CHALLENGING CURRENT CUSTOMER REQUIREMENT OF CHANGING PROCESS THAT RESULTED TO QUALITY PROBLEMS – A SIX SIGMA PROJECT REDUCTION OF IN-PROCESS DEFECT RATE IN SOLDER PASTE PRINTING PROCESS

Luz M. Arenas
Airene S. Matienzo
Loraine M. Lopez

Manufacturing Systems, Manpower Services, Assembly Production
GRUPPO EMS INC.
117 Technology Avenue, SEPZ Laguna Technopark, Bińan, Laguna 4024
luzm@ems.com.ph
airenem@ems.com.ph
lorainel@ems.com.ph

ABSTRACT

As PCBA technology advances, improving of process capability, automation and product quality are the key improvements that every Electronics Manufacturing Services (EMS) companies are aiming, **following customer requirement to use Surface Mount Technology (SMT) process for Pin Through Hole (PTH) Component**. With this, the team experimented to utilize the SMT Mounter Machine and SMT Reflow Curing Process for PTH Component mounting process, **which originally being processed through manual insertion and solder wave process**.

However, this process caused quality issue which resulted to **62.4%** of the problem amounting to **Php.4,000,000** cost impact for just eight months. This triggers the team to prioritize, otherwise it will incur huge rejection cost to the company. **It gives a challenge to satisfy Customer requirement of changing the current process**.

A thorough analysis through Six Sigma approach pinned down the root cause of the problem at SMT Mounter Machine and Reflow Curing Process. Through a combination of multi-level Pareto Analysis, Root cause analysis, Simulation and Experimentation (DOE), the team identified the Pin Through Hole Component material design was the main cause.

Design of experiment with Failure Mode and Effect Analysis (FMEA) was conducted that resulted to elimination of the problem and prevented the potential loss of the company projected to Php6,000,000 annually if not resolved. It also raised the product's quality concurrently.

1. 0 INTRODUCTION

As Pin Through Hole components originally being mounted manually, it is great challenge to provide the same, if not better, result in terms of quality by using SMT Mounter Machine and Reflow Curing Process. During the first 8 months of production run, 62.4% rejection occurred in SMT which amounts to Php. 4,000,000 cost impact.
With that, the team provided a solution for the problem which aims to eliminate the SMT defects caused by automation of PTH mounting process, and simultaneously improve the product quality.

1.1 Problem Statement

In the last 8 months, 62.4% of defects on the SMT Process were contributed by Solder Paste Printing Process, causing significant impact on the company's financials amounting up to Php. 6,000,000 in annual computation due to rework and its inability to produce conforming products, thus affecting delivery commitments, customer requirement, and sales.

Through data gathering and Multi-level Pareto analysis, Insufficient Solder on Pin Through Hole -PTH (CN206) was identified to be the top contributor of the SMT defects. To fully understand the reason why the PTH is the top contributor, team used the root cause analysis, simulation and experimentation through Six Sigma approach as seen on Figure 1 and 2. As a result, the team identified that the **material design** of the Pin Through Hole component, specifically its **pin length** which exceeded to maximum requirement, is the main cause.

Figure 1. Comparison of Pin Length Requirement versus Actual Material

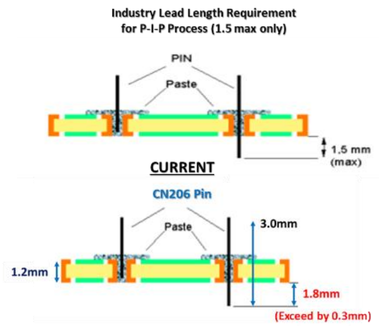
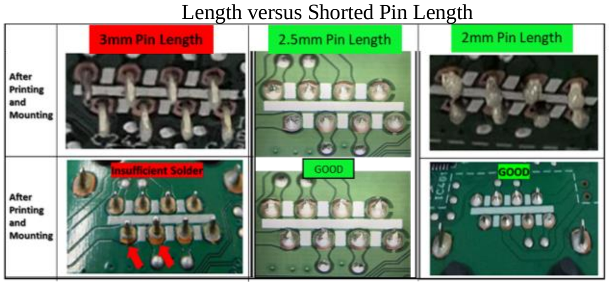


Figure 2. Solder Condition Comparison
Length versus Shorted Pin Length



1.2. Project Objective

The project's main objective is to ponder for solution to eliminate Insufficient Solder defect on PTH Component (CN206) and prevents the potential loss of the company projected to Php6,000,000 annually.
Simultaneously, it aimed to improve the quality of the product.

1.3. Understanding the Problem

Solder Paste Printing is the most vital process in SMT Assembly where solder paste is applied onto the PCB through the use of Stencil and Squeegee as seen on Figure 3.

Figure 3. Solder Paste Application Machine and its key Process Inputs

This process requires careful approach since the solder applied need to have enough volume for the component to adhere into the PCB to have electrical and mechanical bonding. In this process, Insufficient Solder on CN206 occurs as seen on Figure 4. There is not enough solder paste to connect the pin of the component with the PCB pad since the solder paste adheres on the tip of the pin as it pushed out the solder paste due to its long pin length.

Figure 4. Insufficient Solder on CN206

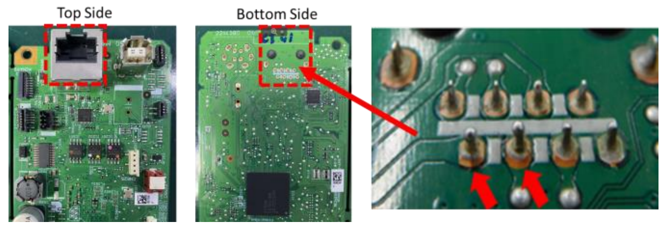


Illustration of component mounted no PCB

Insufficient Solder

2.0 REVIEW OF RELATED WORK

Pin in Paste Application Note
Littelfuse Inc.

"The **Pin in Paste method**, also called through-hole reflow technology, has become increasingly important during the past few years. Reaching a higher degree of automation with existing manufacturing equipment is one primary advantage. Further advantages are as follows:

- Elimination of the soldering by hand or wave methods
- Reduction in manufacturing floor space
- Reduction in manufacturing equipment - consequently in investment cost
- Compatible with the existing processes
- Use of no-clean soldering process possible
- Higher reliability at PC board level due to fewer soldering processes
- Lower heating stress at the component level"

3.0 METHODOLOGY

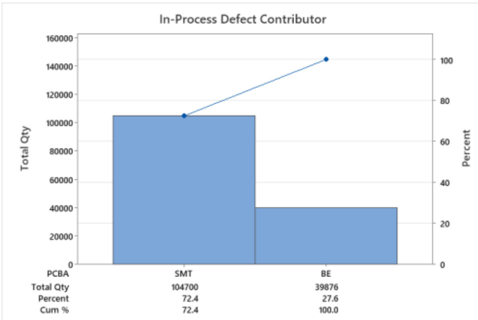
The teams gather and consolidates the monthly overall In-Process Defect Rate that includes both SMT and Back-End (BE) for EPSON IJP (Ink Jet Printer) of EPPI-STXP Business Unit.

