ELECTRONIC ASSEMBLY MISPRINT CLEANING ADVANCEMENTS

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INTRODUCTION

Misprint Circuit Assemblies

- Cleaning misprints is a production gap
- Commonly cleaned in stencil cleaning equipment
- Stencil Cleaning equipment allows for the
  - Collection and filtration of wet solder paste
- Stencil Cleaning equipment short comings
  - Inability to clean B-Side misprints
  - Poor rinse quality

Research Purpose

- Validate new cleaning equipment innovations
  - Clean misprint assemblies in production cleaning equipment
  - Batch and inline production cleaning equipment

REWORKING/CLEANING MISPRINTED ASSEMBLIES

Stencil Printing

- Highly automated process
- During machine setup
  - Small group of boards are misprinted
- During production stencil printing
  - PCBs periodically misprinted due to
    - Clogged apertures
    - Stencil out of alignment
    - Solder paste rheology shifts
    - Other issues

Stencil Misprints

- A-Side
  - Initial print out of alignment with no components previously placed
- B-Side
  - A-Side was successfully printed and components placed and soldered
  - The subsequent process of printing the B-Side results in the solder paste being out of alignment resulting in a B-Side misprint

PCB Misprints

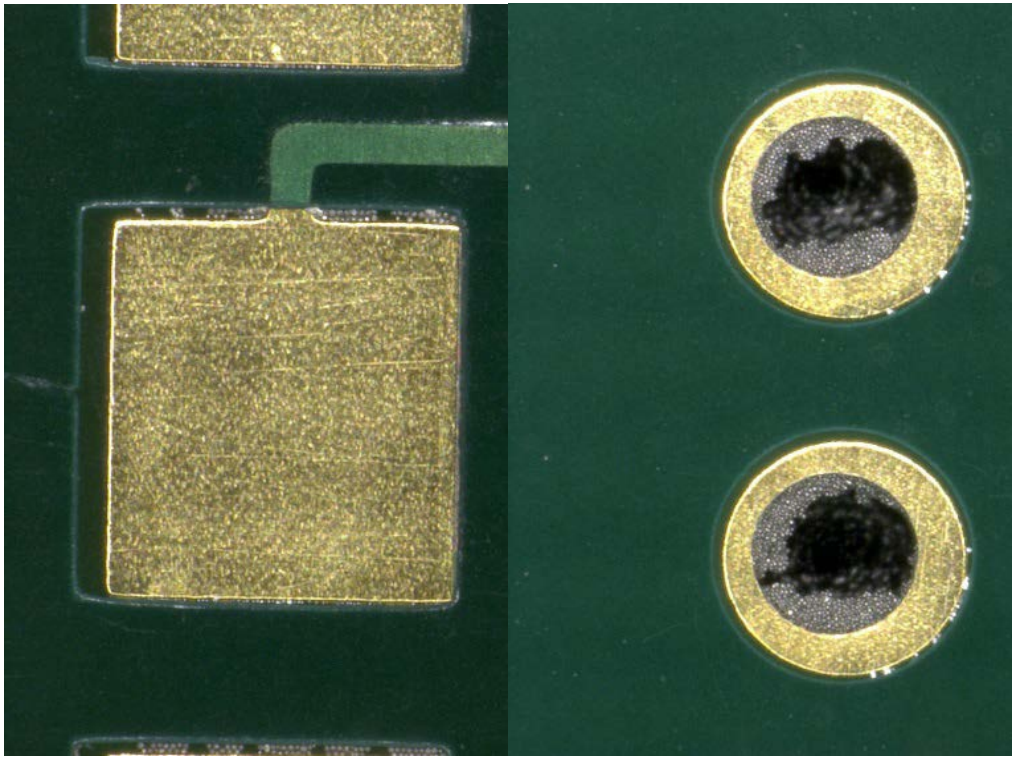
- A costly problem
- No easy rework methodology
- Production cleaning processes
  - Normally not used to clean misprint assemblies
- Potential quality issues
  - Solder balls collecting into the wash tank and being transferred back onto the assembly
  - Solder balls migrating into the rinse streams resulting in hazardous waste from metals in the wash and rinse holding tanks

Misprint Cleaning Complexities

- Potentially compromise repeatability and reliability standards
- Due to these complex issues
  - Most assembly houses do not allow misprints to be cleaned within their production cleaning process

Misprint Cleaning Practices

- Hand wiping the misprinted side of the circuit card
- Clean the misprint in a stencil cleaning machine



MISPRINT CLEANING INNOVATIONS

Production Cleaning Processes

- Potential to clean
  - Wet solder paste
  - Reflowed flux residues
  - Meet quality and Yield objectives

Problem Statement

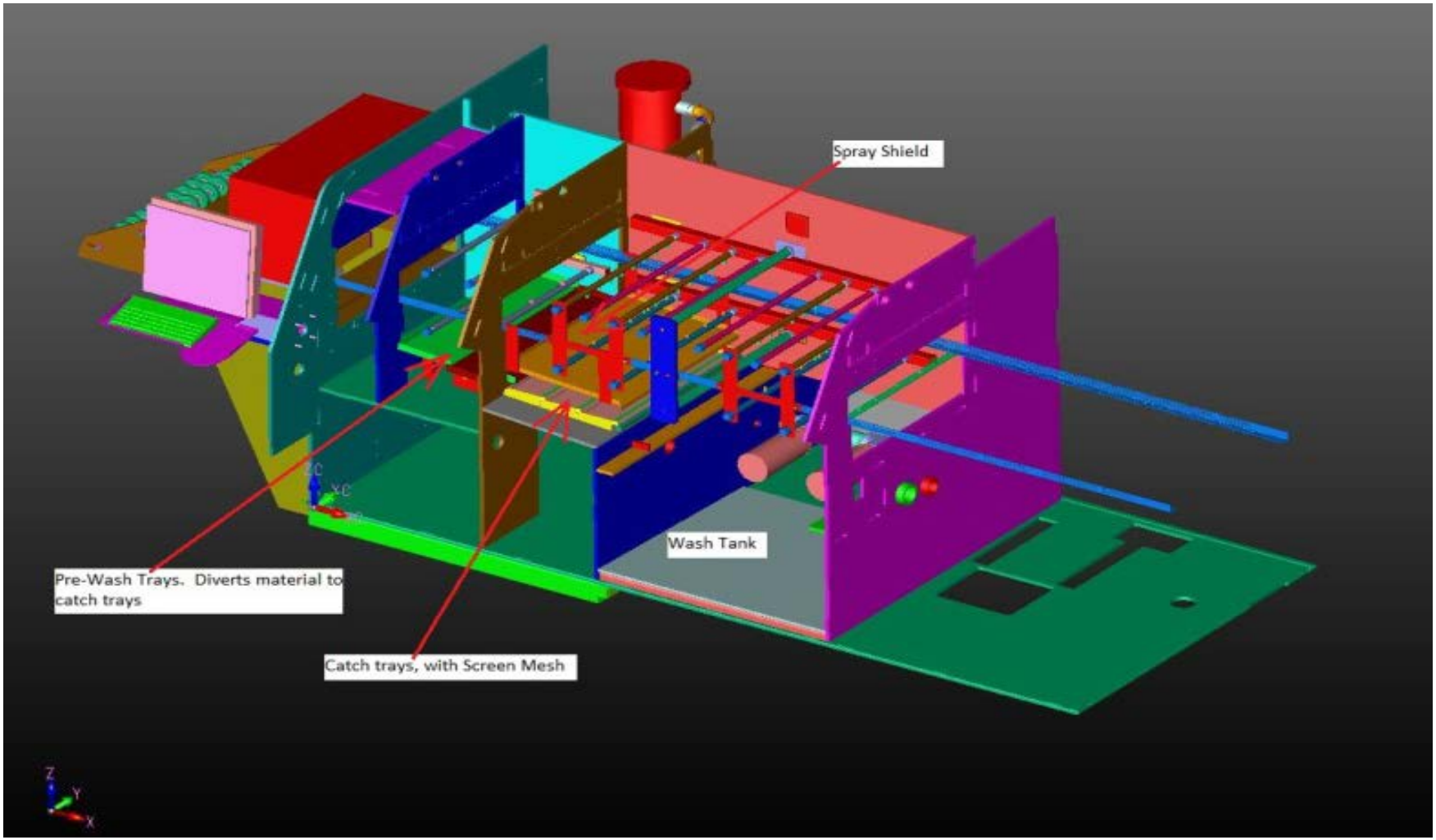
- Cleaning wet solder paste in production cleaning tools
  - Solder Spheres collect in the wash holding tank
  - Solder spheres can be picked up by the pump inlet
  - Sprayed onto assemblies
  - Dragged into the rinse sections
  - Quality and Waste Treatment issues result

Process Solution

- Clean within production equipment
- Collection and filtration methods
  - To collect and filter solder spheres
- Contains the solder spheres
- Mechanical filtration systems
- Prevents solder balls from being pumped through spray manifolds

