Reinventing the Wheel

Jody Saultz

Applications Engineer

IPC
Association Connecting Electronics Industries

SMTA
Surface Mount Technology Association

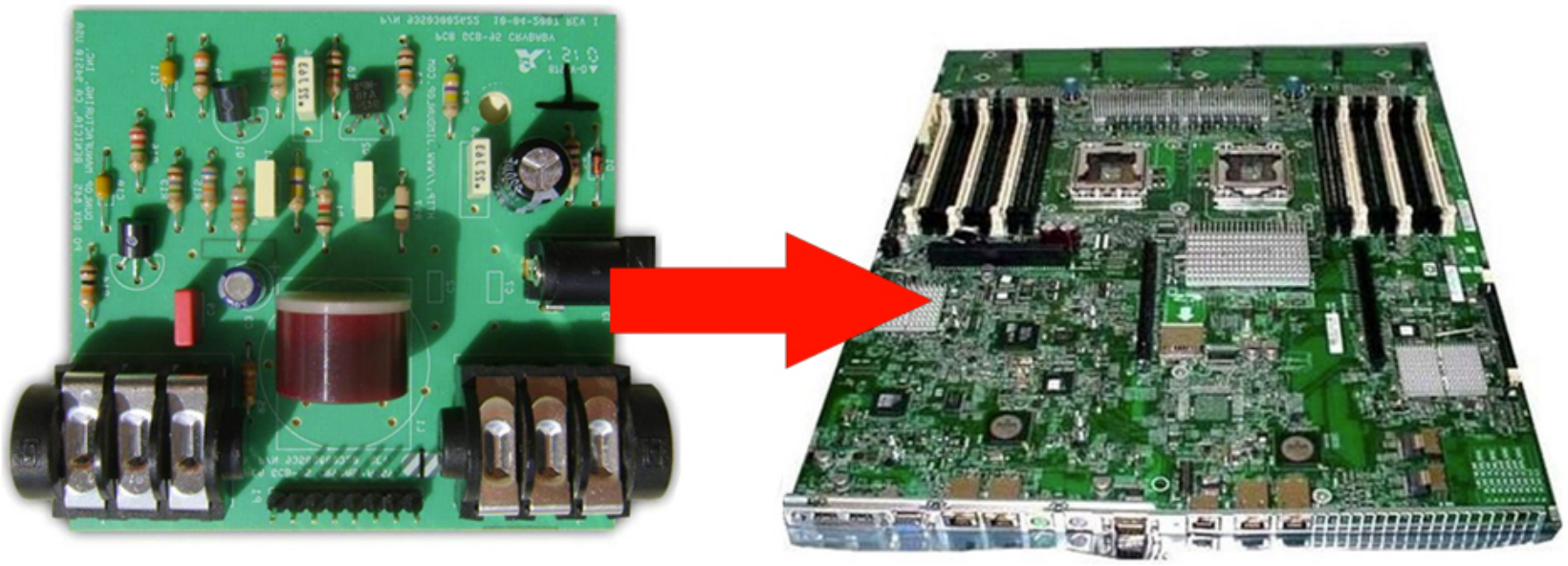
Reinventing the Wheel

- Background
- Methodology
- Test Results
- Conclusion

IPC
Association Connecting Electronics Industries

SMTA
Surface Mount Technology Association

Advancement of Electronics



Association Connecting Electronics Industries

Surface Mount Technology Association

Background

- Numerous cleaning process options for electronics manufacturers
- Focus of this study
  - Assess the cleaning effectiveness of precision cleaning spray technologies utilizing
    - Inline cleaner
    - Aqueous based cleaning agent

Background

- Main energy sources of a cleaning system are:
  - Thermal energy
    - Impacted by the temperature of the cleaning media
  - Chemical energy
    - Impacted by the ability of the cleaning agent to solubilize the residues
  - Mechanical energy:
    - Impacted by effectiveness of the impingement force on the substrate surface
  - Dwell time

Background

- Efficient cleaning system requires optimization of:
  - Thermal energy
  - Chemical energy
  - Mechanical energy
  - Critical to optimizing mechanical energy:
  - Spray manifold design and configuration
  - Spray nozzle type and quantity

Background

- Inline cleaners include:
  - Pre wash
  - Wash section
  - Chemical Isolation
  - Rinse & Final rinse
  - Dry
- Mechanical energy impacts the pre wash and wash sections
- Study focus:
  - Influence of spray bar configuration, nozzle design and utilization on cleaning efficiency

Methodology

- Four (4) spray nozzle technology methods were evaluated
  - Spray Under Immersion (SUI)
  - High Volume V-Jet Nozzles (HVVJ)
  - Standard Intermix Nozzles (SI)
  - Intermix High Volume Nozzles (IHV)

Methodology

- Evaluation methodology:
  - Utilized populated ZESTRON® Test Vehicle
  - Three pastes types considered
    - Paste A: Water Soluble
    - Paste B: No-clean
    - Paste C: RMA
- All pastes reflowed per manufacturer recommended profile

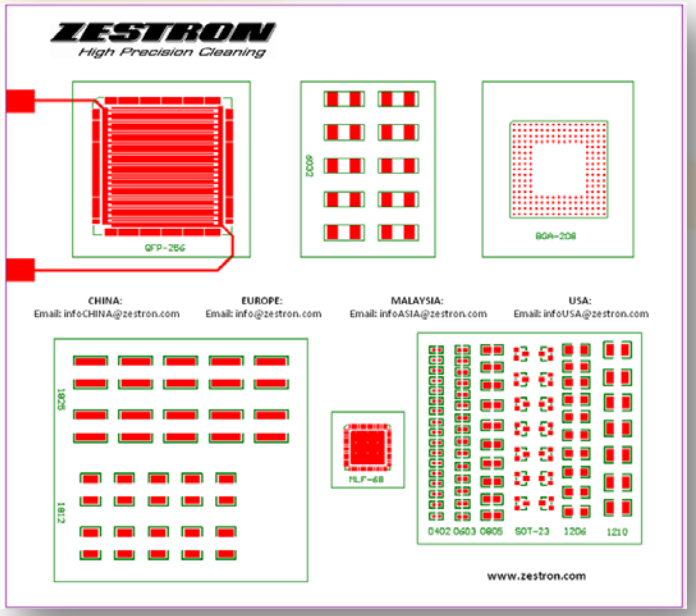
Methodology

- Components used per test vehicle: 5 each type
- Total components per test vehicle: 45