At PCBA in general, Solder Paste Printing (SP) was the most critical as this is the first process, any abnormality on Solder Paste Printing will also manifest solder anomalies in Parts Mounting (e.g. Missing due to No Solder) and Reflow Process (e.g. Tombstone due to mis-align print).
Thus, SP Printing needs to be prioritized for improvement.

3.1 Define Phase – Define the problem

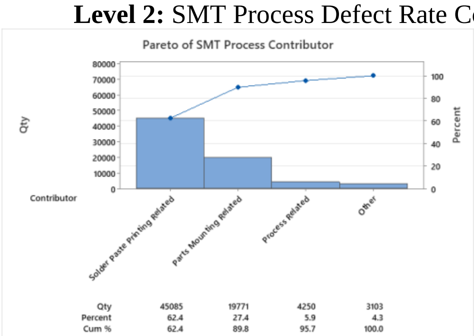
Multi-level Pareto Analysis – problem identification

Level 1: In-Process Defect Contributor per Area



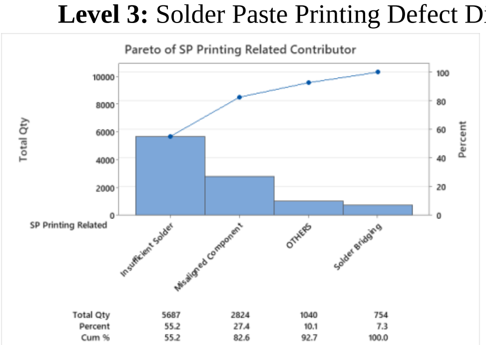
Level 1 Pareto shows SMT Process contributes 72.4% of the In-Process Defects

Level 2: SMT Process Defect Rate Contributor



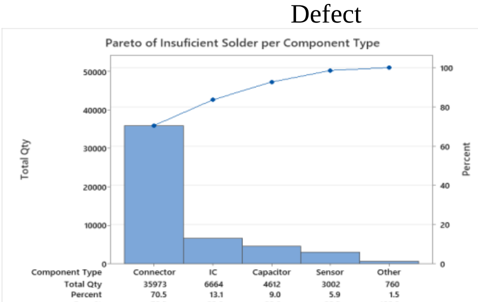
Level 2 Pareto shows, the Solder Paste Printing Process related was the top contributor with 62.4%.

Level 3: Solder Paste Printing Defect Distribution



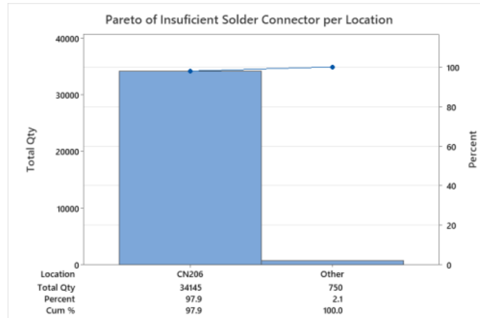
Level 3 Pareto shows, Insufficient Solder was the highest percentage of SMT In-Process Defect with 55.2% contribution.

Level 4: Component Distribution of Insufficient Solder Defect



Level 4 Pareto shows, Connector component has the majority of contribution with almost 70% of Insufficient solder defects.

Level 5: Connector Location Distribution of IS Defect



Level 5 Pareto shows, based on contribution drill down, CN206 location was the top location contributor as shown on the graph above.

3.2 Measure Phase – Measure the problem

Process Root Cause:

Among the unit models, **CN206 component was considered as PTH connector and is more recommended to be manually inserted and processed at solder wave**, however **Customer requested to apply a special process for this component which is the Pin-in-Paste (PIP) Solder Process** or through Surface Mount Technology (SMT) and Reflow Curing Process, and resulted to Insufficient Solder.

It is also known as Intrusive Reflow, Pin in hole reflow (PIHR), Pin-Through-Paste Process, and multi-spot soldering.

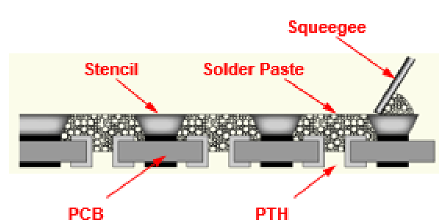
Following this request, the team conducted thorough study and analyze Customer requirement based on 2 key areas for CN206: **Process Root Cause** and **Detection Capability.**

3.2.1 P-I-P Basic Process Flow:

3.2.1.1 SMT and Through Hole device will be soldered ONLY IN ONE process.

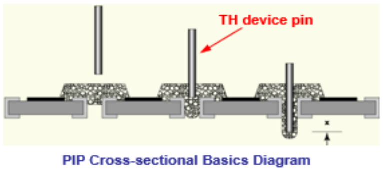
3.2.1.2 Solder paste is printed on top of the pin-through-holes (PTH) together with SMT as shown on Figure 5.

Figure 5. Pin-in-Paste Printing Process



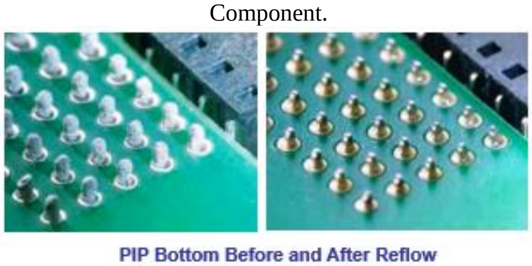
3.2.1.3 SMT and PTH components are mounted on the surface of the PCB as shown on Figure 6.

Figure 6. PTH Component Mounting at SMT Process.



3.2.1.4 The PCB will go through reflow and the solder paste will cure and adhere at the bottom component pin while also filling the via-holes, creating electrical and mechanical bond as shown on Figure 7.

Figure 7. Sample picture of PIP Process used in a PTH Component.

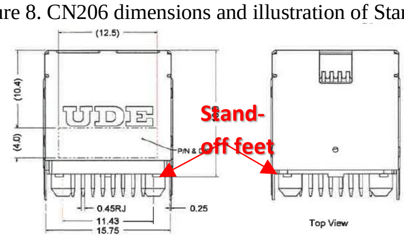


3.2.2. P-I-P Process Limitations:

3.2.2.1 Pint Through Hole (PTH) parts should be rated to withstand reflow temperatures, usually at 250°C. Reflow profiles will have to accommodate PIP thermal density together with the SMT population.

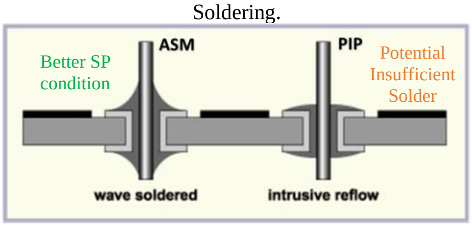
3.2.2.2 PTH parts should have sufficient bottom flush space or stand-off feet for solder paste to flow. Paste cannot flow inside the hole if the part bottom is totally blocking the PTH via holes as shown on Figure 8.

Figure 8. CN206 dimensions and illustration of Stand-off feet.



3.2.2.3 PIP fillets form a more concave shape while wave solder has a more convex fillet shape which may cause potential Insufficient Solder.

Figure 9. ASM (Auto Soldering Machine) versus PIP (Pin-In-Paste) Soldering.