INLINE CLEANING MACHINE DESIGN

Inline Wash Module



Pre-Wash Section

Pre-Wash Section

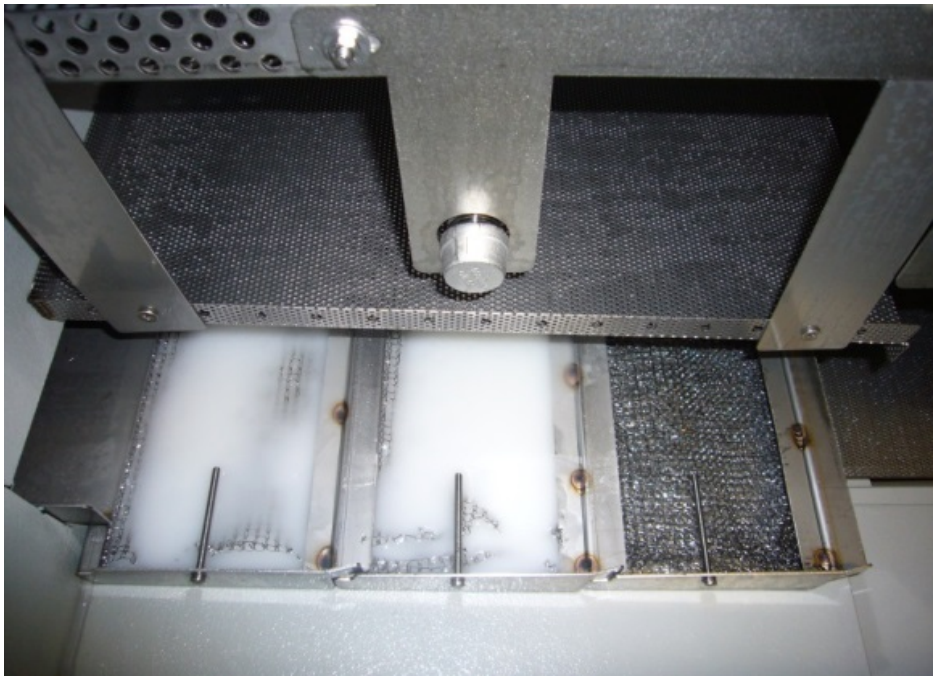
- Designed to wet
- Elevate the circuit board to wash temperature
- Soften reflowed flux residues
- Remove wet solder paste
  - Raw solder paste cleans easier than does reflowed flux residues
  - An S-Jet™ spray nozzle design
  - Displaces greater than 90% of the solder paste on a misprint circuit board

Pre-Wash Section

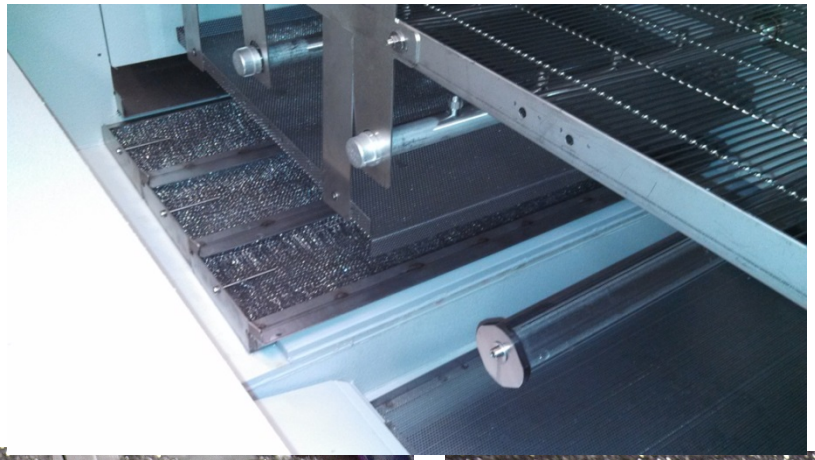
- Deflectors that contain the raw solder paste
- Close in the pre-wash spray manifolds
- Prevent solder spheres from escaping

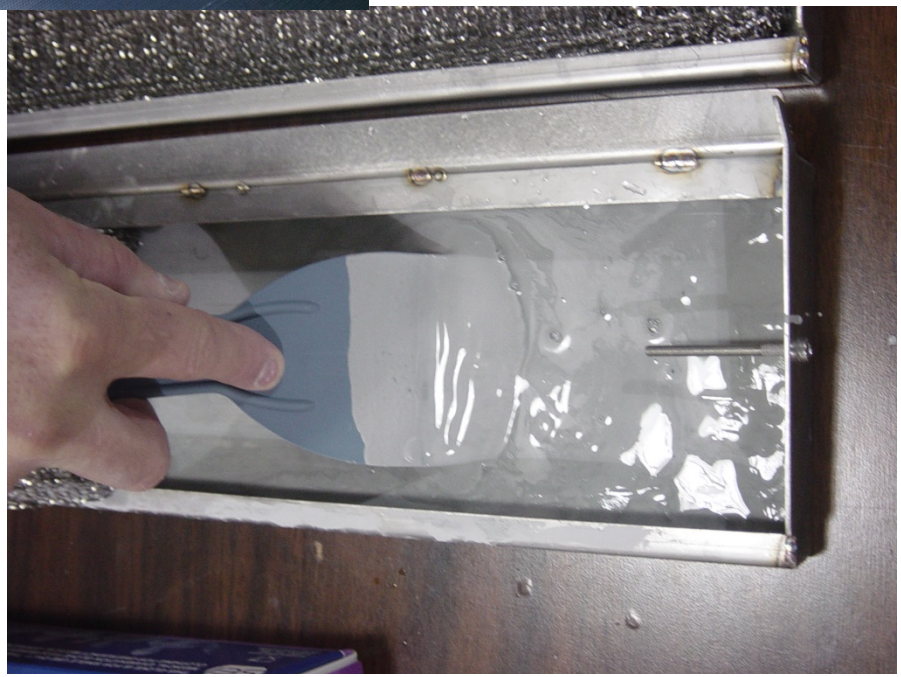
Pre-Wash Section

- Displaced solder balls and wash fluid
  - Drain into the catch trays
  - Solder balls channeled into sluice boxes
  - Contains the bulk of the solder balls



Sluice Boxes





Wash Section

- Solder balls not collected
- Drain into the wash fluid holding tank
- Three pump intake strainers prevent large spheres from entering the pump

Wash Section

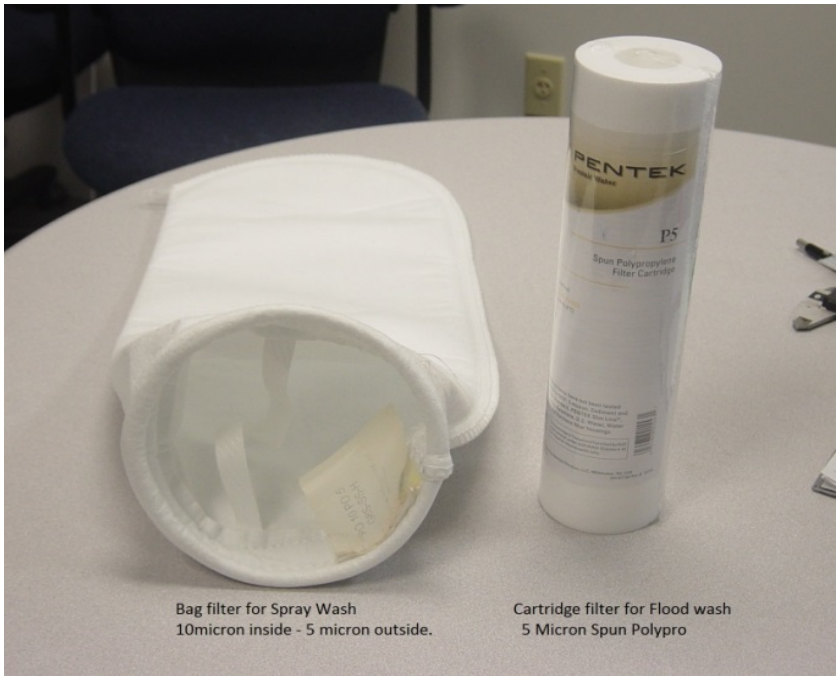
- Smaller solder spheres
  - Pass through the strainers
  - Captured in a bag filter from wash liquid pumped through the outlet of the pump

