**PRODUCT DATA SHEET**

**WS-446HF Flux**

**Introduction**

WS-446HF Flux is a robust, halogen-free, water-wash flux that was designed to provide one simple solution to complicated applications, especially those with a single cleaning step for both BGA ball-attach and flip-chip processes. It has a powerful activator system to promote good wetting on even the most demanding substrate metalizations such as Cu OSP, ENEPIG, and ENIG. Its rheology is suitable for dipping flip-chip applications, as well as pin transfer or printing BGA ball-attach applications, for sphere sizes 0.25mm and above. WS-446HF helps to improve production yield by minimizing non-wet-open defects, missing balls, and electrochemical migration (ECM).

**Features**

- Designed for flip-chip dipping and BGA ball-attach pin transfer/printing applications
- Promotes excellent solderability and wetting on a wide range of surfaces
  - Good results on AuNi and even on oxidized Cu OSP (up to 0.3mm thick OSP)
- Cleans well with room temperature DI water
  - Saves money on water heating
  - Avoids formation of white residue
- Eliminates ECM or dendrite formation caused by residue
- Designed for Pb-free applications
  - Suitable for all high-tin solders
- Halogen-free — per IPC and IEC specifications
- Ensures consistent joint quality by providing consistent dipping, pin transfer, and printing performance over extended periods
- Promotes strong, low-voiding joints
- Minimizes die skew, non-wet-open, and “missing balls”
  - Maintained tackiness during heating results in faster soldering
- Eliminates warpage due to “prefluxing” with lower process costs
- Reflows in air or nitrogen
- Stable at room temperature for up to 1 year
  - Ease of storage and use without crystals or gel balls
  - Ready to use, straight from the jar or cartridge

**Cleaning**

WS-446HF residue can be cleaned with DI water, or water with an added cleaner. Ideal conditions for spray-cleaning: 25°C (room temperature) to 40°C for >1 minute at 60psi or higher.

**Packaging**

WS-446HF is available airlessly packaged in 10 and 30cc syringes, and is also available in jars or cartridges, on customer request.

**Storage**

For maximum shelf life, WS-446HF syringes and cartridges should be stored tip down. Storage temperatures should not exceed 30°C. If using cold storage, WS-446HF should be allowed to stand for at least 4 hours at room temperature before using.

**Technical Support**

Indium Corporation sets the industry standard in providing rapid response, onsite technical support for our customers worldwide. Indium Corporation’s team of Technical Support Engineers can provide expertise in all aspects of materials science and semiconductor packaging process applications.

**Safety Data Sheets**

The SDS for this product can be found online at http://www.indium.com/sds
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WS-446HF Flux

Flip-Chip Application

**WS-446HF** is intended to be used in an air or nitrogen reflow environment of 50ppm oxygen or less. **WS-446HF** can be used on many surface finishes. **WS-446HF** has been developed to allow tin and tin/silver solder bumps, in both standard bump shapes and as microbumps on copper pillars, to solder well to any quality of substrate metallization. **WS-446HF** also allows poor-quality OSP to be soldered to, without non-wet open solder joints.

Flip-Chip Flux Dipping Process

The dipping depth should be adjusted to exact needs. Guidelines are given in the illustration below. The flux reservoir (dip tray) should be cleaned and replenished every shift.

![Dipping Depth Diagram](image)

Properties

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Viscosity</td>
<td>21k cps (5 minutes)</td>
<td>Brookfield HB DVII+CP @ 5 rpm</td>
</tr>
<tr>
<td>Typical Acid Number</td>
<td>93mg KOH/g</td>
<td>Titration</td>
</tr>
<tr>
<td>Typical Tack Strength</td>
<td>310g</td>
<td>J-STD-005 (IPC-TM.650: 2.4.44)</td>
</tr>
<tr>
<td>Shelf Life</td>
<td>12 months at 0–30°C</td>
<td>Viscosity change/microscope exam</td>
</tr>
</tbody>
</table>

Industry Standard Test Results and Classification

<table>
<thead>
<tr>
<th>Flux Classification</th>
<th>ORH0*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on the testing required by IPC J-STD-004A.</td>
<td></td>
</tr>
</tbody>
</table>

| Halogen-free per     | <900ppm Cl             |
| IEC 61249-2-21,      | <900ppm Br             |
| Test Method EN14582  | <1,500ppm total        |

Ball-Attach Application

**WS-446HF**’s special activator package promotes good wetting on the most demanding surfaces such as Cu OSP. Typically, ball-attach for BGA application is the last step in the assembly process as, at this stage, the pads have gone through multiple heat cycles, wash cycles, etc. These pads are therefore heavily oxidized or contaminated, which affects the solderability of the sphere onto the pad. Good wetting performance of the flux is necessary to ensure final strong joints.