3.3 Analyze Phase – Analyze the problem

ROOTCAUSE ANALYSIS SUPPORTED BY DESIGN OF EXPERIMENT ON THE FOLLOWING FACTORS:

1.Solder Paste Mixing Method
2.SP Cooling Unit Temperature
3.Component Pin Length
4.Solder Paste / Stencil Design
5. Solder Paste Printing Program / Cleaning Program

X's	Description		Current	Proposed	Metric/Response	Description	Analysis Methodology	Tools
X1	Solder Paste Mixing Method		Manual Mixing - 36 Stirs	Auto Mixing Auto Mixing + Manual Mixing	Defect Rate, Solder Paste Viscosity	Solder Paste Viscosity	Improve Solder Paste Viscosity, Uniformity of Mixing method	Normality Test, One Way ANOVA, Test for Equal Variances (Multiple Comparison)
X5	SP Cooling Unit Temperature		No Monitoring	20 - 26 degC	Defect Rate	Solder Paste Viscosity Solder Paste Temp Requirement	Eliminate hardening of Solder Paste, Maintain good solder paste rolling at Stencil	Normality Test, 2 sample T, Test for Equal Variance
X6	Component Pin Length		3mm	2mm	Defect Rate	Component Design Solder Paste wetting of Pin to PCB Pad	Different measurement pin length of CN206 to improve solder paste wetting from pin to pad	Normality Test,2 sample T, Test for Equal Variance
X7	Stencil Design		0.11 mm Stencil Thickness	Step-up Design 0.2 mm	Defect Rate	Solder Paste Height/Volume	Increase Solder Deposit on CN206 thru Solder Paste Height/Volume	Normality Test, 2 sample T, Test for Equal Variance
X17	Solder Paste Printing/Cleaning Program	X2- Printing Pressure X3 - Printing Speed X4 - Print Gap X8 - Stencil Cleaning	Current Parameter	Optimized Parameter	Solder Paste Height/Volume, Defect Rate	Optimization of SP Parameters Solder Paste Height	Optimization of printing/cleaning parameter, Solder Paste Height/Volume Measurement	Normality Test, 2 sample T, Test for Equal Variance

See Appendix A.

SUMMARY OF IMPROVEMENT FOCUS (ROOTCAUSE)

X's	Description		Metric/Response	Current	Proposed	Result: Mean Analysis	Result: Variance Analysis	Remarks
X1	**Solder Paste Mixing Method**		**Defect Rate**	Manual Mixing - 36 Stirs	Auto Mixing + Manual Mixing	**Significant**	**Significant**	**Proceed to IMPROVE Phase**
			Solder Paste Viscosity			**Significant**	Not Significant	
X5	**SP Cooling Unit Temperature**		**Defect Rate**	No Monitoring	20 - 26 degC	**Significant**	**Significant**	**Proceed to IMPROVE Phase**
X6	**Component Pin Length**		**Defect Rate**	3mm	2.5mm	**Significant**	**Significant**	**Proceed to IMPROVE Phase**
X7	Stencil Design		Defect Rate	0.11 mm Stencil Thickness	Step-up Design 0.2 mm on CN206 area	**Based on PIP computation, changes on stencil thickness to increase Solder Paste Volume will be a significant on Defect Rate of CN206.** ***This factor is significant but WILL NOT proceed fabrication of stencil (step-up of CN206) as advised by Customer due to may damaged the squeegee straightness and affect printing on adjacent apertures.***		
X17	Solder Paste Printing/Cleaning Program	X2- Printing Pressure X3 - Printing Speed	Solder Paste Height/Volume	Current Parameter (Parameter 1)	Optimized Parameter (Parameter 2)	**Significant**	Not Significant	
		X4 - Print Gap X8 - Stencil Cleaning	Defect Rate			**Significant**	Not Significant	

See Appendix B.

3.3.1 FACTOR 1: SOLDER PASTE VOLUME / STENCIL DESIGN

Solder Paste Volume required for PIP vs. Stencil Design:

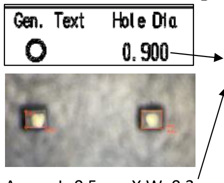
- If the solder paste volume is not enough, insufficient solder defects occur.
- Computation of volume thru getting existing area of stencil aperture of the 4 affected pins based on the Stencil Gerber file, actual PCB thru hole and actual CN206 component.

3.3.1.1. Analysis

Based on the actual measurement of the current stencil design for CN206, the measured total area of the aperture used on existing stencil design is only 7.5869 mm² compared to the computed requirement area of 10.39 mm². This is the required aperture area to have a good barrel fill and fillet on connector CN206.

Figure 10: CN206 connector volume computation for PIP process

Figure 10.1 CN206 Connector

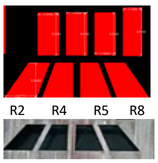


1. PCB: CN206 Connector

Item	Uom	Data	Remarks
Diameter of PCB Hole	mm	0.9	
Component pin (AREA)	mm²	0.15	RJ45 Pin
Annular ring	mm	1.4	
PCB thickness	mm	1.2	

Area = L: 0.5mm X W: 0.3mm

Figure 10.2 Actual CN206 Stencil solder paste area

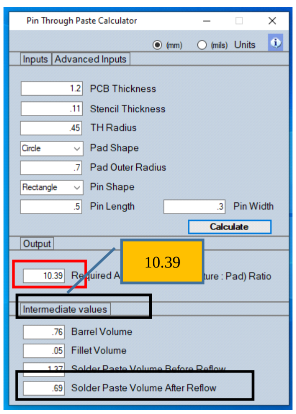


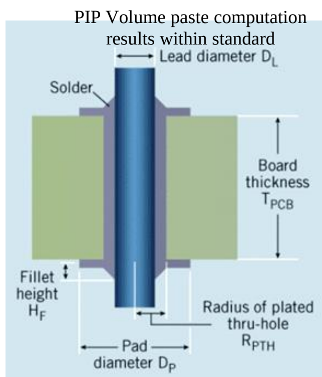
2. CN206 Stencil

Item	Uom	Data	Remarks	Volume
R2	mm²	7.9165	Area was	0.870815
R4	mm²	7.2574	computed	0.798314
R5	mm²	7.2574	based on	0.798314
R8	mm²	7.9165	stencil design	0.870815
Stencil Thickness	mm²	0.11		
Average		7.58695		0.834565

The result shows Insufficient Solder

Figure 10.3 Computed CN206 Required Solder paste area and result



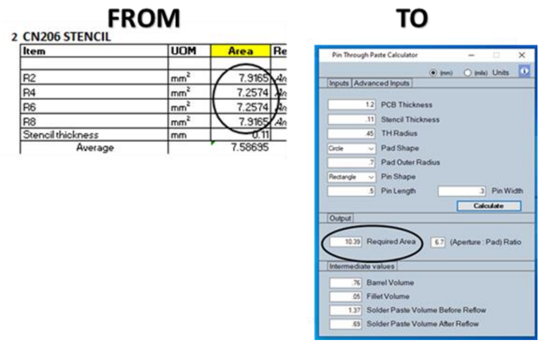


1. Computing for the volume, computed solder paste volume before reflow is 1.37 mm^{3,} (see figure 10.3) however compared to the actual computed average of 0.8345 mm^3. (see figure 10.3)
2. There is an indication that the stencil aperture opening is not sufficient to provide enough solder/fillet at CN206 connector up to bottom side.