Component Types Used		
1825	1812	0402
0603	0805	SOT-23
1206	1210	6032

Methodology

- Populated test vehicle



Methodology

- Inline cleaner operating parameters

Cleaning agent type:	**Aqueous based micro phase**
Fixed Parameters:	
Concentration:	15%
Wash temperature:	140˚ F
Variable Parameters:	
Dwell time (SUI – RMA, No-Clean):	10 minutes / 5 minutes
Dwell time (SUI - Water Soluble):	2 minutes / 1.66 minutes
Dwell time (spray in air – RMA & No Clean):	5.3 min minutes / 2.45 minutes
Dwell Time (Spray in air - Water Soluble)	1.06 minutes / 0.55 minutes

IPC Association Connecting Electronics Industries

SMTA Surface Mount Technology Association

Methodology

- Two (2) test vehicles were cleaned at each belt speed
- Cleanliness assessment evaluation conducted by:
  - Visual inspection
    - Components mechanically removed for undercomponent inspection
    - Cleanliness assessment per IPC 61
- Ion Chromatography Analysis
  - Per IPC-TM-650 2.3.28

Methodology

- Spray Technology and nozzle method details

Configuration type	Type
Standard Intermix	
• Top spray bar	4 V-Jet Bars 4 JIC Bars
• Bottom Spray Bar	4 V-Jet Bars
Intermix High Volume	
• Top spray bar	4 V-Jet Bars 4 JIC Bars
• Bottom Spray Bar	4 V-Jet Bars

IPC
Association Connecting Electronics Industries

SMTA
Surface Mount Technology Association

Methodology

- Spray bar and nozzle design details

Configuration type	Type
High Volume V-Jet	
• Top spray bar	8 V-Jet Bars
• Bottom Spray Bar	4 V-Jet Bars
Spray under immersion	
• Top spray bar	8 V-Jet Bars
• Bottom Spray Bar	4 V-Jet Bars
• Immersion bath	1 “ liquid height/conveyor .375

Methodology

- Spray bar and nozzle design details

Configuration	Pre Wash Upper Pressure (PSI)	Pre Wash Lower Pressure (PSI)	Wash Upper Pressure (PSI)	Wash Lower Pressure (PSI)
Standard Intermix	55	45	70	45
Intermix High Volume	55	45	70	45
High Volume V-Jet	55	45	60	40
Spray Under Immersion	55	45	60	40