Wash Filtration

- Internal filter canister
- Prevents
  - Back flow
  - Resistance

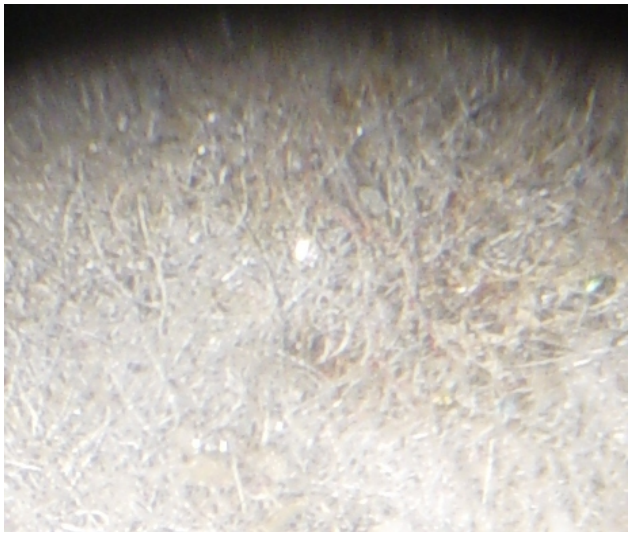
Wash Filtration

- 10/5 micron bag filter cartridge
  - 10 microns on the inside
  - 5 microns on the outside
  - Contain stray solder balls

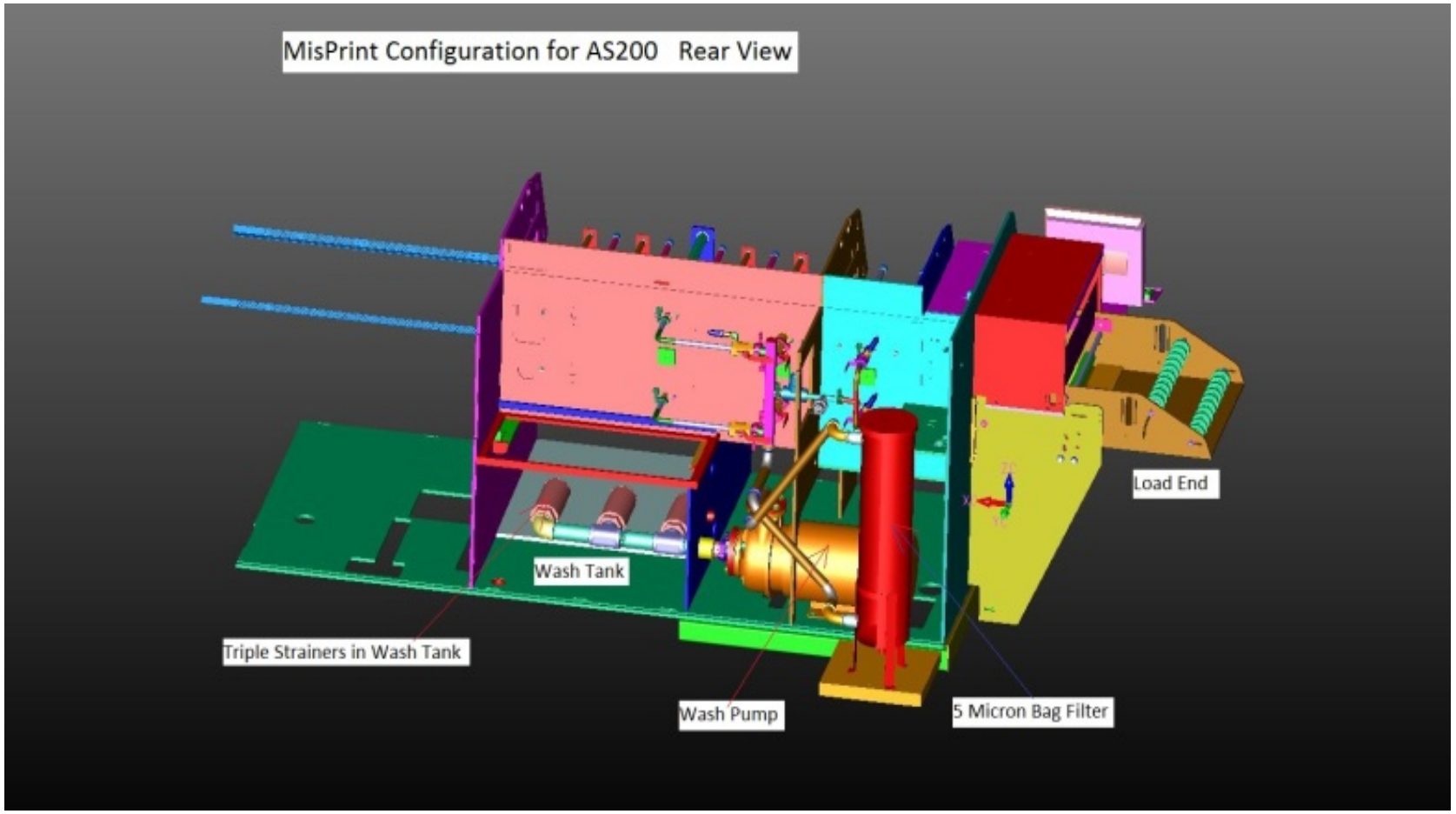


Wash Filtration

- Filtration removes solder balls as small as Type 5 Solder Paste
- Preventing solder balls going to the manifolds
- Pressure drops are minimal



Filtration Section Cutaway



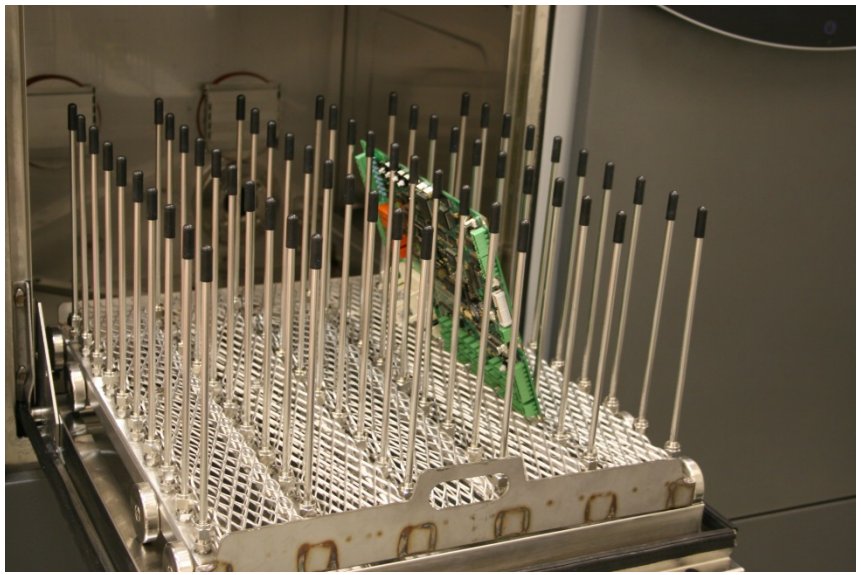
BATCH CLEANING MACHINE DESIGN

Batch Cleaning Machine

- Batch cleaning machines
  - Programmable wash/rinse cycles
  - Design provides the ability to
    - Trap and collect wet solder paste
- The design objective
  - Clean their normal production runs
  - Clean both A-side and B-side misprint
  - Completely rinse and dry the product

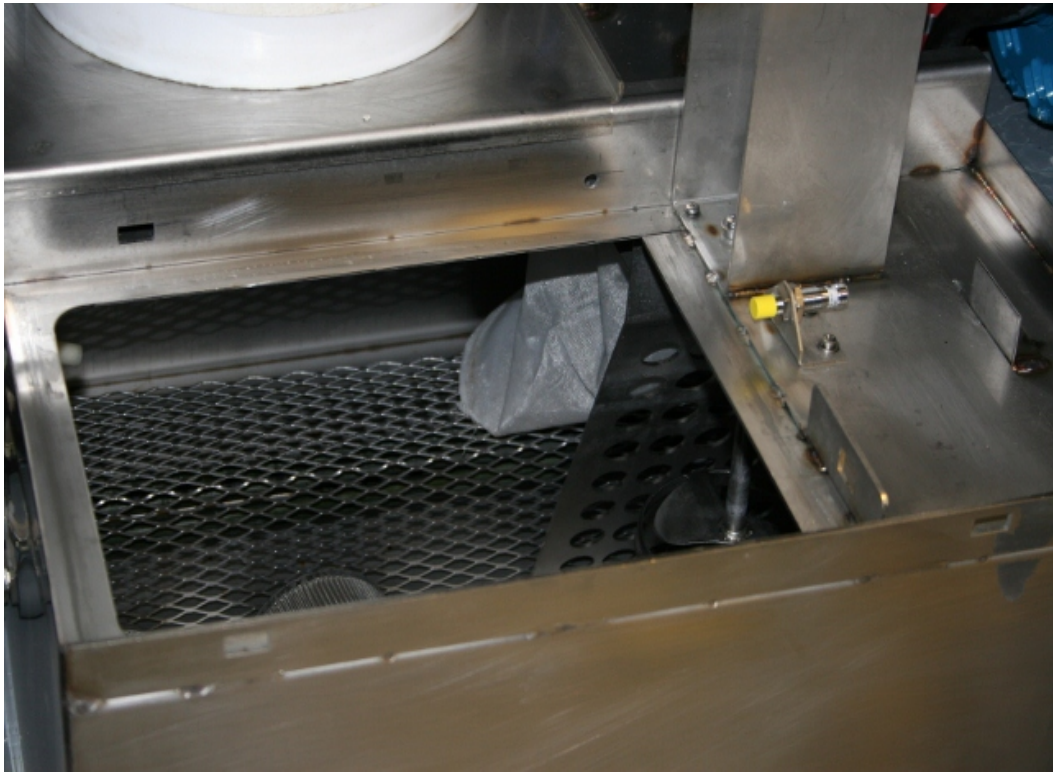
Batch Cleaning Machine Design

- Multi-stage filtration
  - Collect solder spheres
  - Prevent the spheres from being sprayed onto the board assembly