3.3.1.2. Stencil Design Revision that may cause Insufficient Solder

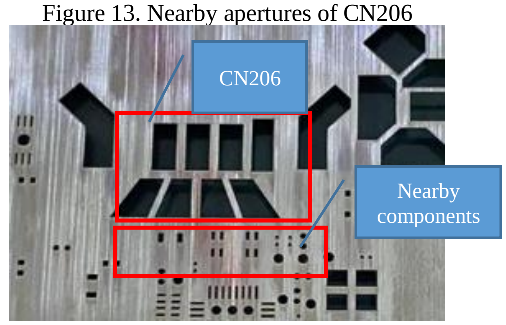
1. Revised stencil design and increase aperture size opening /area to accommodate more paste without affecting the other components, increase to total area of the aperture from 7.5mm^2 of 10.9mm2 based on computation.

Figure 12. Computation of proposed Solder paste volume for CN206



Assessment: However, there will be limitation on resizing the CN206 aperture design to increase the area to meet the volume, due to nearby adjacent components that may occur solder bridging.

Figure 13. Nearby apertures of CN206

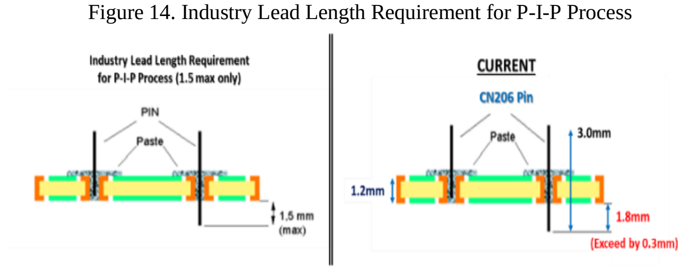


3.3.2 FACTOR 2: COMPONENT PIN LENGTH

Required Pin Length for PIP Process

- The required lead length of the component is dependent on the thickness of the PC board.
- Very long component pin can push out too much paste and thus during reflow soldering, the solder cannot flow back to the solder joint.
- If the component pin length is longer than the board thickness, the lead length protruding from the bottom of the board should not exceed 1.5mm.
- The actual thickness of board is 1.2mm, whereby the CN206 component lead length is 3.0mm. Thus, the actual lead length of CN206 in reference with the board thickness is 1.8mm – **therefore the CN206 current lead length is a factor for the Insufficient Solder.**

Figure 14. Industry Lead Length Requirement for P-I-P Process



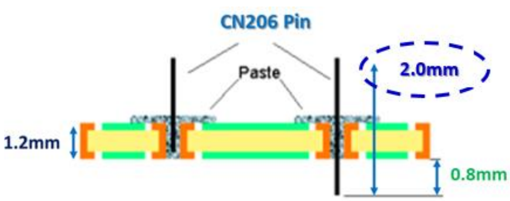
As shown on Figures 14, CN206 lead length protruding is 1.8 mm, longer by 0.3mm than the ideal length of 1.5mm

3.3.2.1 Design of Experiment on Shorted Pin Length

Using Design of Experiment, simulation was conducted to determine if the pin length is the main factor.

DOE 1: Using 2mm pin length, dummy test run was conducted (8pcs) and resulted to zero (0) defect on Insufficient solder for CN206 location.

Figure 15. 2.0mm Pin Length



- The measured pin length is 2.0mm minus the PCB thickness (1.2mm), this will result to 0.8 mm.
- Thus, CN206 deposit paste will flow back to solder joint/PTH pad and completely form a fillet 360 degrees to PTH.

Figure 16. Dummy test run using 2.0mm pin length

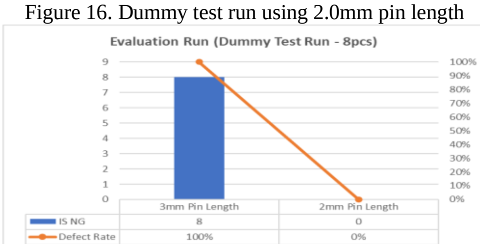
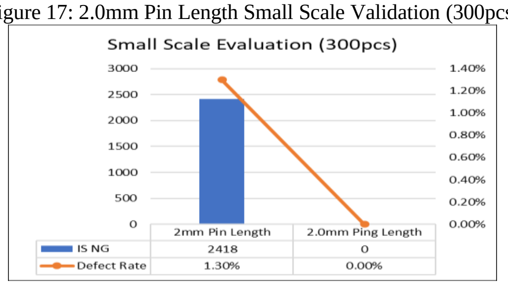


Figure 17: 2.0mm Pin Length Small Scale Validation (300pcs)

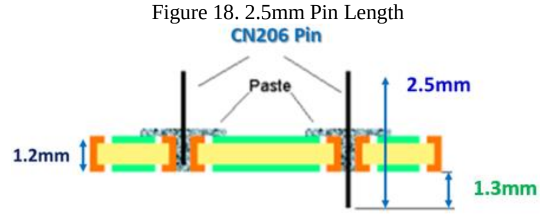


From, **1.30%** defect rate, it was subsided to **0%** & defect rate by using the 2mm pin length of CN206. **Component Pin Length reduction from 3mm to 2mm.**

Proven effective on initial evaluation of trimming 308pcs to 2mm – all CN206 pins meet the required solder fillet – 100% good.

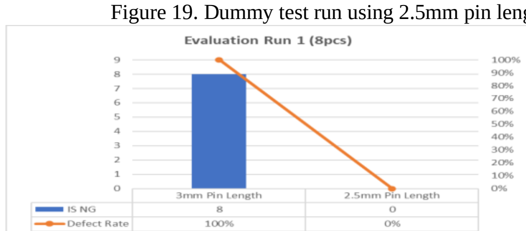
DOE 2: Using 2.5mm pin length, dummy test run was conducted (8pcs) and resulted to zero (0) defect on Insufficient solder for CN206 location.

Figure 18. 2.5mm Pin Length



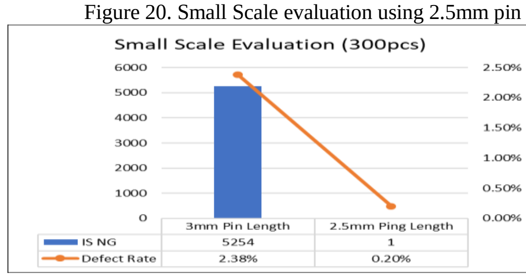
- The measured pin length is 2.5mm minus the PCB thickness (1.2mm), this will result to 1.3mm.

Figure 19. Dummy test run using 2.5mm pin length



Based on this simulation of **2.5mm** pin length of CN206, Insufficient Solder **will still be eliminated**.

Figure 20. Small Scale evaluation using 2.5mm pin length



Based on this evaluation result 299/300 Passed on Good on solderability on CN206 (0.20% defect rate),

Assessment: It is concluded, during the design of experiment on 2mm and 2.5mm pin length, that **current pin length is the main cause of Insufficient Solder** and **shortening its length solves the problem based on DOE**, both 2.5mm and 2.0mm is proven effective on solving the problem of Insufficient Solder but **2.0mm** was found to be the optimum design which resulted to elimination of defect Insufficient Solder on CN206.