Methodology

- Standard and High Volume Intermix

Association Connecting Electronics Industries

Surface Mount Technology Association

Methodology

- High volume V-Jet

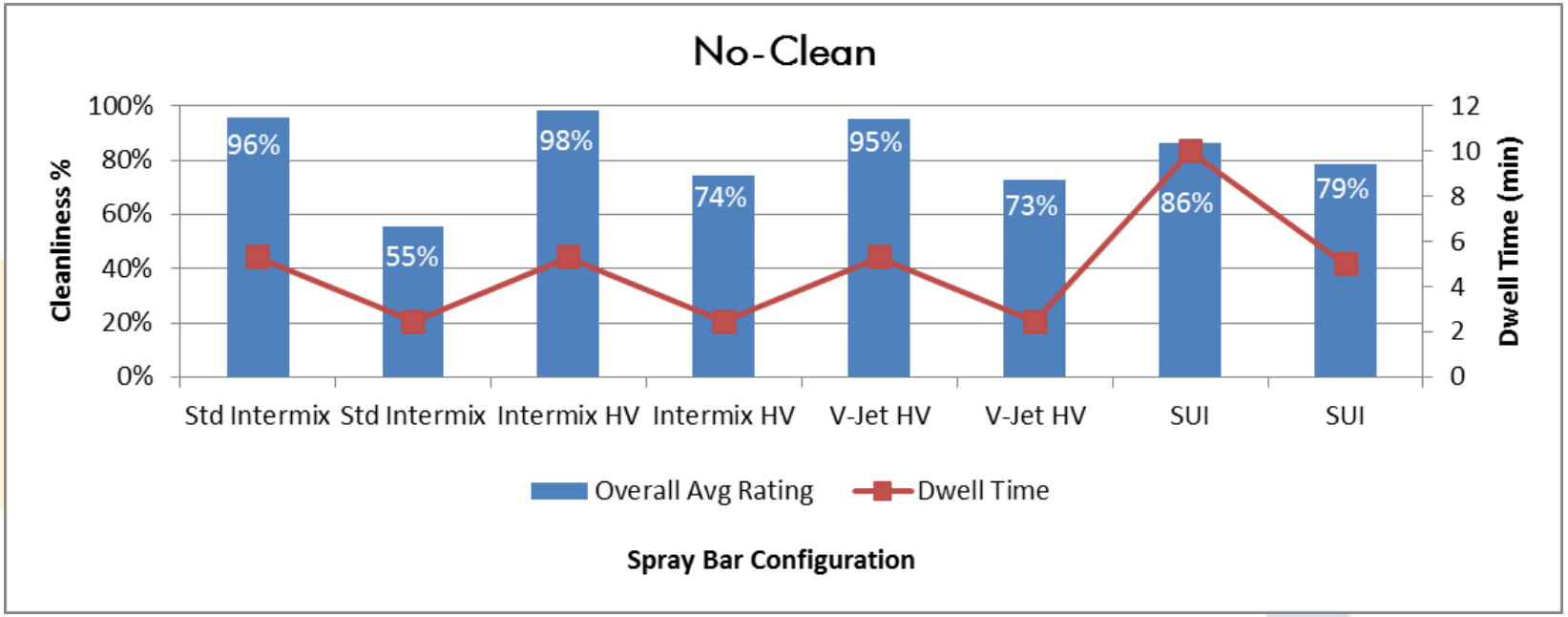
Methodology

- Spray Under Immersion