**WS-446HF** proves to be a true single-step ball-attach flux to eliminate the preflux process, thus to avoid the costly, wasteful, and warpage-inducing effects.

The “Standard Ball-Attach Process” diagram shows the typical two-step flux processing that is needed to create reliable, ball-to-pad joints from final BGA balling. The prefluxing step can only be eliminated if the flux has sufficient activity to overcome the extent of the oxidation on copper, and create strong solder joints.

Ball-Attach Process

![Ball-Attach Process Diagram](image)

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**WS-446HF Flux**

**Proven Flux Rheology Consistency**

**Viscosity Test Method**
- **Equipment**
  - Brookfield Cone & Plate
  - Model: DV3THBCB
- **Parameters**
  - Spindle: CP-51
  - Temperature: 25°C
  - Rpm: 10rpm

**Tack Test Method**
- **Equipment**
  - Texture technologies TA.XT2
- **Parameters**
  - Ambient conditions
  - Humidity: 50% ± 3%
  - Room temperature: 21.5°C ± 2°C

**Viscosity as a Function of Time**

*Viscosity Controls*

- Shear stress $\tau = F / (B \cdot Y)$
- Shear $\gamma = X / Z$
- Shear rate $\dot{\gamma} = \Delta \gamma / \Delta t$

**Tack as a Function of Time**

**Consistent Flux Rheology Over Time**

WS-446HF’s consistent viscosity and tack ensure uniform flux volume on all solder joints. This assures consistent joint quality and a consistent process for better control over time.

- **Flip-chip application**
  - Holds die in place, minimizing die skew and non-wet open defects
- **Ball-attach application**
  - Holds spheres well to eliminate “missing ball”

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WS-446HF Flux

Reflow

Recommended Profile

WS-446HF is suitable for air and nitrogen reflow, and can work well in a variety of reflow profiles.

Reduce Open Joint

- Good wetting
- Good tack to hold FC die in place even though there is warpage issue

Increase Joint Strength

Joint strength is high due to good wetting. From the solderability testing results, the spreading ratio of WS-446HF is excellent even on a heavily oxidized Cu test coupon. This ensures the solder bump or sphere has good wetting even on demanding surfaces.

\[
S_R = \frac{D - H}{D} \times 100 \; \; \; \text{.................. (16)}
\]

where, \( S_R \): spreading ratio (%)
\( H \): height of the spread solder (mm)
\( D \): diameter of the solder, when it is assumed to be a sphere (mm)
\( V = 1.24V^{1/3} \)

\[
V = \frac{\text{mass (12)}}{\text{density of tested solder}}
\]

Solderability Test Method

- Print flux onto metalized surface
- Place spheres onto flux deposit
- Reflow (air or \( N_2 \), typical)
- Measure reflowed height deposit
- Calculate spreading ratio (wetting)

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WS-446HF Flux

Cleaning

FIB (Focused Ion Beam) and SIMS (Secondary Ion Mass Spectrometry) Analysis on Cu OSP Substrate

Fresh Cu OSP Substrate

Cu OSP Substrate after WS-446HF Flux Clean

Cleaning Test
• Very mild (forcing) condition
  − Deionized water
  − Deionized water conductivity ≤1.00μS/cm
  − Zero pressure
  − Flow rate 5cc/minute

Simplified, Low-Cost Cleaning
WS-446HF is cleanable with room temperature deionized (DI) water only, eliminating chemical cleaning costs and costs of heating water.