3.4 Improve Phase – Solve the problem

Using design of experiment, it was identified that reduction from 3.0 mm to 2.0mm and 2.5mm pin length will both improve the defect rate of Insufficient Solder CN206.

For the deployment of this improvement, discussion with the customer was conducted and it was approved that the reduction would be **from 3.0mm to 2.5mm**. This change was immediately coordinated with the part supplier.

In April 2024, the reduced pin length of CN206 arrived and was used for mass production.

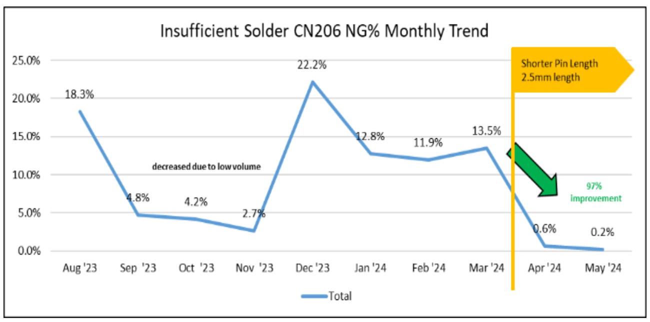
3.5 Control Phase – Maintain the solution

Revision of Process Control Plan for Parts Preparation, Kitting and Issuance process to include sampling measurement of CN206 pin length. The customer also changed the part number of PTH component CN206 and updated it in the Bill of Materials (BOM). See Appendix C.

4.0 RESULTS AND DISCUSSION

The figure below shows the significant reduction rejection rate trend of Insufficient Solder on CN206 after implementation of shorter pin length (2.5mm).

Data shows, **97% improvement** was observed on first two months of implementation compared to the average data from previous eight months, which significantly made an impact on cost savings of the company and better quality.



5.0 CONCLUSION

Based on the evaluation conducted, it is proven that shorter pin length solves the problem of Insufficient Solder on Pin Through Hole (CN206). Both evaluated pin length which are 2.5mm and 2mm is effective. With that, the team proposed to the customer for their approval to change the design of Pin Through Hole (CN206).
Even as this is a Major change on their product (Material Change / BOM Change), Customer pushed the changes on their Japan Product Development.

6.0 RECOMMENDATIONS

With the approval of customer, it is recommended to use 2.5mm pin length for Pin Through Hole Component. This design is also recommended to other PTH components for future the new models.

7.0 ACKNOWLEDGMENT

In every project's success comes with collaborative efforts and ideas of each involved departments. Product and Quality Engineering who led this project did an exceptional job.

The team also acknowledges the support and coordination of Production, Maintenance and Line Engineering team to make this project goes smoothly. The team is looking forward for future collaborations and success with them.

8.0 REFERENCES

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4. ***Pin-in-Paste Application Note*** *https://m.littelfuse.com/~/media/electronics_technical/application_notes/fuses/littelfuse_pin_in_paste_application_note.pdf*

9.0 ABOUT THE AUTHORS

Luz Arenas has been with Gruppo EMS Inc. for 3 years and 1 month, handling various roles. She's currently a Product Engineer for 1 year and 10 months, and was previously an Equipment Engineer for 1 year and 3 months. Before joining her current company, she's been with various Electronics Manufacturing Services Companies, that fortified her with the vital skills, knowledge, and experience on this line of profession. She graduated from the Lyceum of the Philippines University-Batangas with a Bachelor of Science Degree Major in Computer Engineering.

Loraine Lopez has been working as Quality Engineer for 8 years from different industry. She has been serving Gruppo EMS, Inc. in various business units for the past 6 years. She has a Bachelor of Science in Industrial Engineering from Lyceum of the Philippines University-Cavite, that equipped her with the analytical thinking skills which is required on her current job position.

Airene Matienzo has been working as a Quality Assurance Engineer for 6 years, currently serving at Gruppo EMS for 2 years. She earned a Bachelor of Science degree in Mechanical Engineering from Laguna University. Her education and experience provide her with the knowledge and skills that she is now contributing to the company.

10. APPENDICES

Appendix A. Factors to consider for Analyzing the problem

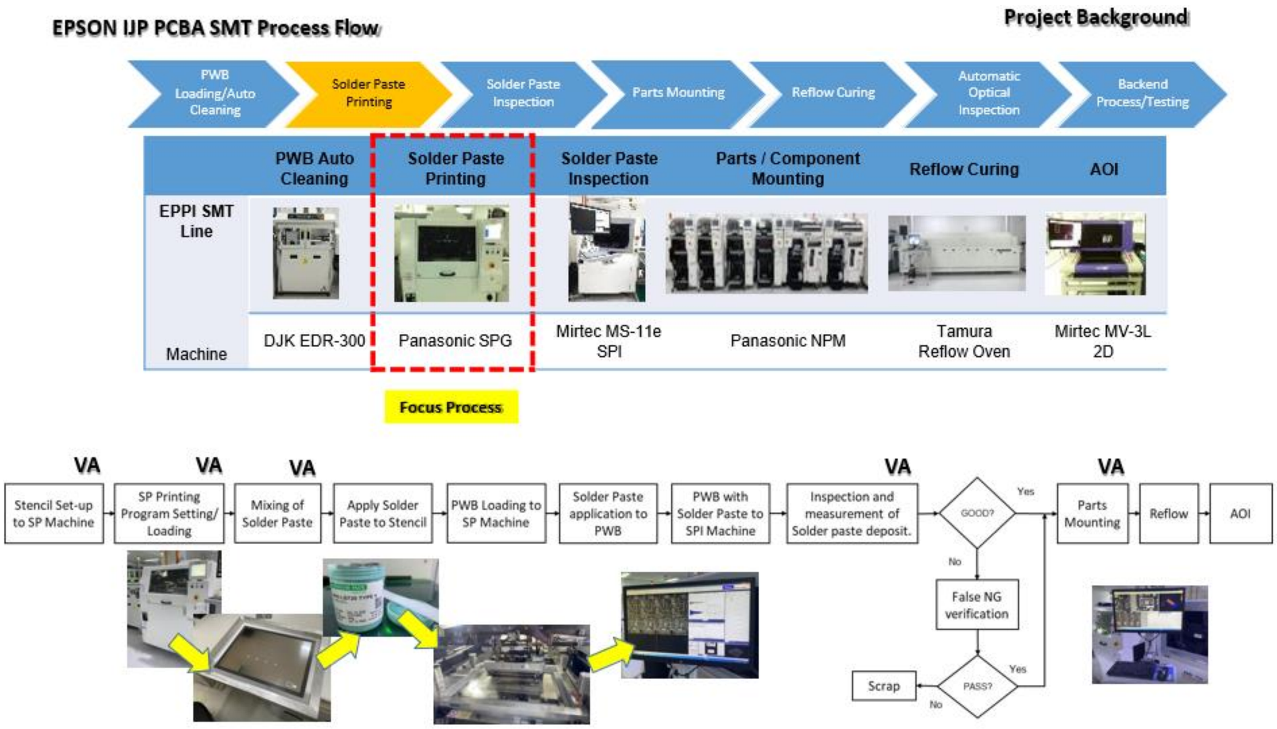
<table>
<tr><th>X's</th><th colspan="2">Description</th><th>Current</th><th>Proposed</th><th>Metric/Response</th><th>Description</th><th>Analysis Methodology</th><th>Tools</th></tr>
<tr><td>X1</td><td colspan="2">Solder Paste Mixing Method</td><td>Manual Mixing - 36 Stirs</td><td>Auto Mixing
Auto Mixing + Manual Mixing</td><td>Defect Rate, Solder Paste Viscosity</td><td>Solder Paste Viscosity</td><td>Improve Solder Paste Viscosity, Uniformity of Mixing method</td><td>Normality Test, One Way ANOVA, Test for Equal Variances (Multiple Comparison)</td></tr>
<tr><td>X5</td><td colspan="2">SP Cooling Unit Temperature</td><td>No Monitoring</td><td>20 - 26 degC</td><td>Defect Rate</td><td>Solder Paste Viscosity
Solder Paste Temp Requirement</td><td>Eliminate hardening of Solder Paste, Maintain good solder paste rolling at Stencil</td><td>Normality Test, 2 sample T, Test for Equal Variance</td></tr>
<tr><td>X6</td><td colspan="2">Component Pin Length</td><td>3mm</td><td>2mm</td><td>Defect Rate</td><td>Component Design
Solder Paste wetting of Pin to PCB Pad</td><td>Different measurement pin length of CN206 to improve solder paste wetting from pin to pad</td><td>Normality Test,2 sample T, Test for Equal Variance</td></tr>
<tr><td>X7</td><td colspan="2">Stencil Design</td><td>0.11 mm Stencil Thickness</td><td>Step-up Design 0.2 mm</td><td>Defect Rate</td><td>Solder Paste Height/Volume</td><td>Increase Solder Deposit on CN206 thru Solder Paste Height/Volume</td><td>Normality Test, 2 sample T, Test for Equal Variance</td></tr>
<tr><td rowspan="4">X17</td><td rowspan="4">Solder Paste Printing/Cleaning Program</td><td>X2- Printing Pressure</td><td rowspan="4">Current Parameter</td><td rowspan="4">Optimized Parameter</td><td rowspan="4">Solder Paste Height/Volume, Defect Rate</td><td rowspan="4">Optimization of SP Parameters Solder Paste Height</td><td rowspan="4">Optimization of printing/cleaning parameter, Solder Paste Height/Volume Measurement</td><td rowspan="4">Normality Test, 2 sample T, Test for Equal Variance</td></tr>
<tr><td>X3 - Printing Speed</td></tr>
<tr><td>X4 - Print Gap</td></tr>
<tr><td>X8 - Stencil Cleaning</td></tr>
</table>