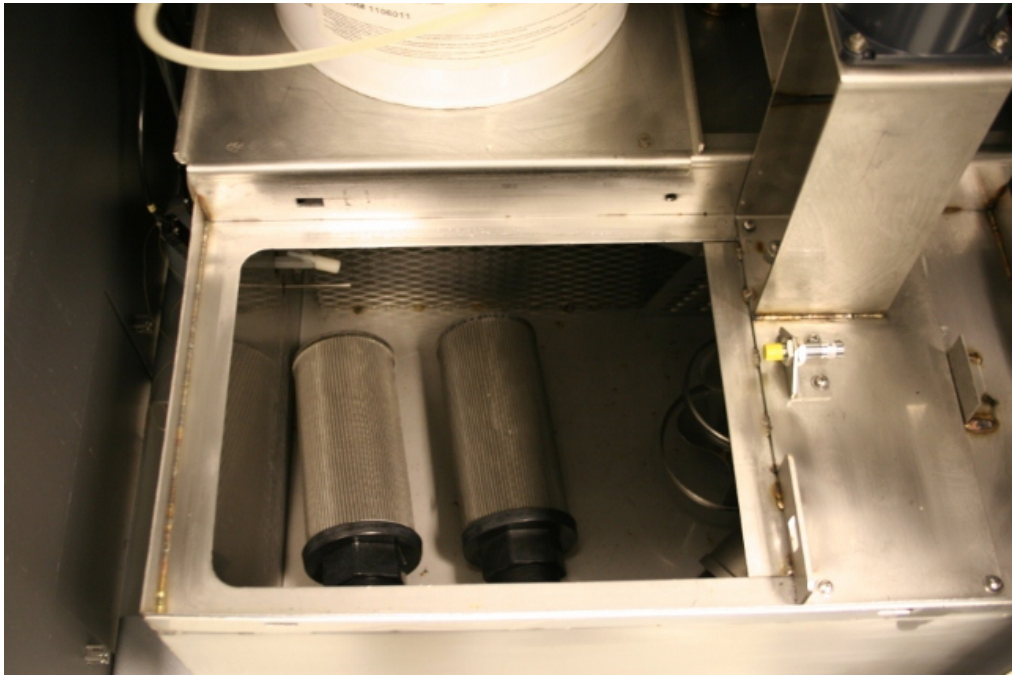
Pre-Wash

- Wet Solder Paste
  - Easier to remove than the reflowed paste
  - Internal bag type filter is used to capture the raw solder paste



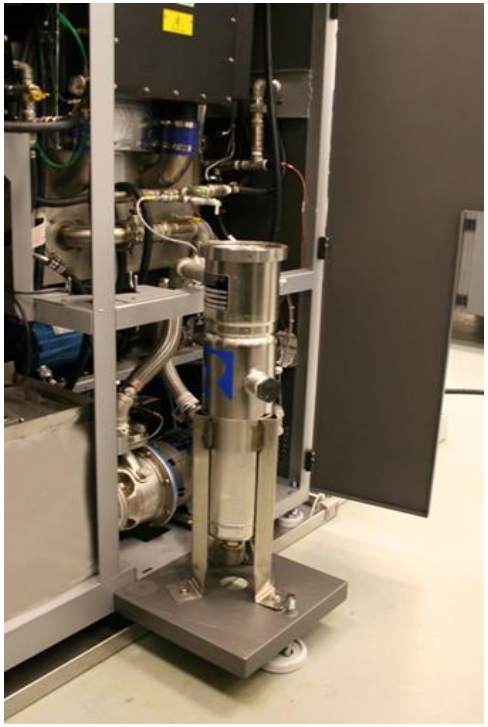
Wash Holding Tank

- Solder spheres not collected in the bag filter
  - Collect in the wash fluid holding tank
  - Two intake pickup strainers prevent large solder spheres from entering into the wash pumps



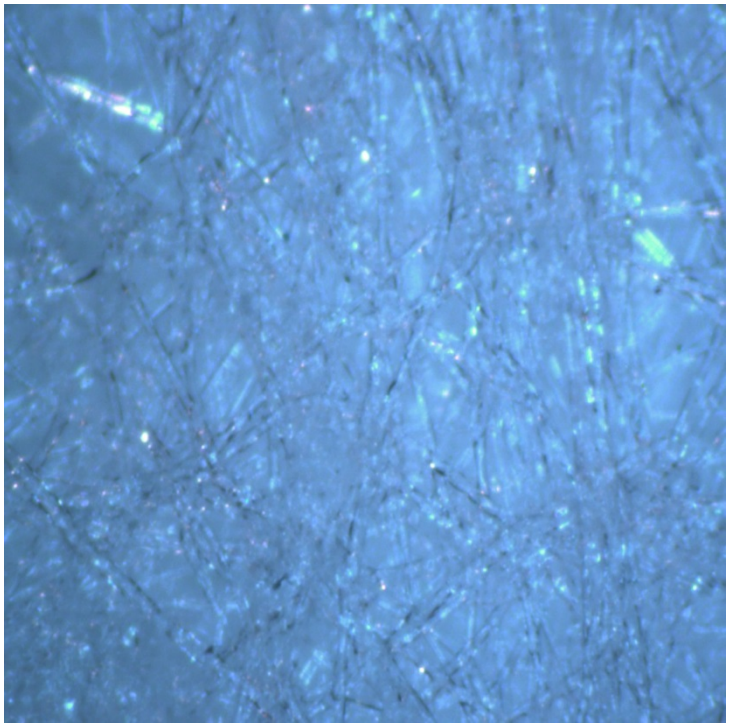
Wash Filtration

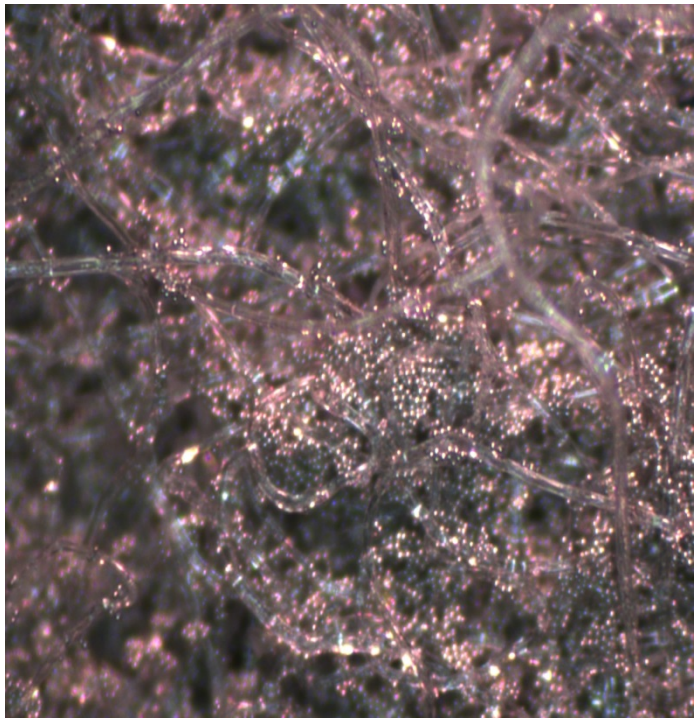
- Filtration system designed to
  - Capture the smallest of solder spheres
  - Prevents solder spheres from being sprayed through the wash fluid spray delivery system



Filtration Design

- Capture Type 5 solder paste





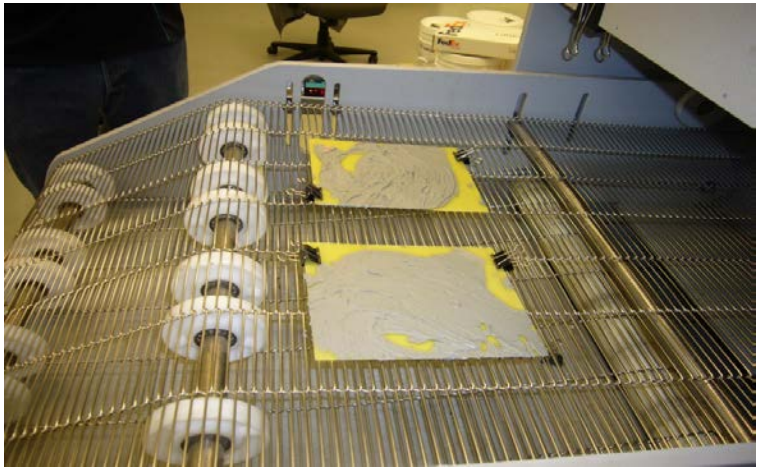
METHODOLOGY

DOE #1- Inline SP Loading

- The DOE objective is to
  - Validate the efficiency of capturing solder spheres
- 1000 grams of solder paste washed off boards
  - 5 additions of 100 grams of LF NC and 100 grams of WS NC
- After each 200 gram addition
  - Wash section was sampled at the outlet of the spray manifold
  - Millipore Filtration to determine level of solder spheres in wash solution
  - Non-Volatile Residue to determine flux loading