Association Connecting Electronics Industries

Surface Mount Technology Association

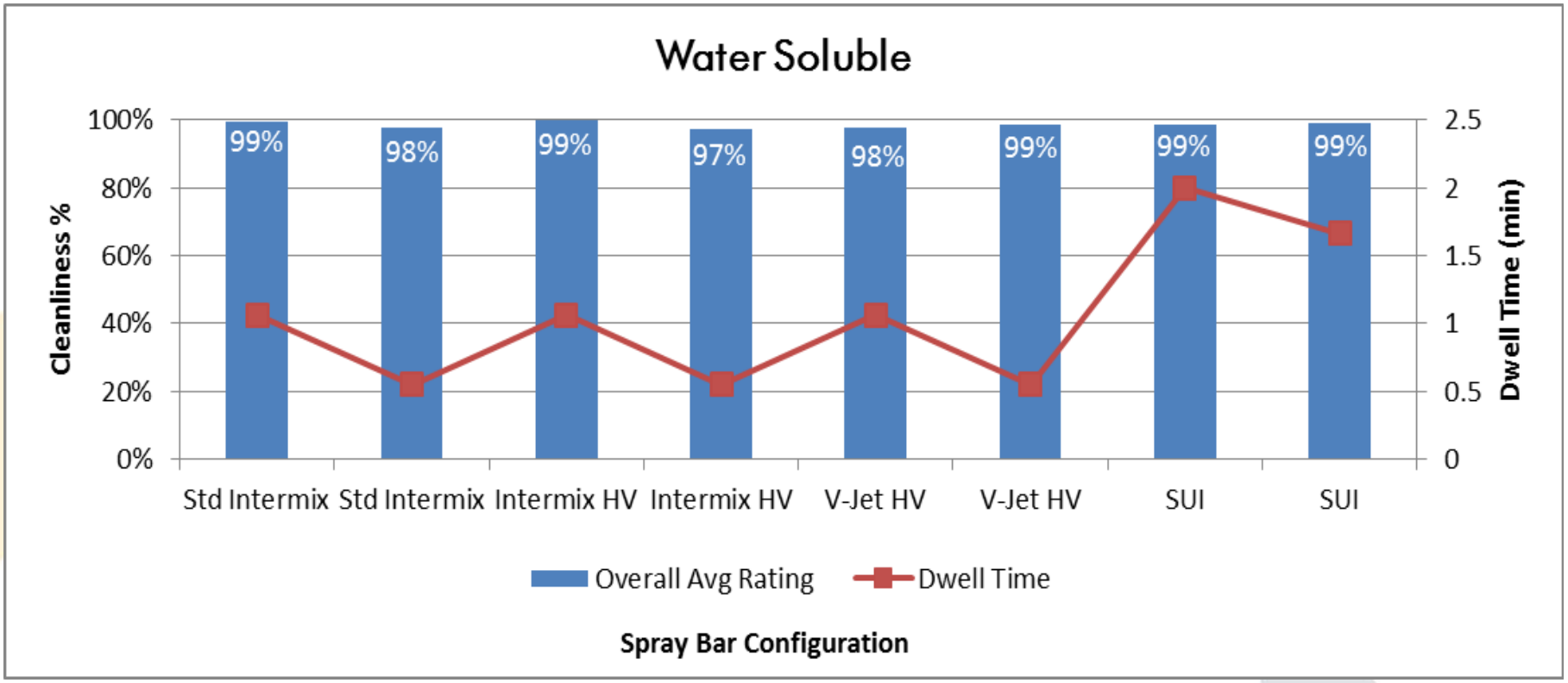
Results



Association Connecting Electronics Industries

Surface Mount Technology Association