Appendix B. Result of Study for each factors considered

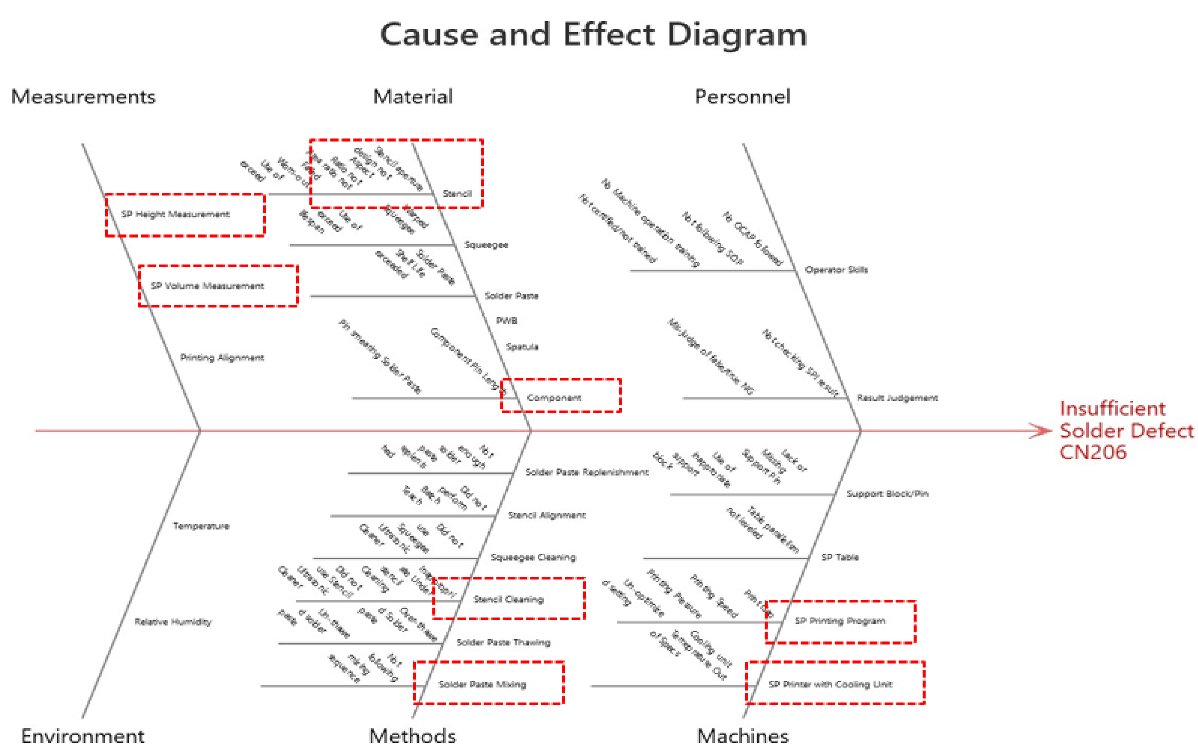
<table>
<tr><th>X's</th><th colspan="2">Description</th><th>Metric/Response</th><th>Current</th><th>Proposed</th><th>Result: Mean Analysis</th><th>Result: Variance Analysis</th><th>Remarks</th></tr>
<tr><td rowspan="2">X1</td><td colspan="2" rowspan="2">Solder Paste Mixing Method</td><td>Defect Rate</td><td rowspan="2">Manual Mixing - 36 Stirs</td><td rowspan="2">Auto Mixing + Manual Mixing</td><td>Significant</td><td>Significant</td><td>Proceed to IMPROVE Phase</td></tr>
<tr><td>Solder Paste Viscosity</td><td>Significant</td><td>Not Significant</td><td></td></tr>
<tr><td>X5</td><td colspan="2">SP Cooling Unit Temperature</td><td>Defect Rate</td><td>No Monitoring</td><td>20 - 26 degC</td><td>Significant</td><td>Significant</td><td>Proceed to IMPROVE Phase</td></tr>
<tr><td>X6</td><td colspan="2">Component Pin Length</td><td>Defect Rate</td><td>3mm</td><td>2.5mm</td><td>Significant</td><td>Significant</td><td>Proceed to IMPROVE Phase</td></tr>
<tr><td>X7</td><td colspan="2">Stencil Design</td><td>Defect Rate</td><td>0.11 mm Stencil Thickness</td><td>Step-up Design 0.2 mm on CN206 area</td><td colspan="3">Based on PIP computation, changes on stencil thickness to increase Solder Paste Volume will be a significant on Defect Rate of CN206.