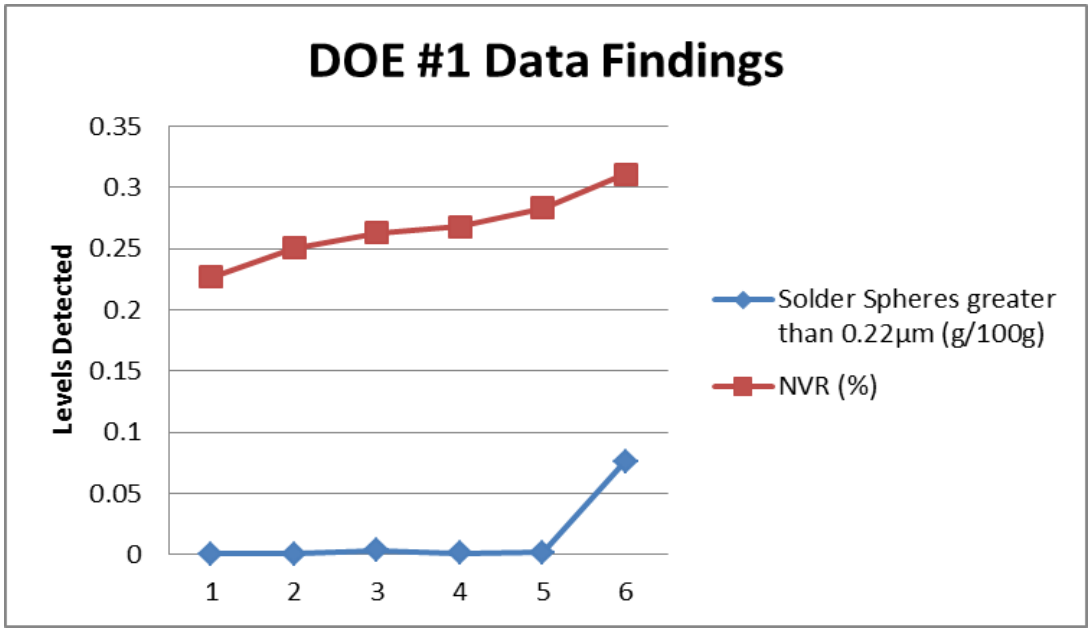
Solder Paste Additions

Addition	Solder Paste	Test Vehicle	Solder Paste Addition
1	Indium 8.9 LF - No Clean	Plain FR4 Board 8"x8"	100 grams
1	FCT WS888 (SN100C)	Plain FR4 Board 8"x8"	100 grams
2	Indium 8.9 LF - No Clean	Plain FR4 Board 8"x8"	200 grams
2	FCT WS888 (SN100C)	Plain FR4 Board 8"x8"	200 grams
3	Indium 8.9 LF - No Clean	Plain FR4 Board 8"x8"	300 grams
3	FCT WS888 (SN100C)	Plain FR4 Board 8"x8"	300 grams
4	Indium 8.9 LF - No Clean	Plain FR4 Board 8"x8"	400 grams
4	FCT WS888 (SN100C)	Plain FR4 Board 8"x8"	400 grams
5	Indium 8.9 LF - No Clean	Plain FR4 Board 8"x8"	500 grams
5	FCT WS888 (SN100C)	Plain FR4 Board 8"x8"	500 grams



Data Findings

Sample ID	Solder Pastes Selected	Solder Paste Added	Solder Spheres greater than 0.22µm (g/100g)	NVR (%)
Control	None	0	0.00058666	0.227
Sample 1	Indium 8.9, FCTWS888	200	0.00046654	0.250
Sample 2	Indium 8.9, FCTWS888	400	0.003457833	0.263
Sample 3	Indium 8.9, FCTWS888	600	0.00132265	0.268
Sample 4	Indium 8.9, FCTWS888	800	0.001747419	0.283
Sample 5	Indium 8.9, FCTWS888	1000	0.07610376	0.311



Inferences from Data Findings

- Millipore test
  - No detection of solder spheres was found up to 800 grams of solder paste added
  - At 1000 grams added to the wash bath, the levels found were very low at 0.07g/100gram
  - The data findings infer that very little to no solder balls are being sprayed onto boards being washed through the cleaning machine

Inferences from Data Findings

- The NVR test tracked the non-volatile flux solids added to the wash solution
  - Less than 0.02% flux solids were added to the wash bath per 200 grams of raw solder paste additions
  - Less than 0.02% flux solids would be accumulated into the wash tank per 200 grams of raw solder paste cleaned in the wash section

Sluice Box Collection

1. Sluice Box #1: 15 grams of solder spheres
2. Sluice Box #2: 95 grams of solder spheres
3. Sluice Box #3: 485 grams of solder spheres

DOE #2 – Batch SP Loading

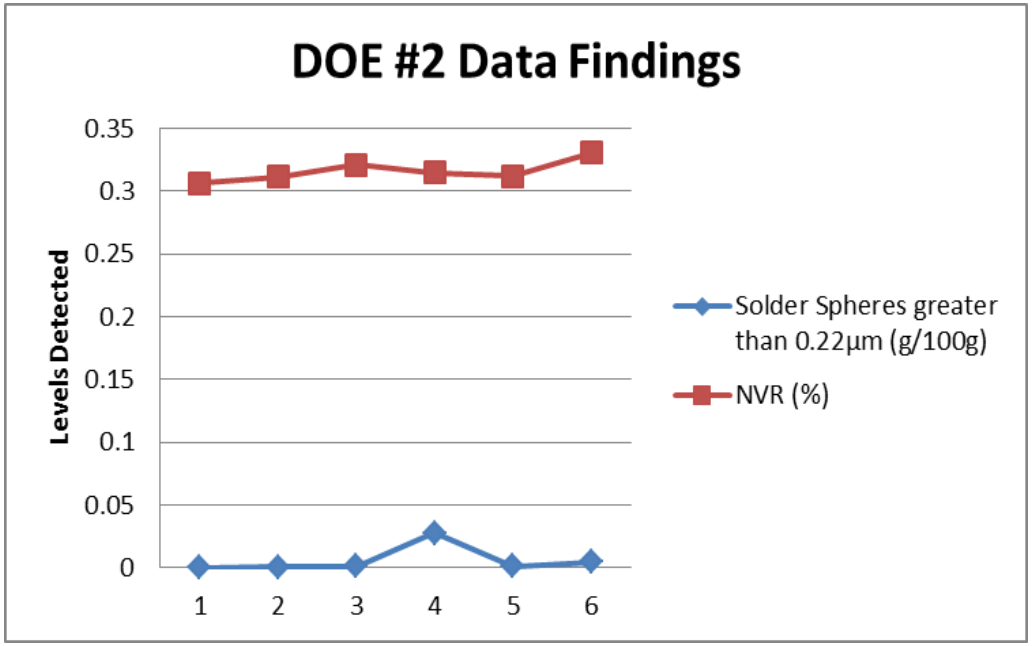
- Solder spheres from the batch cleaning machine are collected using a multi-stage filtration system
  - Double strainers at the intake side of the power wash pump
  - Five micron bag filters at the exit side of wash pumps
  - 300 micron bag filter at the drain back exit
- Multi-stage filtration is
  - Designed to capture solder spheres
  - Prevent solder spheres from being sprayed in the wash fluid

DOE #2- Batch SP Loading

- The DOE objective is to
  - Validate the efficiency of capturing solder spheres
- 1000 grams of solder paste washed off boards
  - 5 additions of 100 grams of LF NC and 100 grams of WS NC
- After each 200 gram addition
  - Wash section was sampled at the outlet of the spray manifold
  - Millipore Filtration to determine level of solder spheres in wash solution
  - Non-Volatile Residue to determine flux loading

Data Findings

Sample ID	Solder Pastes Selected	Solder Paste Added	Solder Spheres greater than 0.22µm (g/100g)	NVR (%)
Control	None	0	0.000319957	0.307
Sample 1	Indium 8.9, FCTWS888	200	0.000893214	0.311
Sample 2	Indium 8.9, FCTWS888	400	0.00127982	0.321
Sample 3	Indium 8.9, FCTWS888	600	**0.02771**	0.315
Sample 4	Indium 8.9, FCTWS888	800	0.00121	0.312
Sample 5	Indium 8.9, FCTWS888	1000	0.0047187	0.331