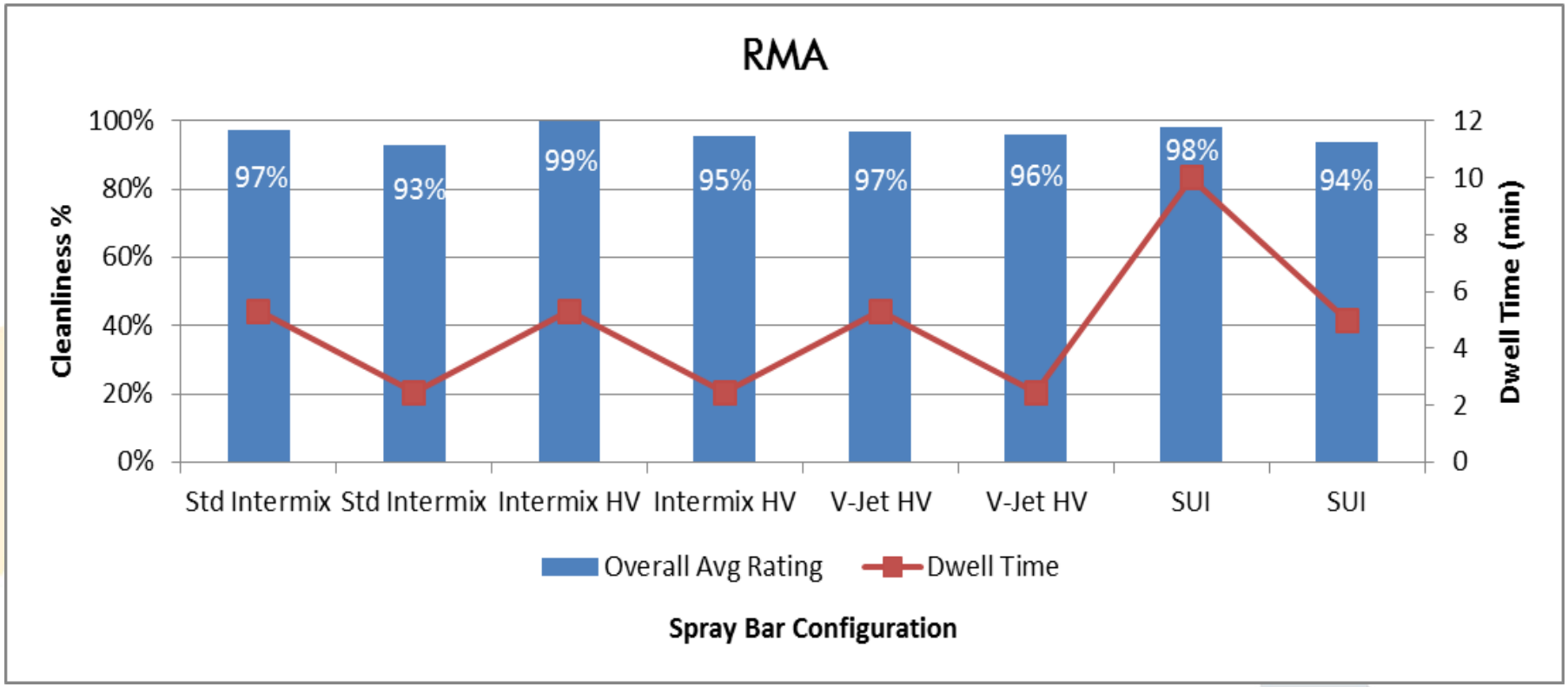
Results



Association Connecting Electronics Industries

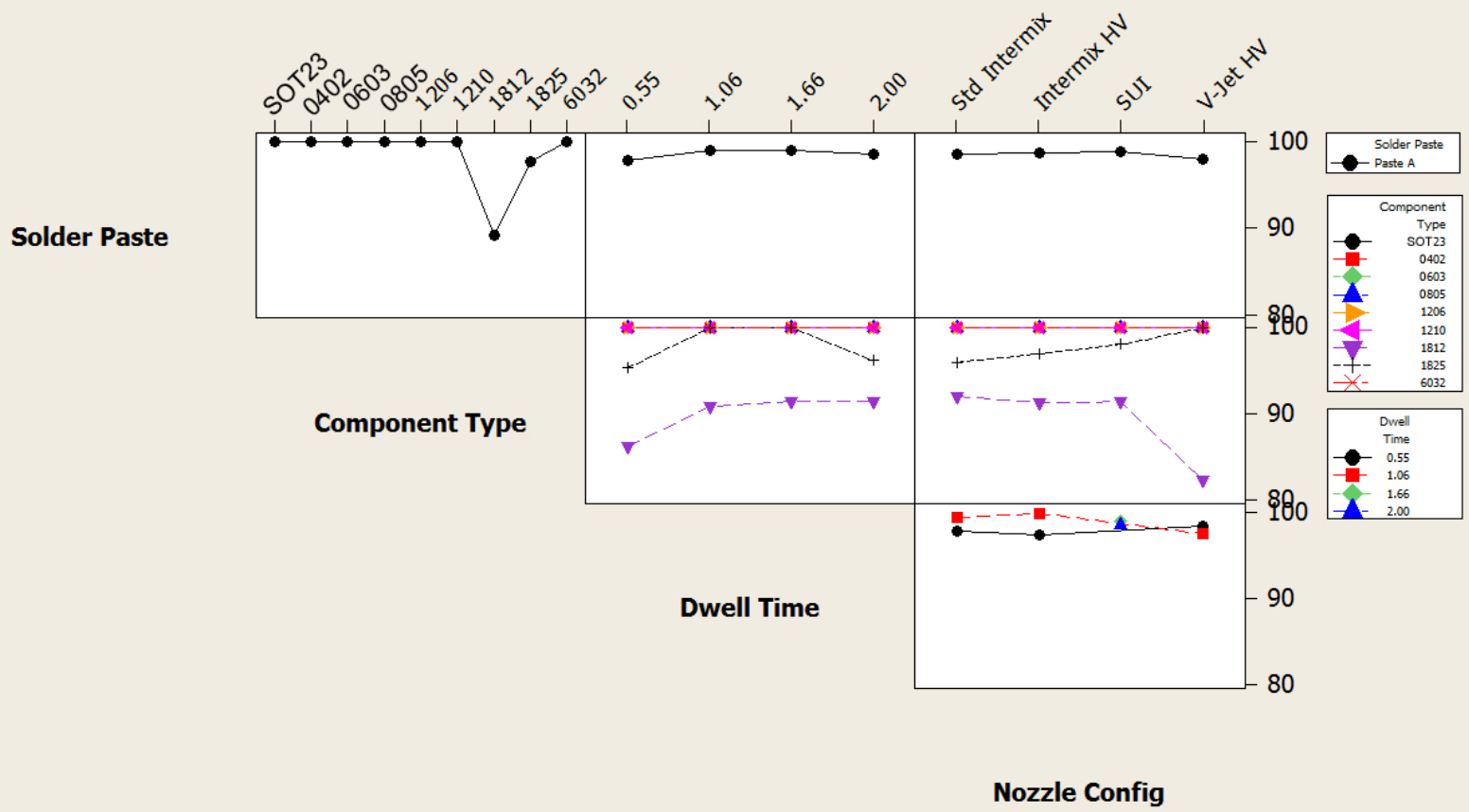
Surface Mount Technology Association

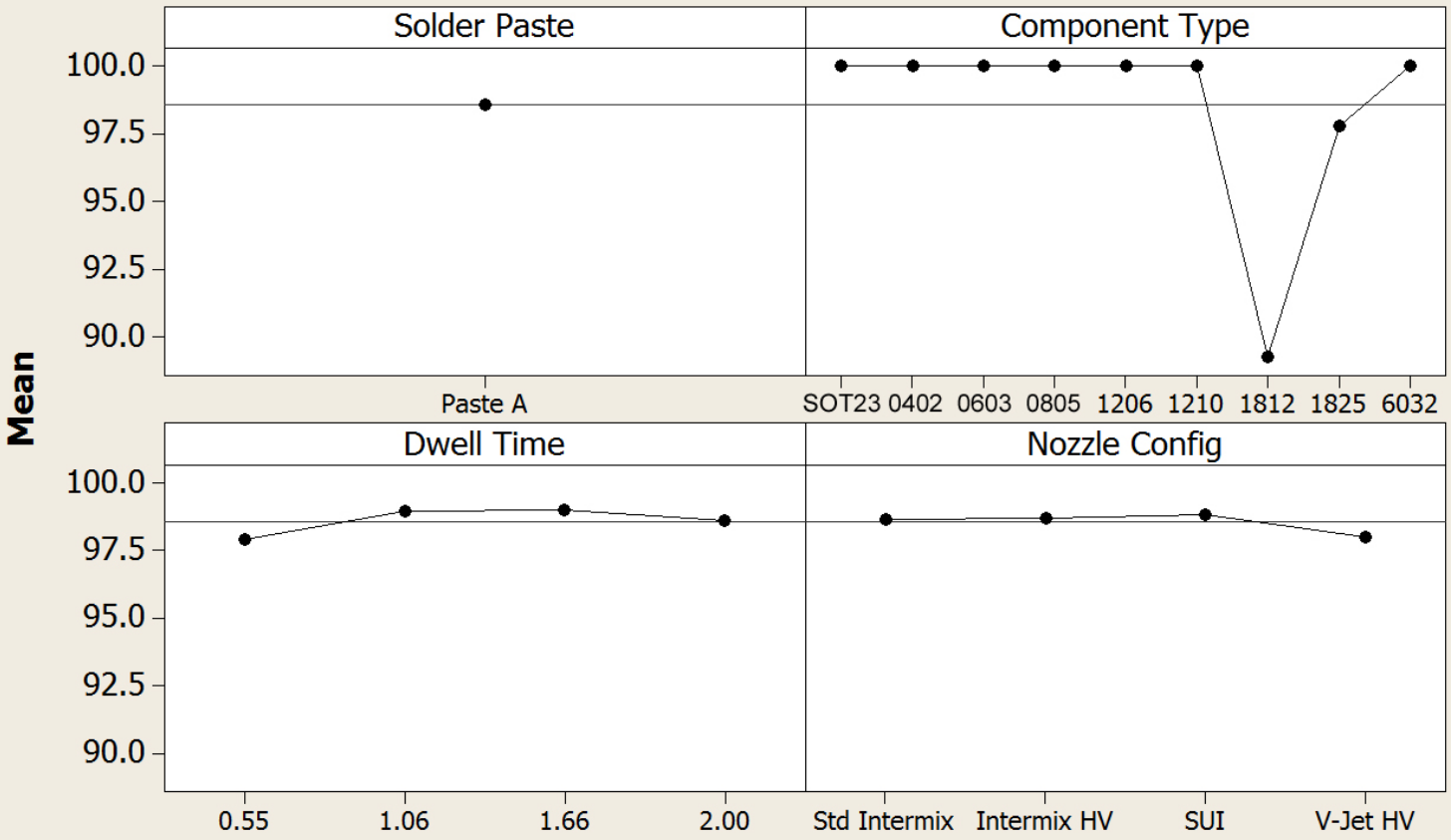
Results

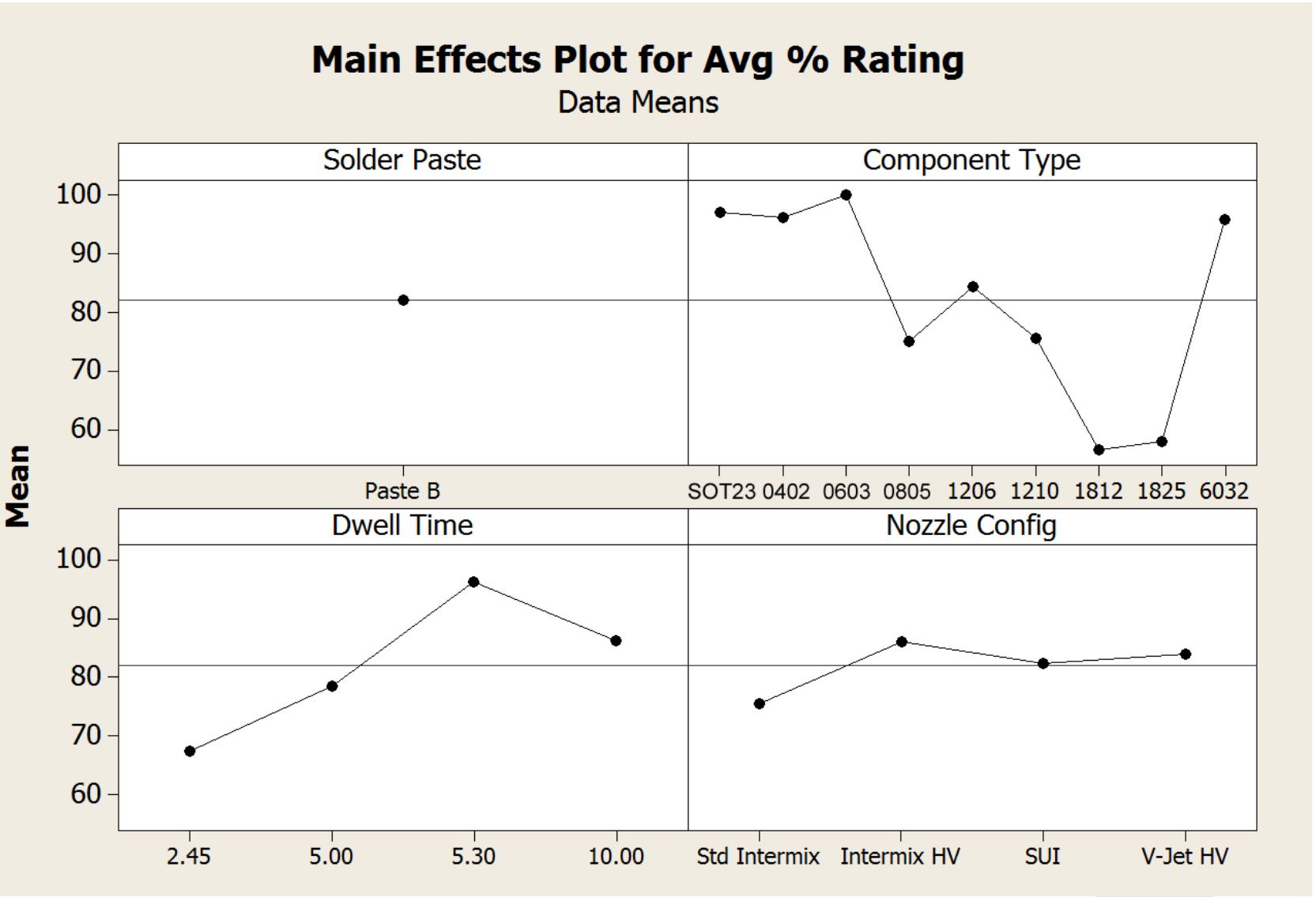