This factor is significant but WILL NOT proceed fabrication of stencil (step-up of CN206) as advised by Customer due to may damaged the squeegee straightness and affect printing on adjacent apertures.</td></tr>
<tr><td rowspan="4">X17</td><td rowspan="4">Solder Paste Printing/Cleaning Program</td><td>X2- Printing Pressure</td><td rowspan="2">Solder Paste Height/Volume</td><td rowspan="4">Current Parameter (Parameter 1)</td><td rowspan="4">Optimized Parameter (Parameter 2)</td><td rowspan="2">Significant</td><td rowspan="2">Not Significant</td><td rowspan="2"></td></tr>
<tr><td>X3 - Printing Speed</td></tr>
<tr><td>X4 - Print Gap</td><td rowspan="2">Defect Rate</td><td rowspan="2">Significant</td><td rowspan="2">Not Significant</td><td rowspan="2"></td></tr>
<tr><td>X8 - Stencil Cleaning</td></tr>
</table>

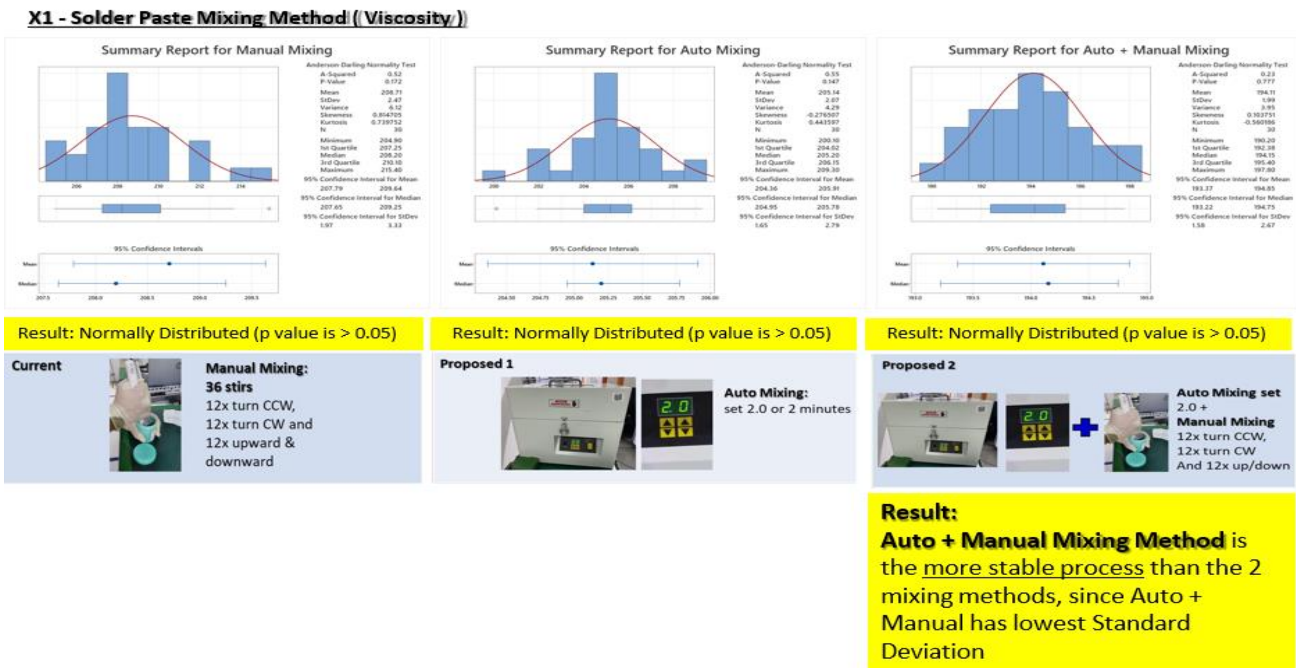
Appendix C. PCBA Process Flow



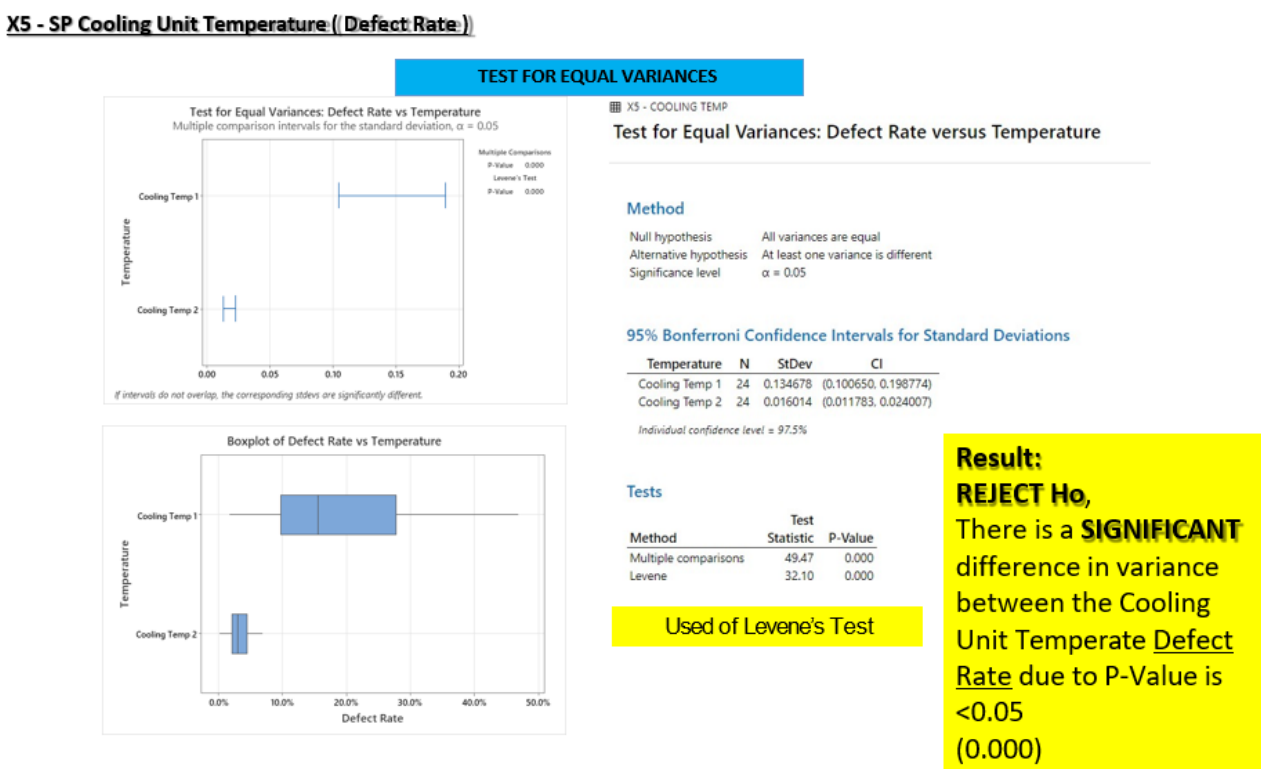
Appendix C. PCBA Process Flow



Appendix D. Factors analysis - Solder Paste



Appendix E. Factors analysis – Cooling Unit Temperature



Appendix F. Factors analysis – Pin In Paste (PIP)