Inferences from Data Findings

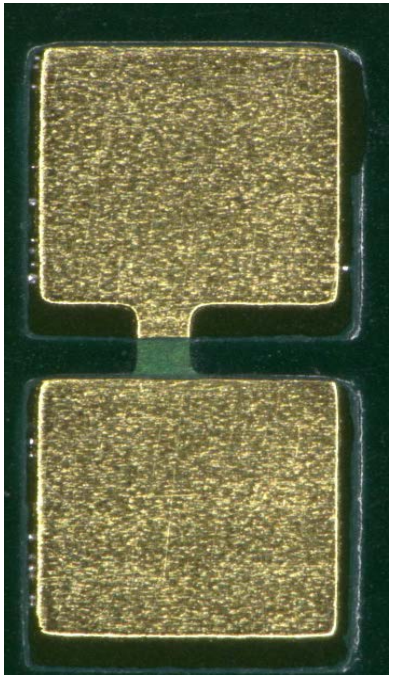
- Millipore test
  - No detection of solder spheres was found from samples except sample #3
  - The level for sample #3 was 0.02g/100g indicating practically no breakthrough
- NVR test
  - For each 200 gram addition of raw solder paste, the range of flux solids added to the wash bath ranged from 0.005 – 0.02%

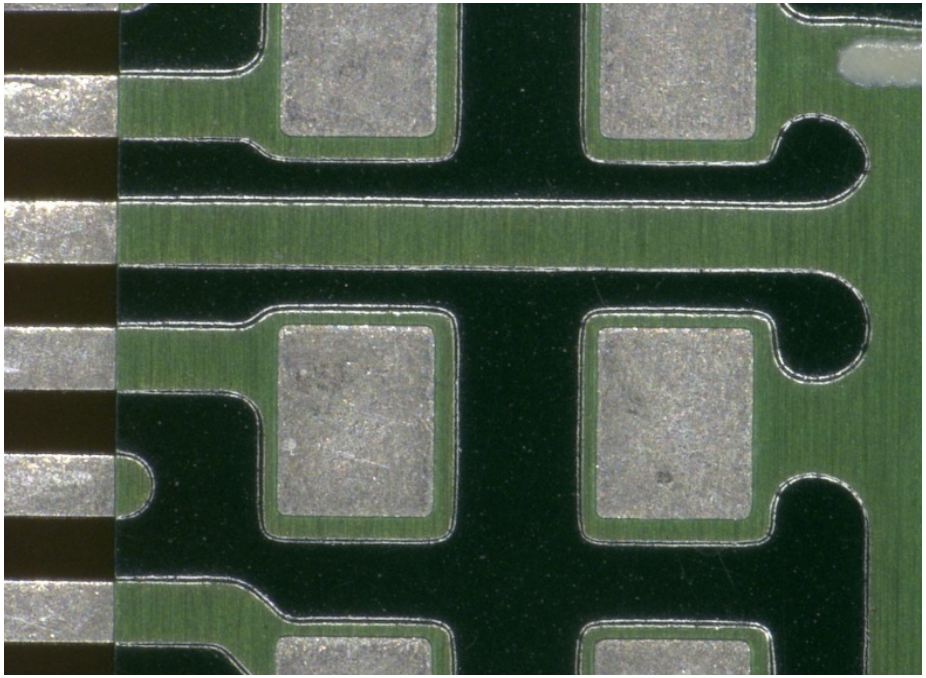
Data Findings

- Most of solder spheres captured in filters
- Small amount in wash tank

DOE #3: A-Side Misprints

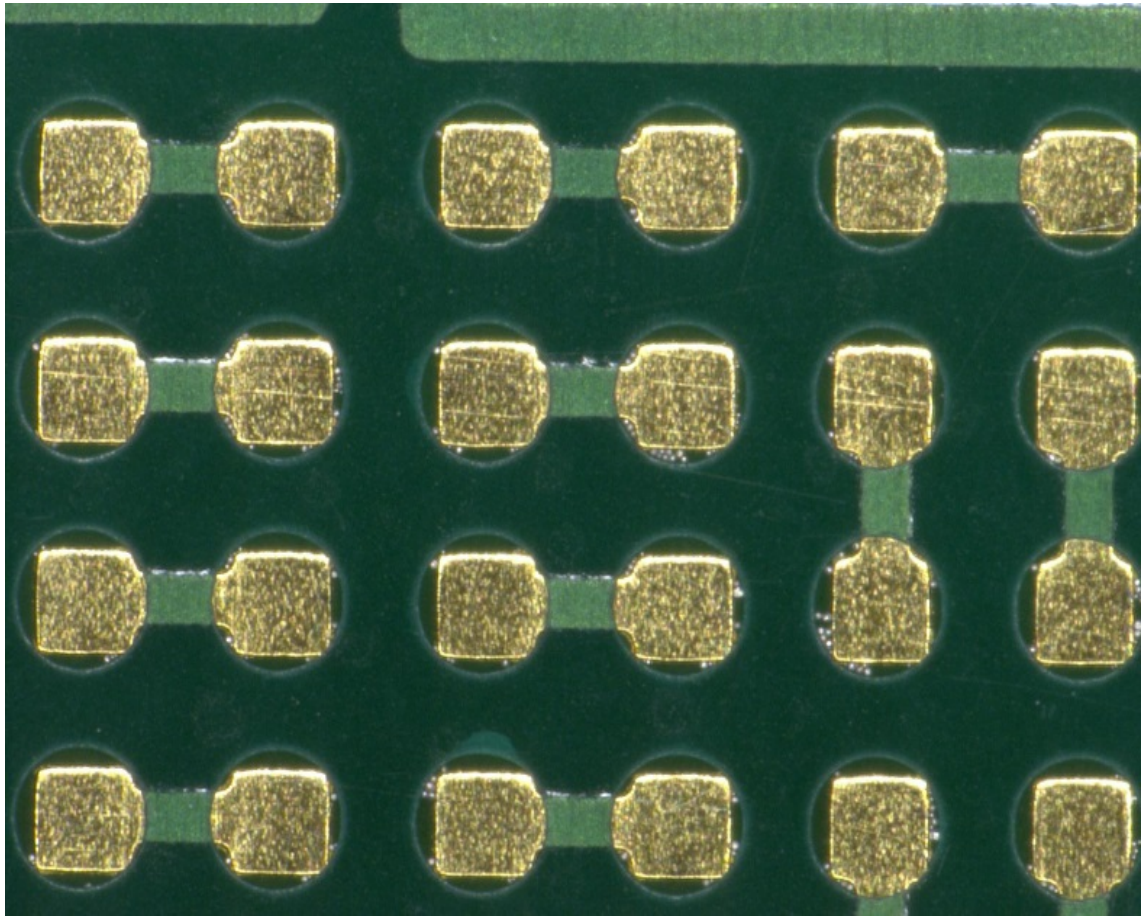
- The objective of DOE #3 was to
  - Test the effectiveness of removing miss-registered wet solder paste printed on two different board designs





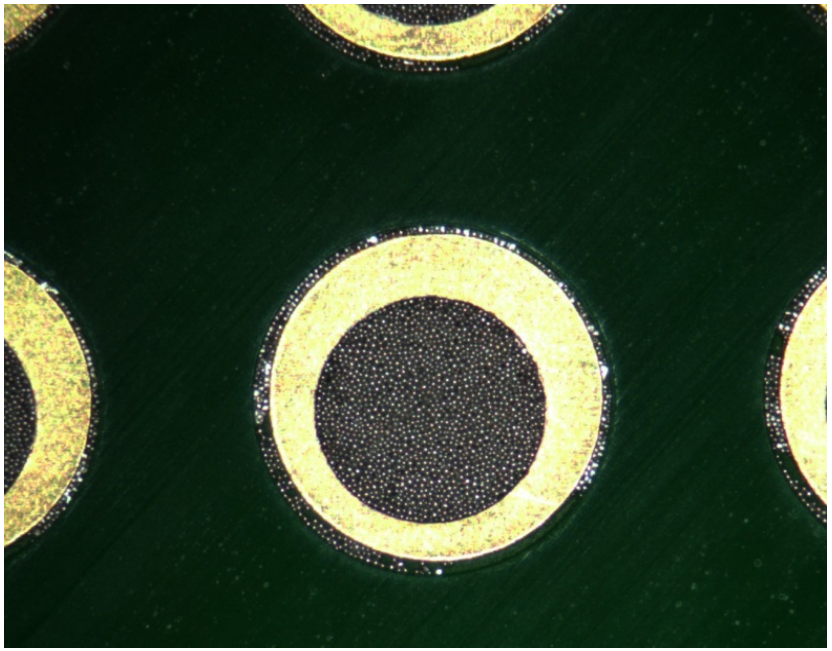
Non-Solder Mask Defined

- Potential to wedge solder spheres



Risk of Wiping

- Many assemblers wipe the excess solder paste off the board before cleaning
- The risk of wiping is the potential to wedge solder balls in the solder mask defined troughs and in the through-hole vias