Association Connecting Electronics Industries

Surface Mount Technology Association

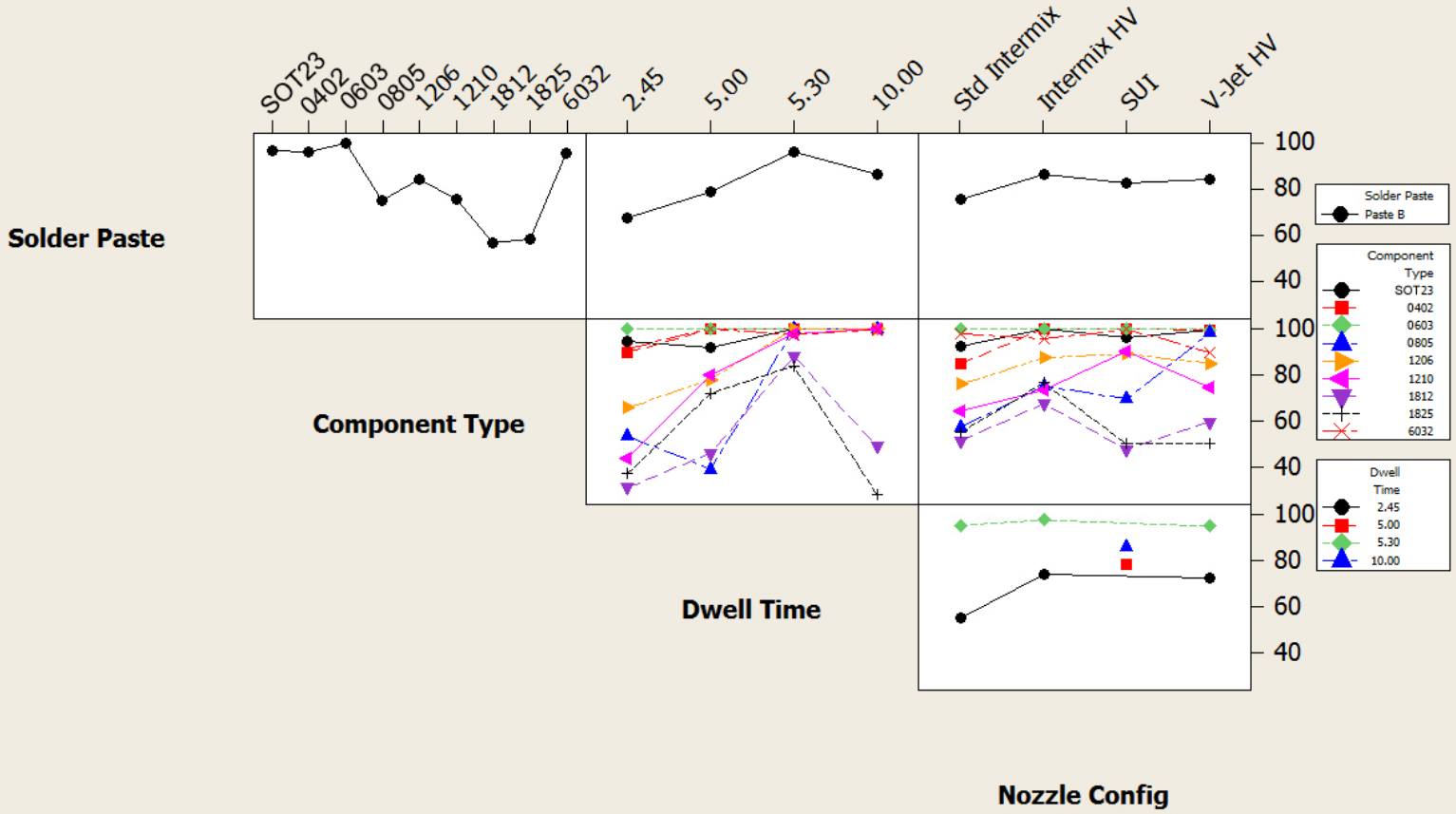






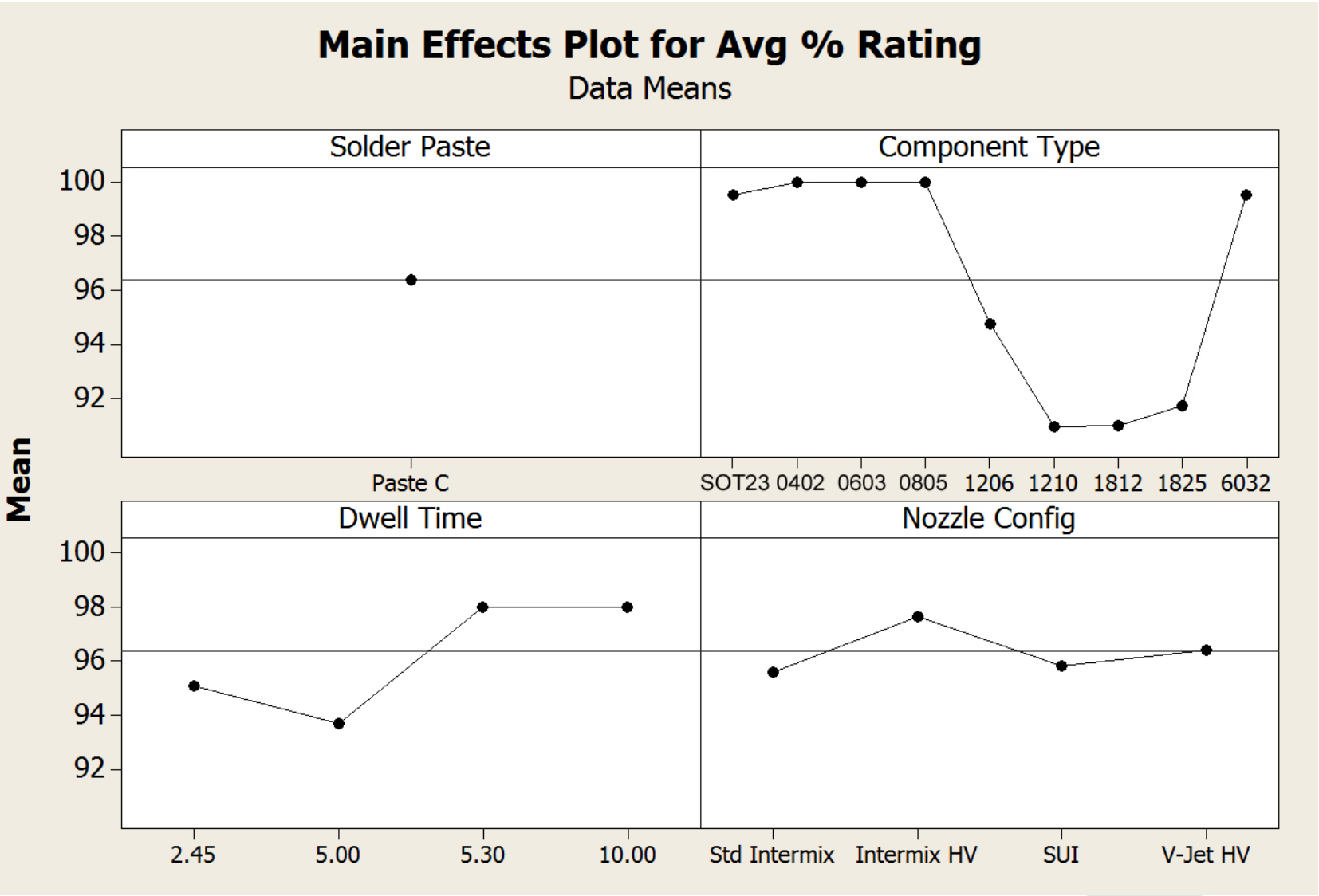
IPC
Association Connecting Electronics Industries

