Case study

Improving PCBA Yield

Subrat Prajapati

Title:

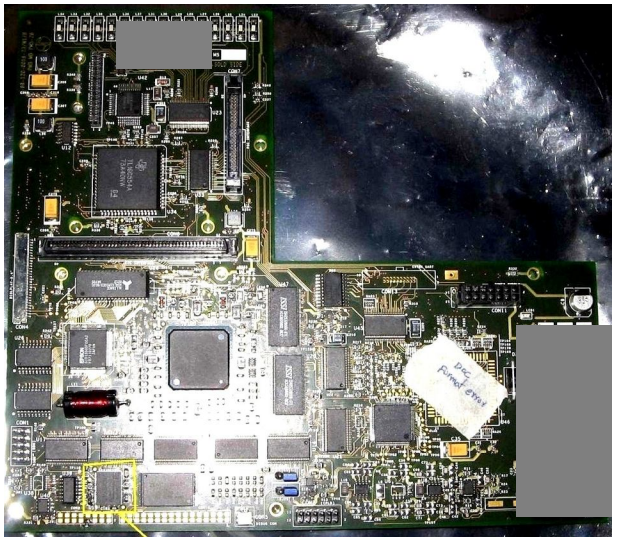
Improve the Yield of PCBA from 82% to 92% at PCBA functional Test Stage.

Current situation: Present Rejection = 18%,
Sigma Level = 2.42

Scope of Project: Vendor PCB Assembly to Functional Testing of PCBA

Characteristics	Measure	Defect Definition
Yield at PCBA functional testing	Percentage	Yield < 92%