DOE Factors

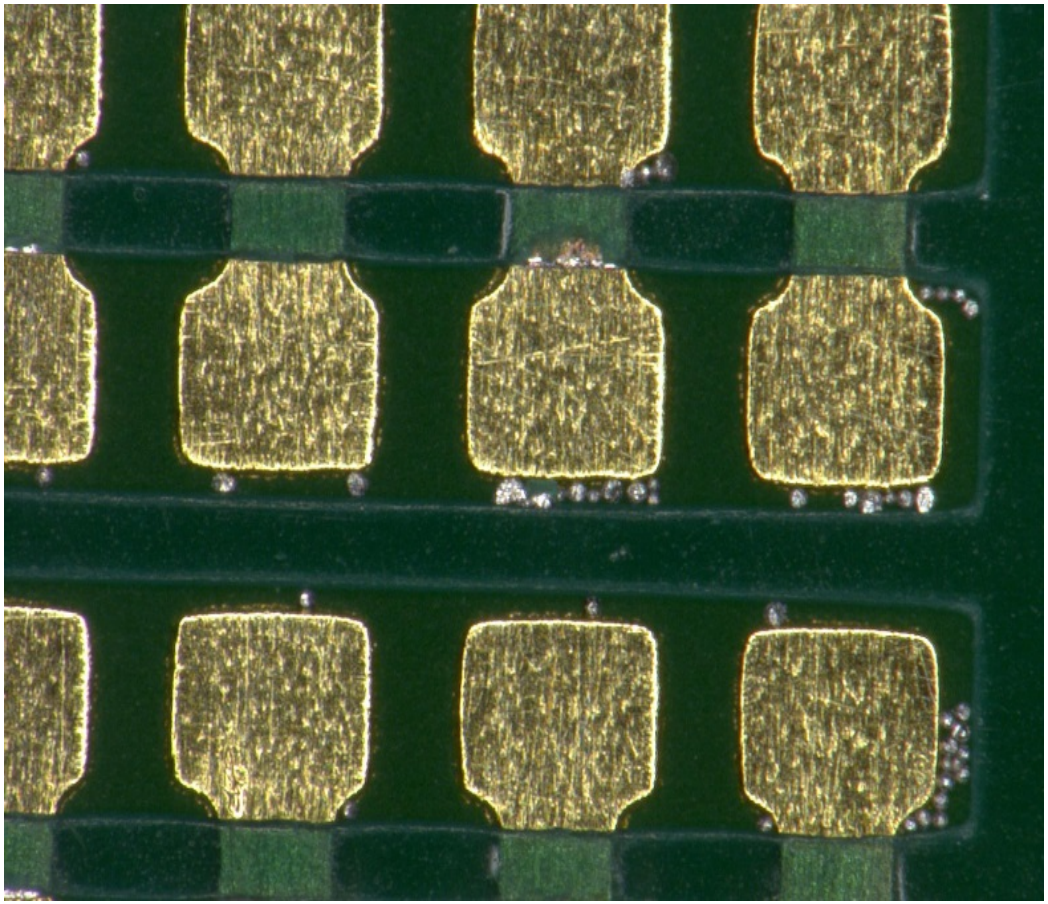
1. Test Board
   - Non Solder Mask Defined Pads
   - Solder Mask Defined Pads
2. Stencil Printer
   - Set to an offset so the board is misprinted
3. Cleaning Machine
   - Inline Spray-in-Air
   - Batch Spray-in-Air
4. Time from print to clean
   - 1 hour
   - 2 hours
   - 4 hours
5. Cleaning Agent
   1. Engineered Aqueous #1
   2. Engineered Aqueous #2
6. Pre-Wash
   - S-Jets for the inline
   - Flood wash for the batch
7. Wash
   - Intermix of coherent and fan jets for inline
   - Power basket with coherent nozzles for batch
8. Wash Time
   - Inline
     - 8 minutes
     - 4 minutes
     - 3 minutes
     - 2 minutes
     - 1.2 minutes
   - Batch
     - 15 minutes
     - 20 minutes
9. Wipe or No Wipe Before Cleaning
   - Wipe
   - No Wipe

Data Findings

- Wet solder paste was consistently removed in both the batch and inline cleaning machines
- Wash time and the time window from 1-4 hours after the misprint was not significant from a cleaning perspective.
- Significant finding was the risk of wedging solder balls in solder mask defined troughs

Inferences from Data Findings

- Do not wipe before cleaning



DOE #4: B-Side Misprints

- Common on double SMT boards
- B-Side Misprint
  - A-Side contains reflowed flux
  - B-Side contains wet solder paste
- More challenging cleaning requirement

Stencil Cleaning Equipment

- Not designed to remove reflowed flux residues
- Rinse water is commonly reused
  - Not ionically clean
- The problem is that
  - Most assemblers do not allow misprints to be cleaned in production cleaning equipment
  - Production cleaning machines are not equipped to capture and filter out solder spheres
  - Most assemblers either wipe the raw solder paste or clean the assembly in a machine designed for cleaning stencils
  - Both practices present reliability risks.

DOE #4 Objective

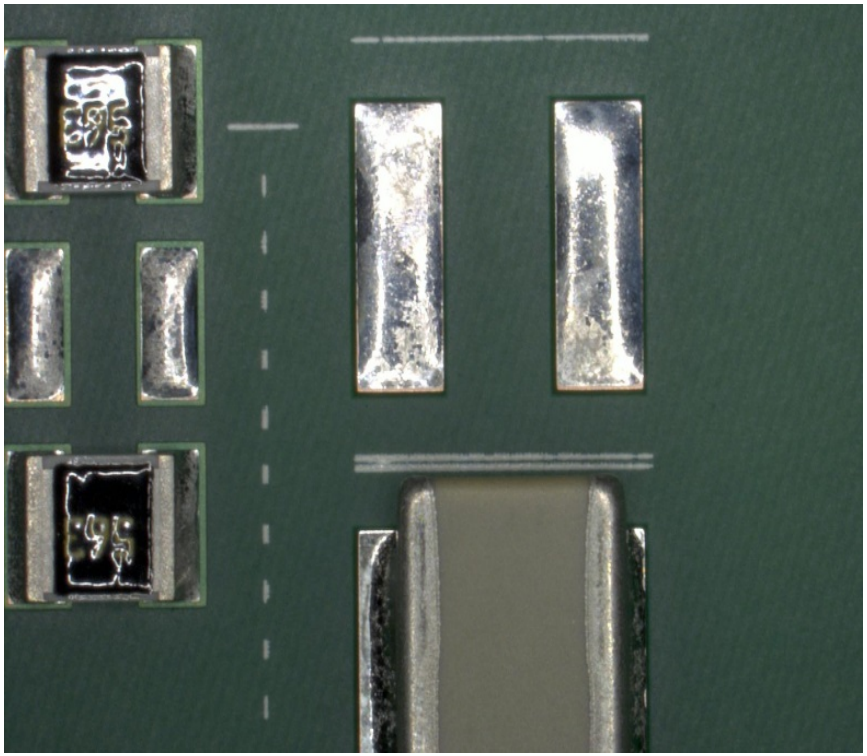
- Test the effectiveness of removing
  - Wet solder paste
  - Reflowed flux residues
  - Ionic contamination from B-side misprints