SMTA
Surface Mount Technology Association



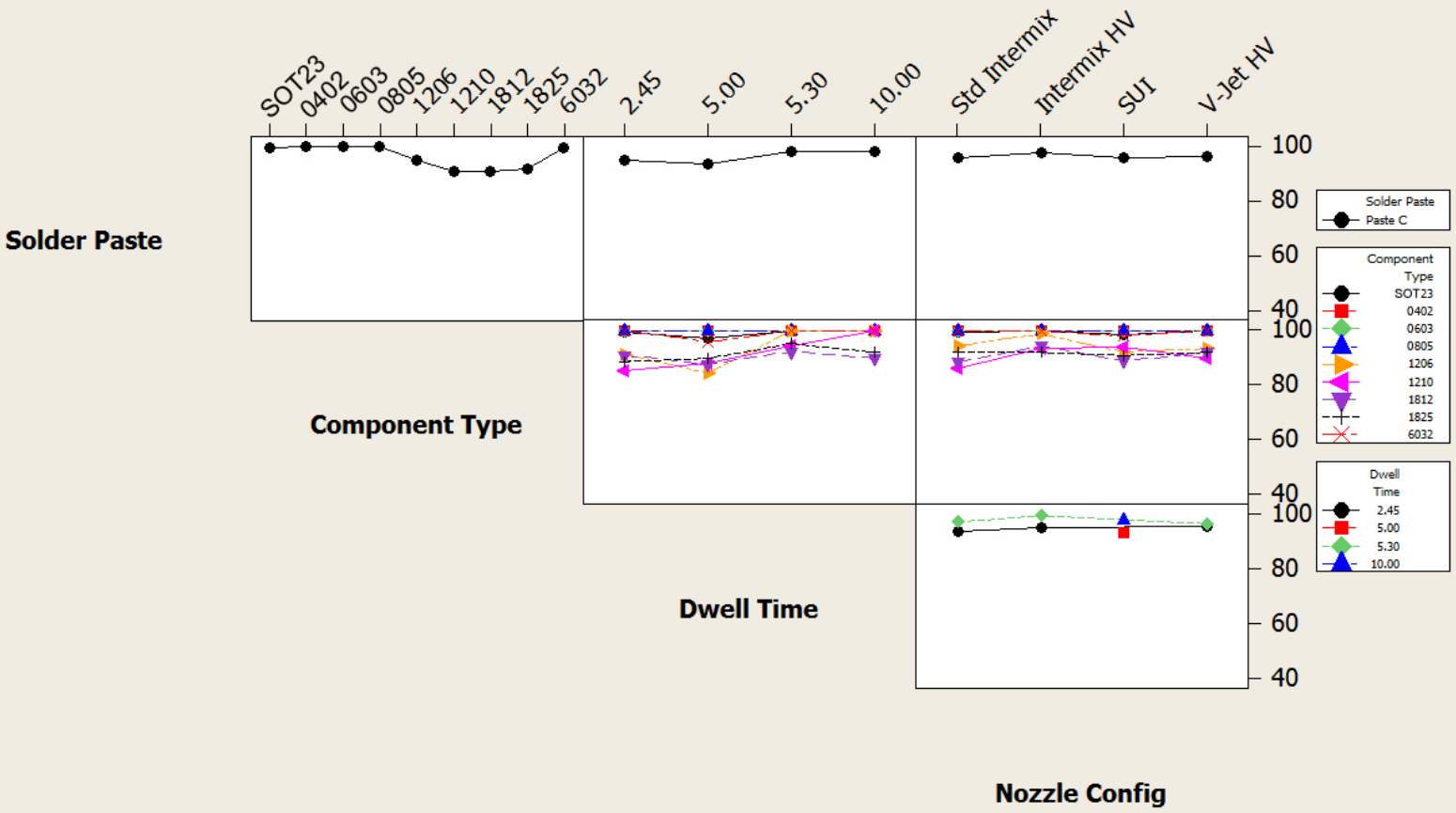
Association Connecting Electronics Industries

Surface Mount Technology Association



IPC
Association Connecting Electronics Industries

SMTA
Surface Mount Technology Association



Association Connecting Electronics Industries

Surface Mount Technology Association

Results

- Visual inspection results:
- No clean
  - Best results at 5 min dwell:
    - Intermix high volume: 98%
    - Standard Intermix: 96%
    - V-Jet HV: 95%
    - SUI achieved 86% required 10 min dwell

Results

- Visual inspection results:
- RMA
  - Best results at 5 min dwell:
    - Intermix high volume: 99%
    - Standard Intermix: 97%
    - V-Jet HV: 97%
    - SUI achieved 98% - required 10 min dwell

Results

- Visual inspection results:
- Water Soluble
  - Best results at 0.55 min dwell:
    - V-Jet HV: 99%
  - Best results at 1.06 min dwell
    - Intermix high volume: 99%
    - Standard Intermix: 97%
    - SUI achieved 99% - required 2 min dwell

Results

- Ion Chromatography Analysis: Lead-free, No Clean

Anion Species (µg/in^2)									
Ionic Species	Maximum Contamination Levels	Dwell Time (min) / Nozzle							
		5.3 / HVVJ	2.45 /HVVJ	10 / SUI	5 / SUI	5.3 / SI	2.45 / SI	5.3 / IHV	2.45 / IHV
Fluoride (F^-)	3	0.1001	0.0351	0.0472	ND	0.0615	0.0451	0.0964	0.0882
Acetate ($C_2H_2O^-_2$)	3	ND	ND	ND	ND	ND	ND	ND	ND
Formate ($CH_2O^-_2$)	3	0.1719	ND	0.5733	ND	0.4883	0.1809	0.5802	0.2883
Chloride (Cl^-)	4	0.0855	0.095	0.1877	0.239	0.1861	0.1026	0.1163	0.1068
Nitrite (NO_2^-)	3	0.5136	0.4307	0.4559	0.6196	0.6103	0.5827	0.7383	0.6554
Bromide (Br^-)	10	1.9635	ND	ND	ND	ND	ND	ND	1.9272
Nitrate (NO_3^-)	3	ND	1.5343	1.3299	1.496	1.6405	1.2496	1.2785	ND
Phosphate (PO_4^{2-})	3	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate (SO_4^{2-})	3	ND	ND	ND	ND	ND	ND	ND	ND
WOA (Weak Organic Acid)(MSA)	25	ND	ND	ND	0.336	ND	ND	ND	ND

