional solder will insure reliability of solder joints and provide assurance that connections will be made regardless of possible package warping

PoP Fluxes are suitable for stacking CBGAs and small PBGAs, which are not subject to flexing.

PoP Pastes are useful when board flexing may occur during reflow, such as larger PBGAs. The presence of a small amount of metal powder allows complete reflowed joints to form, even when the substrate twists and gaps form between the solder sphere and the substrate.
Advanced Technology PoP

### PoP Products

**FLUXES**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Application Method</th>
<th>Flux Designation</th>
<th>Halogen-Free*</th>
<th>Residue Level %</th>
<th>Typical Viscosity (kcps)</th>
<th>Typical Tack (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoP Flux 030B</td>
<td>Dipping &amp; Dispense</td>
<td>ROLO</td>
<td></td>
<td>~41%</td>
<td>130 (Brookfield)</td>
<td>140</td>
</tr>
<tr>
<td>PoP Flux 89HFLV</td>
<td>Dipping &amp; Dispense</td>
<td>ROLO</td>
<td></td>
<td>~35%</td>
<td>8.5 (C&amp;P - 5min)</td>
<td>170</td>
</tr>
</tbody>
</table>

**PASTES**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Application Method</th>
<th>Flux Designation</th>
<th>Halogen-Free*</th>
<th>Residue Level (% of Paste)</th>
<th>Typical Viscosity (kcps)</th>
<th>Typical Tack (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PoP Paste Indium5.79 (for SAC305 only)</td>
<td>Dipping - BGA Repair</td>
<td>ROLO</td>
<td></td>
<td>~7%</td>
<td>270</td>
<td>90</td>
</tr>
<tr>
<td>PoP Paste Indium9.88HF</td>
<td>Dipping &amp; Dispense</td>
<td>ROLO</td>
<td></td>
<td>~8%</td>
<td>250</td>
<td>65</td>
</tr>
</tbody>
</table>

*No intentionally added halogens.*
Considerations when using Engineered Solder
Alloy selection depends on:

- **Temperature Constraints**
  - What is the max operating temp / reliability testing temp?

- **End-Reliability Requirements**
  - Au/Sn is the strongest solder (highest tensile & shear strength)
  - In-containing alloys are ductile – takes care of CTE mismatch
    - great for heat transfer
  - Bi-containing alloys are brittle and are not suitable for drop / vibration applications
Alloy selection depends on:

- **Metallization thickness** - If Au thickness exceeds 15 microinches (0.381 microns)
  - only Au & In-containing alloys recommended, as IMC (intermetallic) growth is less – good for solder joint
  - Sn-based alloys if used will cause excess IMC & make the joint brittle & fail

- **Step Soldering Operations**
Alloy selection depends on:

Step Soldering

• Multiple Sequential Solder Operations
• Cannot re-melt existing solder joints
• Alloy Selection - ▲ T of 30-50C between melting point of higher-temp alloy & max reflow temp of older lower-temp alloy
• Example – Au/Sn (280C); Sn/Ag (221C); In/Pb/Ag (154C)
Engineered Solder Products

- Available in a variety of electronic grade alloys that meet customer needs
- Available in numerous forms:
  - Preforms & Integrated Preforms
  - Clad preforms
  - Ribbon*
  - Solid* & Flux cored wire
  - Foil
  - Spheres
  - Shot
  - Ingot

*Available as research kit
Preform Types

- Discs
- Frames
- Squares
- Rectangles
- Washers
- Split Rings
- Spheres
- Arrays
- Special
Solder Preforms vs Solder Paste

• Paste by its very definition has 50% flux by volume. Flux causes
  – Outgassing / Voiding
  – Potential cleaning issues with more flux residue

• Some aggressive metallizations need unique standalone fluxes that cannot be used as paste flux for rheology
  – Eg. Soldering to Aluminium

• For non-planar substrates, placing a preform is easier than depositing paste
  – Eg. Soldering in cavity setup
Preform Benefits:

The same solder joint is made over and over again.

- Many copies in each Reflow Cycle
- Exact Amount of Solder Every Time
- No Scrap
- Flux-less Soldering
- Highly Reproducible
- Solder Hidden Areas
- Solve Non-Planar Problems
- Low to no voids
Preforms Manufacturing Process:

Material Flow

- Ingot Cast
- Extrusion
- Punch
- Preform
- Packaging
Preforms Manufacturing Process:

• **Billet Cast**
  - Alloy purity determined
  - Alloy lot-number assigned
  - Form and size designed for extrusion press

• **Extrusion**
  - Billet pressed into flat ribbon
  - This is an intermediary process
    - final ribbon thickness is determined at rolling
Preforms Manufacturing Process:

Punch

- Die technology determines the X-Y dimensional tolerance
- Our knowledge of alloy properties is critical to our success in punch
  - Die design
  - Release mechanism
  - Handling
Preforms Manufacturing Process:

Package, Label & Ship

• Many alloys and forms are soft so proper packaging is critical to avoid damage

• Packaging design is important to proper integration with customer processes (especially tape & reel)
Key Success Factors:

• Purity
• Dimensional Precision & Consistency
• Surface Characteristics
  – Cleanliness
  – Low Oxide
  – Flatness
• Packaging
Preform Packaging:

- Bulk
- Stack pack
- Layer pack
- Tape and reel
- Waffle pack
- Custom packaging
Preform Packaging – Jar or Bulk Pack:
Preform Packaging – Tape & Reel:
Preform Packaging – Layer Pack:
Preform Packaging – Stack & Waffle Pack:
Preform Packaging – Tray Pack:
Integrated Preforms

- Provides exact solder volume
- Special shapes
- Made from Indium, Tin, Lead, Silver or alloy combinations of these.
- Thickness range from 0.005” (0.127 mm) to 0.018” (0.457 mm)
- Reduce process steps
- Standard Sheet Size is 5” (125 mm) x 9” (225 mm)
Preform Flux Coatings

- Controlled solder volume
- Controlled flux quantity 1-3% (No manual flux application)
- Lesser voids

<table>
<thead>
<tr>
<th>FLUX</th>
<th>IPC CLASSIFICATION</th>
<th>SUBSTRATE FINISHES</th>
<th>RELIABILITY J-STD-004</th>
</tr>
</thead>
<tbody>
<tr>
<td>NC-7</td>
<td>ROL0</td>
<td>Au,Ag,Pd,Pt,Cu</td>
<td>Pass</td>
</tr>
<tr>
<td>NC-9</td>
<td>ROL1</td>
<td>Sn,NiAu,SnPb,Cu</td>
<td>Pass</td>
</tr>
<tr>
<td>R</td>
<td>ROL0</td>
<td>Au,Ag,Pd,Pt</td>
<td>Pass</td>
</tr>
<tr>
<td>RMA</td>
<td>ROL0</td>
<td>Sn,NiAu,SnPb,Cu</td>
<td>Pass</td>
</tr>
<tr>
<td>RA</td>
<td>ROL1</td>
<td>Cu,Ni, Cu Alloys (Brass, Bronze)</td>
<td>Cleaning Recommended</td>
</tr>
<tr>
<td>RSA</td>
<td>ROL1</td>
<td>Cu,Ni, Cu Alloys (Brass, Bronze)</td>
<td>Cleaning Recommended</td>
</tr>
</tbody>
</table>
USB Device needs 150µ thick paste deposit, but other components need lesser paste.

0402 Preform Fortification

Image Source: Motorola, Flensburg
Preform Fortification – Surface Mount Component

Comparison

Without Preform

With Preform
Preform Fortification – Through Hole Component – Pin In Paste
Common Stencil Designs for Pin In Paste
Placing Preforms at Pin In Paste

- Preforms are packaged in Tape and Reel
- 0603, 0402 and 0201 size
- Pick and Place equipment
Pin In Paste Results

- Preforms placed in Paste
- Observable Fillet
- 360° circumferential wetting
- IPC-B-610 Class 3
- Pin OD = .0235”
Engineered Solder Preforms
PCBA: Preforms-in-Paste (Solder Fortification®)

Solder Fortification® in Tape and Reel

Without Preform

With Preform

Without Preform

With Preform

Without Preform

With Preform
Preform – RF Shield Attach

Depending on the paste outline, preforms can be engineered to sit in the gaps or on the sides of the shield on top of solder paste:
- 0.015” cubes
- Horse-shoe
- Longer preform strips
Fuse for Automotive Blower Motor – Special Shape “Horse Shoe”
Headlamp

Washer Preform Flux Coated
Mounting of Flex Circuits to Connector

Integrated Preforms (Connected Washers) or separate washers are used
Circular Connector Assembly

Integrated Preform
Pacemaker Assembly

Integrated Preform
Flux-Coated Preform- Fiber-Optic Application

Soldering a fiber optic wire to the housing using flux-coated preforms
Flux Coated Preform – Void Reduction for RF Power Amp

- **Challenge:** Void (>30%) & variability when using paste in convection reflow
- **Goal:** Voiding under PA < 20%

LDMOS Device with paste attach (gray color)

Voiding > 30%

The MRF7538075H LDMOS FET delivers 16 W average power with 13 dB gain and 18 percent power-added efficiency when operating under WiMAX modulated conditions at 3.5 GHz.
Flux Coated Preform – Void Reduction for RF Power Amp

- Challenge: Void (>30%) & variability when using paste in convection reflow
- Goal: Voiding under PA < 20%

LDMOS Device with NC-9 flux-coated preform attach (blue color)

Voiding < 20%
Flux Coated Preform – QFN Void Reduction

- Flux-Coated preform
- Way lesser flux when compared to solder paste

Void reduced from 40% to under 20%
Thank you!