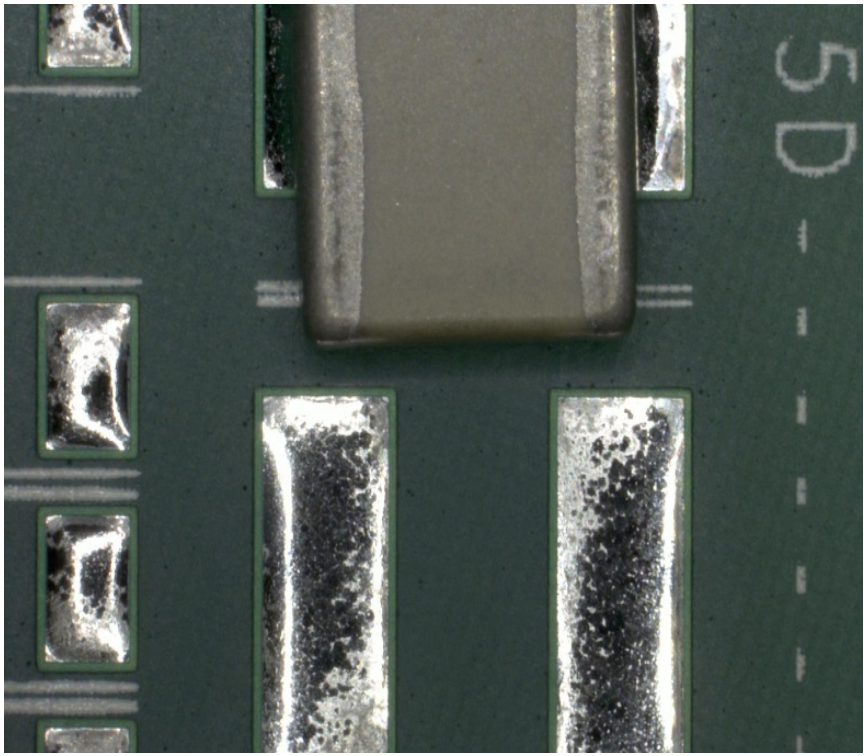
DOE #4 Factors

1. Bottom Termination Test Board
    1. Chip Cap Resistors
    2. BGAs
    3. µBGAs
    4. Single sided QFNs
    5. Double Sided QFNs
2. Solder Mask Definition
    1. Solder Mask Defined Pads
    2. Non-Solder Mask Defined Pads
    3. No-Solder Mask Defined Pads
3. Cleaning Machine
    1. Inline Spray-in-Air
    2. Batch Spray-in-Air
4. Wash Time
    1. Inline
        1. 8 minute wash
        2. 4 minute wash
    2. Batch
        1. 15 minute wash
        2. 20 minute wash
6. Cleaning Agent
    - Aqueous Engineered #1
    - Aqueous Engineered #2
7. Wash Temperature
    - 65°C
8. Rinse
    - Inline
        - 4 minutes
        - 2 minutes
    - Batch
        - 6 minutes
9. Ionic Contamination
    - Ionograph

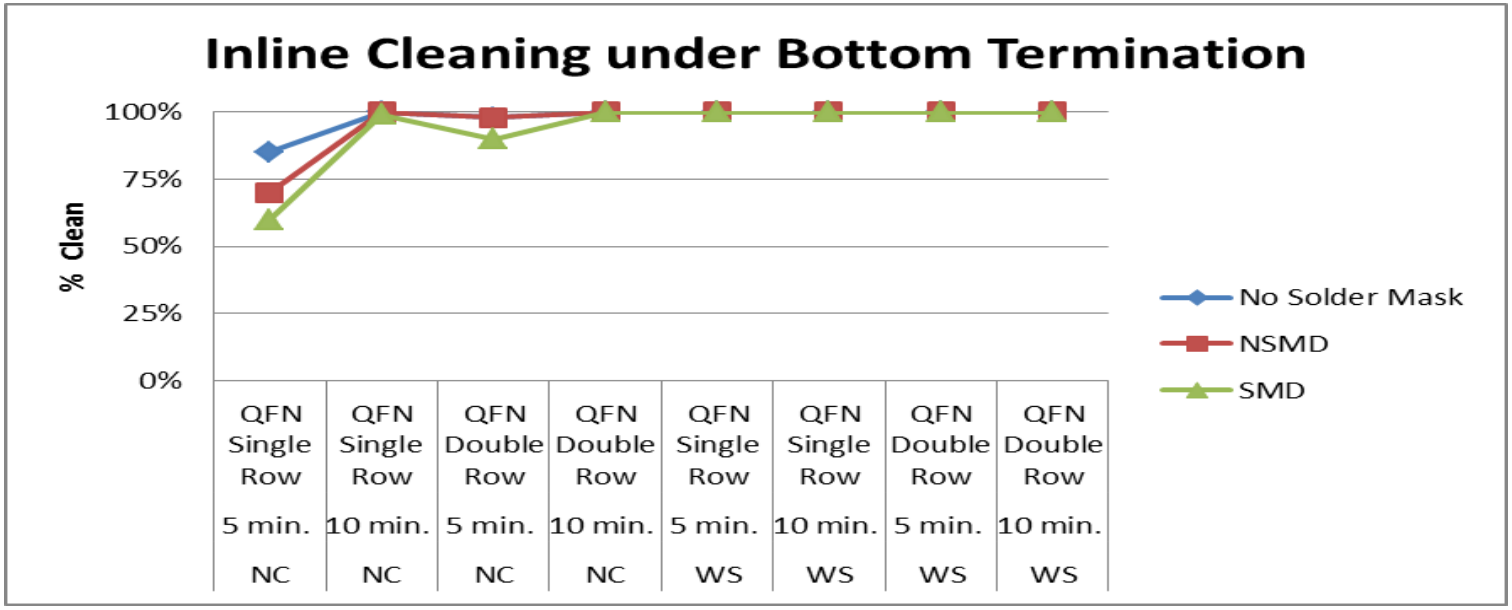
DOE #4 Data Findings

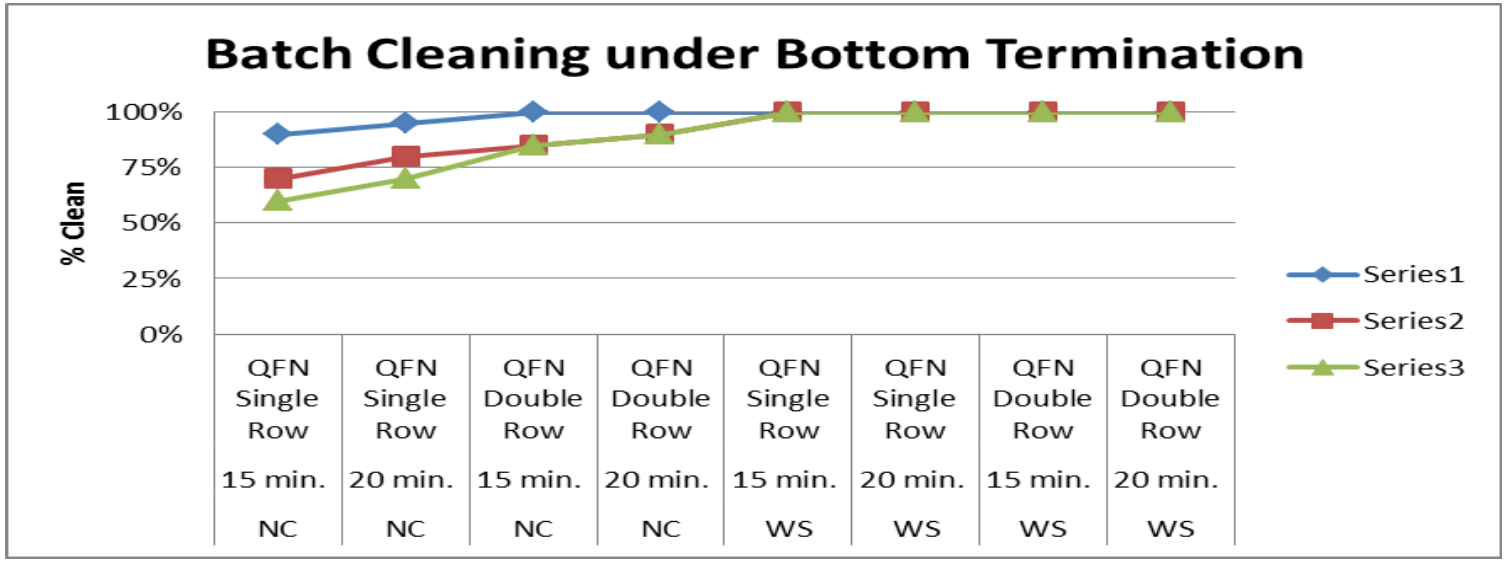
- No visual flux residues





Flux Residue under BTCs





Inferences from the Data Findings

- DOE #4 finds that
  - The levels of solder paste added to the machines did not have any adverse effect in removing reflowed flux residues
  - The boards were ionically clean under all test conditions following the cleaning processes
  - At optimized process parameters, flux residue were removed under BTCs

CONCLUSIONS

Misprint Cleaning Challenges

- A-Side and B-Side misprint cleaning is a complex problem for assemblers
- Stencil cleaner to clean misprints has numerous flaws
- Most assembly houses do not allow misprints to be cleaned in production cleaning machines
  - Risk of contaminating product boards with stray solder balls
  - Waste water metal contamination issues

Filtration and Collection

- Collection and filtration systems
  - Safely captures and contains solder spheres
  - Solder spheres are not sprayed onto production assemblies
  - Prevent raw solder paste from entering the rinse water streams

Beneficial Advances

1. Recovery and rework of expensive hardware
2. Removal of wet solder paste
3. Containment of solder spheres
4. Removal of reflowed flux residues
5. Exceptional rinsing
6. Ionically clean assemblies
7. Repeatable
8. Reproducible

Wiping Wet Solder Paste

- The research finds that
  - Wiping wet solder paste from production assemblies is a bad practice
  - Solder spheres can be wedged into no solder mask defined troughs, vias and other offsets
  - When these solder balls become wedged, high levels of energized sprays may not be sufficient in displacing a wedged solder ball
  - Best practice is to clean the misprint without wiping

Questions

Thank You!