Results

- Ion Chromatography Analysis: Lead-free, No Clean

Cation Species (µg/in^2)									
Ionic Species	Maximum Contamination Levels	Dwell Time (min) / Nozzle							
		5.3 / HVVJ	2.45 /HVVJ	10 / SUI	5 / SUI	5.3 / SI	2.45 / SI	5.3 / IHV	2.45 / IHV
Lithium (Li^+)	3	ND	ND	ND	ND	ND	ND	ND	ND
Sodium (Na^+)	3	0	0	0	0	0	0	0	0
Ammonium (NH_4^+)	3	0.3911	0.3612	0.3979	0.3354	0.3468	0.573	0.3620	0.3321
Potassium (K^+)	3	0	0	0	0	0	0	0	0
Magnesium (Mg^{2+})	1	ND	ND	ND	ND	ND	ND	ND	ND
Calcium (Ca^{2+})	1	ND	ND	ND	ND	ND	ND	ND	ND

Results

- Ion Chromatography Analysis: Lead-free, RMA

Anion Species (µg/in^2)									
Ionic Species	Maximum Contamination Levels	Dwell Time (min) / Nozzle							
		5.3 / SI	2.45 / SI	5.3 / IHV	2.45 / IHV	5.3 / HVVJ	2.45 / HVVJ	10 / SUI	5 / SUI
Fluoride (F^-)	3	ND	0.0059	0.0304	ND	ND	0.0502	0.0615	0.0719
Acetate ($C_2H_2O^-_2$)	3	ND	ND	ND	ND	0.404	ND	ND	ND
Formate ($CH_2O^-_2$)	3	0.2707	ND	ND	0.0869	ND	ND	ND	0.3973
Chloride (Cl^-)	4	0.0044	0.0429	0.0441	0.0316	0.0332	0.0062	0.0414	0.0473
Nitrite (NO_2^-)	3	0.3127	0.3015	0.4234	0.3002	0.4266	0.3226	0.3791	0.2674
Bromide (Br^-)	10	2.2608	2.2178	2.0314	1.9723	1.9866	1.7267	1.5558	1.9785
Nitrate (NO_3^-)	3	ND	ND	ND	ND	ND	ND	ND	ND
Phosphate (PO_4^{2-})	3	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate (SO_4^{2-})	3	ND	ND	ND	ND	ND	ND	ND	ND
WOA (Weak Organic Acid)(MSA)	25	ND	0.2214	0.2067	0.336	0.0648	ND	0.8593	ND

Results

- Ion Chromatography Analysis: Lead-free, RMA

Cation Species (µg/in^2)									
Ionic Species	**Maximum Contamination Levels**	**Dwell Time (min) / Nozzle**							
		5.3 / SI	**2.45 / SI**	**5.3 / IHV**	**2.45 / IHV**	**5.3 / HVVJ**	**2.45 / HVVJ**	**10 / SUI**	**5 / SUI**
Lithium (Li^+)	3	ND	ND	ND	ND	ND	ND	ND	ND
Sodium (Na^+)	3	0.0502	0.1105	0.0323	0	0	0	0	0.1148
Ammonium (NH_4^+)	3	0.8365	0.7631	0.8239	0.8975	0.752	1.1694	1.2491	1.239
Potassium (K^+)	3	0	0	0.072	0	0	0	0	0
Magnesium (Mg^{2+})	1	ND	ND	ND	ND	ND	ND	ND	ND
Calcium (Ca^{2+})	1	ND	ND	ND	ND	ND	ND	ND	ND

IPC
Association Connecting Electronics Industries

SMTA
Surface Mount Technology Association

Results

- Ion Chromatography Analysis: Lead-free, Water Soluble

Anion Species (µg/in^2)									
Ionic Species	Maximum Contamination Levels	Dwell Time (min) / Nozzle							
		1.06 / SI	0.55 / SI	1.06 / IHV	0.55 / IHV	1.06 / HVVJ	0.55 / HVVJ	2 / SUI	1.66 / SUI
Fluoride (F^-)	3	0.0141	0.1122	0.0204	0.0151	0.0583	0.0282	0.0474	0.0153
Acetate ($C_2H_2O^-_2$)	3	ND	1.8145	ND	ND	ND	ND	ND	ND
Formate ($CH_2O^-_2$)	3	0.2973	0.0955	0.2051	0.4298	0.1856	0.1286	0.2874	0.5154
Chloride (Cl^-)	4	ND	ND	ND	ND	ND	ND	ND	ND
Nitrite (NO_2^-)	3	0	0	0	0	0	0	0	0
Bromide (Br^-)	10	0.3947	0.3472	0.3018	1.2257	1.2286	0.9655	0.4687	1.1503
Nitrate (NO_3^-)	3	0.3856	0.5032	0.5069	ND	ND	ND	ND	ND
Phosphate (PO_4^{2-})	3	ND	ND	ND	ND	ND	ND	ND	ND
Sulfate (SO_4^{2-})	3	ND	ND	ND	ND	ND	ND	ND	ND
WOA (Weak Organic Acid)(MSA)	25	ND	ND	ND	ND	ND	ND	ND	ND

Results

- Ion Chromatography Analysis: Lead-free, Water Soluble

Cation Species (µg/in^2)									
Ionic Species	**Maximum Contamination Levels**	**Dwell Time (min) / Nozzle**							
		1.06 / SI	**0.55 / SI**	**1.06 / IHV**	**0.55 / IHV**	**1.06 / HVVJ**	**0.55 / HVVJ**	**2 / SUI**	**1.66 / SUI**
Lithium (Li^+)	3	ND	ND	ND	ND	ND	ND	ND	ND
Sodium (Na^+)	3	0.0497	0.0238	0.0521	0.0271	0.0104	0.0552	0.0477	0.0081
Ammonium (NH_4^+)	3	1.2615	1.3633	1.1063	1.2014	1.2762	1.3897	1.3055	1.0912
Potassium (K^+)	3	0.23	0.1711	0.3385	0.1983	0.2181	0.3142	0.1772	0.1622
Magnesium (Mg^{2+})	1	ND	ND	ND	ND	ND	ND	ND	ND
Calcium (Ca^{2+})	1	ND	ND	ND	ND	ND	ND	ND	ND

IPC Association Connecting Electronics Industries

SMTA Surface Mount Technology Association

Conclusion

- Spray bar configuration and nozzle design and utilization impacts mechanical energy generated
- Water soluble residue is easiest to clean followed by RMA and No Clean
- Intermix high volume nozzles provided the best overall cleaning result

Conclusion

- Lead-Free flux no-clean flux residues are harder to clean
- Cleaning agent that matches up with the residue is critically important
- Mechanical Energy is critically important
  - Most component gaps are filled with flux residue
  - Deflective energies are needed to move the cleaning agent to soil
  - Break through will be required to create a flow channel
  - Longer wash (dwell) times will be required

Reinventing the Wheel

Questions?

Association Connecting Electronics Industries

Surface Mount Technology Association