Eliminate Dendrite
• Good cleanability with non-conductive residue

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**WS-446HF Flux**

Heterogeneous Integration & Assembly Materials

- 3D Logic / Memory and Flip-Chip
  - Wafer Bumping (Bump Fusion) Flux
  - Flip-Chip Flux
- System-in-Package
  - Wafer-Level Ball-Attach Flux
  - Ultrafine-Pitch Solder Paste
- Ball Grid Array
  - Ball-Attach Flux
- Lidded MEMS
  - Dispensable Fine-Pitch Solder Paste

### Recommended Semiconductor Fluxes and Solder Pastes

<table>
<thead>
<tr>
<th>Material Group</th>
<th>Material Type</th>
<th>Material Name</th>
<th>Flux Type</th>
<th>Halogen-Free</th>
<th>Application</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FLUX</strong></td>
<td>Wafer Bumping Flux</td>
<td>WS-3543</td>
<td>Water wash</td>
<td>Yes</td>
<td>Spin coating</td>
<td>High viscosity for taller copper pillars and larger bumps (&gt;40 microns)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WS-3401</td>
<td>Water wash</td>
<td>Yes</td>
<td>Spin coating</td>
<td>Low viscosity for smaller pillars and bumps</td>
</tr>
<tr>
<td></td>
<td>Flip-Chip Flux</td>
<td>WS-446</td>
<td>Water wash</td>
<td>No</td>
<td>Dipping</td>
<td>Best flux for poor solderability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WS-688</td>
<td>Water wash</td>
<td>Yes</td>
<td>Dipping (can be sprayed at 85ºC)</td>
<td>Minimizes voiding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NC-26-A</td>
<td>Ultra-low residue no-clean</td>
<td>Yes</td>
<td>Dipping</td>
<td>Best compatibility with CUF/MUF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NC-26S</td>
<td>Ultra-low residue no-clean</td>
<td>Yes</td>
<td>Dipping</td>
<td>Avoids capillary flow up to die surface for fine-pitch devices</td>
</tr>
<tr>
<td></td>
<td>Flip-Chip &amp; Ball-Attach Flux</td>
<td>WS-446HF</td>
<td>Water wash</td>
<td>Yes</td>
<td>Dipping</td>
<td>Best all-around halogen-free flip-chip and ball mount flux, easily cleaned</td>
</tr>
<tr>
<td></td>
<td>Ball-Attach Flux</td>
<td>WS-446-AL</td>
<td>Water wash</td>
<td>No</td>
<td>Pin transfer</td>
<td>Best flux for poor solderability</td>
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<tr>
<td></td>
<td></td>
<td>WS-575-C</td>
<td>Water wash</td>
<td>Compliant</td>
<td>Pin transfer</td>
<td>Eliminates the prefluxing step for OSP</td>
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<tr>
<td></td>
<td></td>
<td>WS-823</td>
<td>Water wash</td>
<td>Yes</td>
<td>Pin transfer</td>
<td>Best all-around halogen-free ball-attach flux, easily cleaned</td>
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<tr>
<td></td>
<td></td>
<td>WS-759</td>
<td>Water wash</td>
<td>Yes</td>
<td>Printing</td>
<td>Stable printing flux for wafer-level and panel-level packaging (WLP and PLP)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material Group</th>
<th>Material Type</th>
<th>Material Name</th>
<th>Flux Type</th>
<th>Halogen-Free</th>
<th>Alloy</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SOLDER PASTE</strong></td>
<td>Die-Attach Solder Paste</td>
<td>SMQ75</td>
<td>No-Clean (“Power-Safe”)</td>
<td>Yes</td>
<td>All high-Pb and Sb-containing alloys</td>
<td>Ultra-low residue “Power-Safe” no-clean paste suitable for clip-bonded devices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMQ51-SC</td>
<td>Solvent clean</td>
<td>No</td>
<td>BiAgX® mixed alloy system</td>
<td>High-temperature Pb-free solder paste</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BiAgX®</td>
<td>Solvent clean</td>
<td>Yes</td>
<td>BiAgX® mixed alloy system</td>
<td>High-temperature Pb-free solder paste</td>
</tr>
<tr>
<td></td>
<td>Sip Solder Paste</td>
<td>Indium3.2HF</td>
<td>Water wash</td>
<td>Yes</td>
<td>SAC365 and other Pb-free alloys</td>
<td>Type 6-SG solder paste suitable for ultrafine-pitch printing Designed for 01005 and smaller discrete devices</td>
</tr>
</tbody>
</table>

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