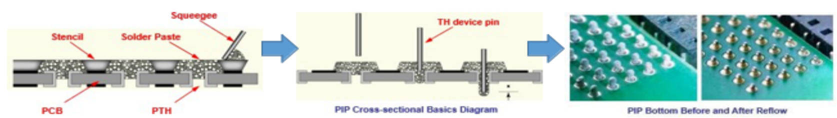
Technical Analysis for X6 and X7:

- Customer applied a special soldering process in CN206 called **Pin-in-paste (PIP) solder process.** It is also known as Intrusive Reflow, Pin in hole reflow (PIHR), Pin-Through-Paste Process, and multi-spot soldering.
- Below are analysis and requirement based on 2 key areas for CN206 : **Process Root Cause** and **Detection Capability.**

Process Root Cause:

1. P-I-P Basics:

1. SMT and Through Hole device will be soldered ONLY IN ONE process.
2. Solder paste is printed on top of the pin through holes (PTH) together with SMT.
3. SMT and PTH components are mounted on the surface of the PCB.
4. The PCB will go through reflow



2. P-I-P Process Limitations:

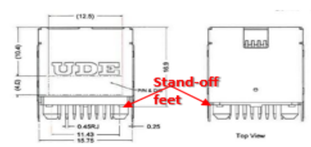
2.1 TH parts should be rated to withstand reflow temperatures. Reflow profiles will have to accommodate PIP thermal density together with the SMT population.

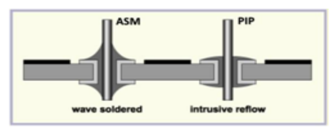
2.2 TH parts should have sufficient bottom flush space or stand-off feet for solder paste to flow. Paste cannot flow inside the hole if the part bottom is totally blocking the TH via holes.

2.3 Solder paste keep out areas have to be carefully considered before deciding on overprint areas. Solder KEEP-OUT areas include:

A. SMT apertures	E. Unmasked ground planes
B. Unmasked Vias	F. Fiducials
C. Test pads	G. Screw holes, press-fit holes, assembly holes
D. Edge of PCBs	

2.4 PIP fillets form a more concave shape while wave solder has a more convex fillet shape



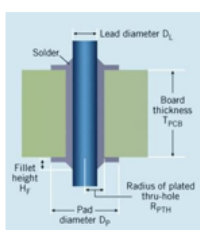


Appendix G. Design Specifications

3. P-I-P Design Requirements:

1.1 Solder Paste Calculation - Volume of stencil paste required and is measured by computing the barrel fill, add the TH via pads' fillets on the top and bottom of the board, subtract the pin volume then factor in the solder paste shrinkage after reflow.

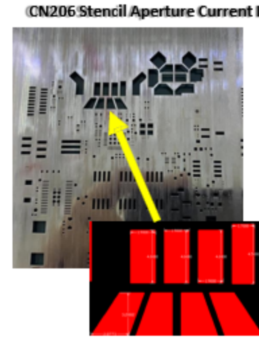
Note: **For PIP Components, Volume of paste will be computed,** as Aspect and Area Ratio is applicable for normal pads. When the volume of paste is computed, the shape and overprint location will then be translated into the stencil design.



$$V = T_S (L_O \times W_O) + V_H = 1/S \{T_B (A_H - A_P) + (F_T + F_B)\}$$

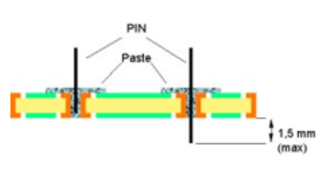
V = volume of solder paste required
S = solder paste shrink factor
A_H = cross-sectional area of the through-hole
A_P = cross-sectional area of the through-hole pin
T_B = thickness of the board
F_T+F_B = total fillet volume required
T_S = thickness of the stencil
L_O = length of overprint aperture
L_P = length of the pad
W_O = width of the overprint aperture
W_P = width of the pad
V_H = solder paste filling the hole during the printing operation

CN206 Stencil Aperture Current Design



3.2 Component Lead Length –

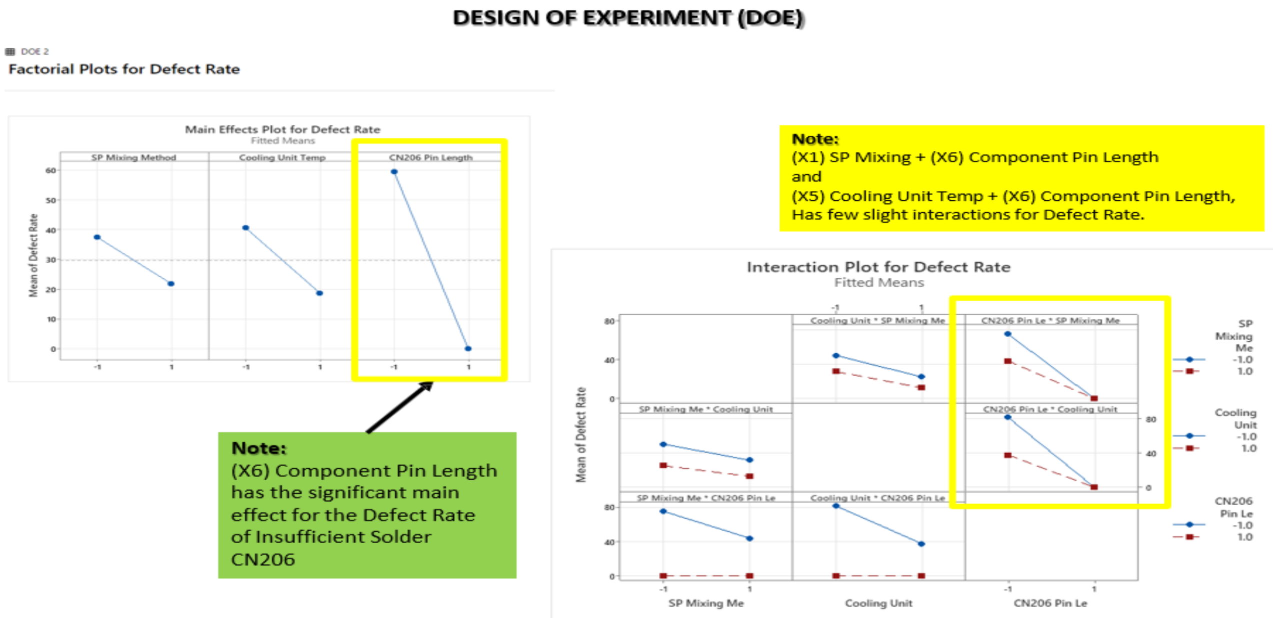
- The required lead length of the component is depended on the thickness of the PC board.
- Very long leads can push out too much paste and thus during reflow soldering, the solder cannot flow back to the solder joint.
- **If the lead length is longer than the board thickness, the lead length protruding from the bottom of the board should not exceed 1.5 mm.**



Drawing Lead Length

Actual measurement

Appendix H. Design Of Experiments



Appendix I. Revised Process Control Plan

Control Plan