Project Black Belt: Subrat Prajapati



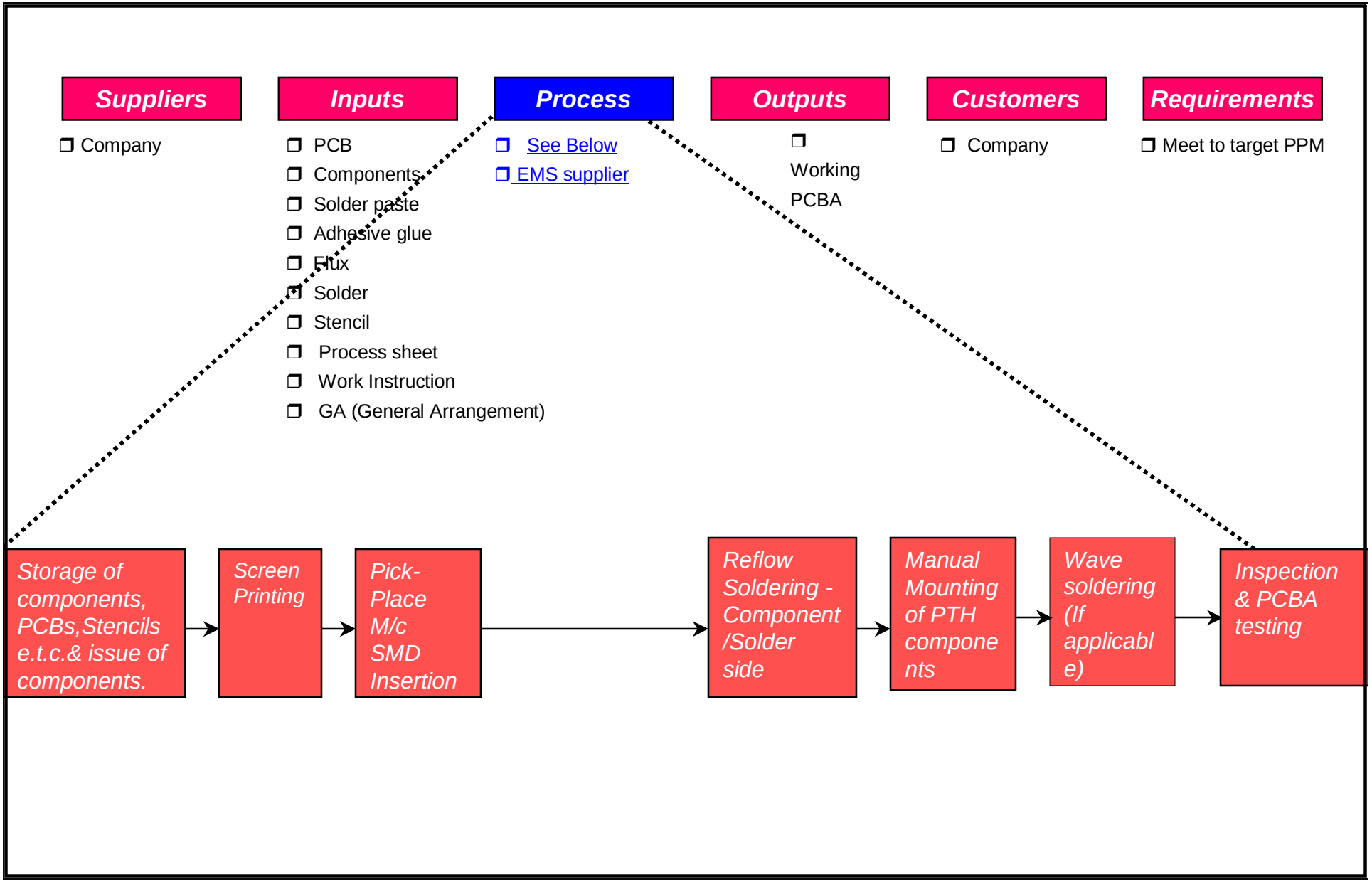
Effect of poor Soldering of PCBA

- **Warranty failure = 2.7%,**
  Annual rework cost = $ 43K
- **Product *not storing* Data**
- **Product malfunctioning**
- **Central data Corrupted**
- ***Wrong misinterpretation of data.***

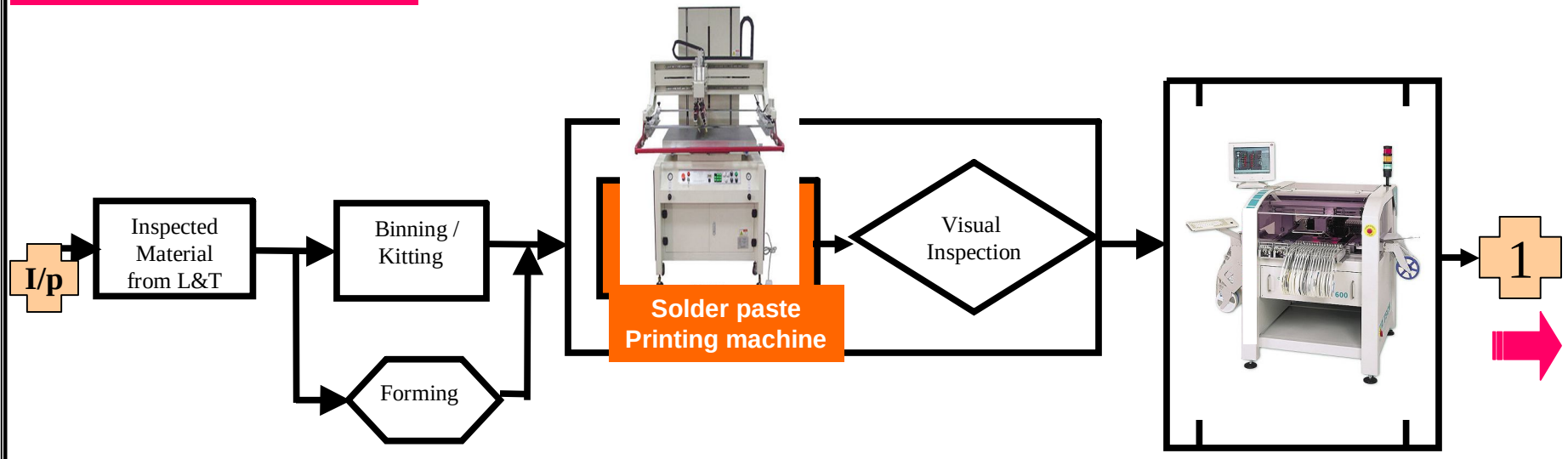
Challenge:

1. **Solder Short in 15 mil Pitch IC.**
2. **BGA-ROHS part soldering in Non-ROHS Environment**

SIPOC Diagram

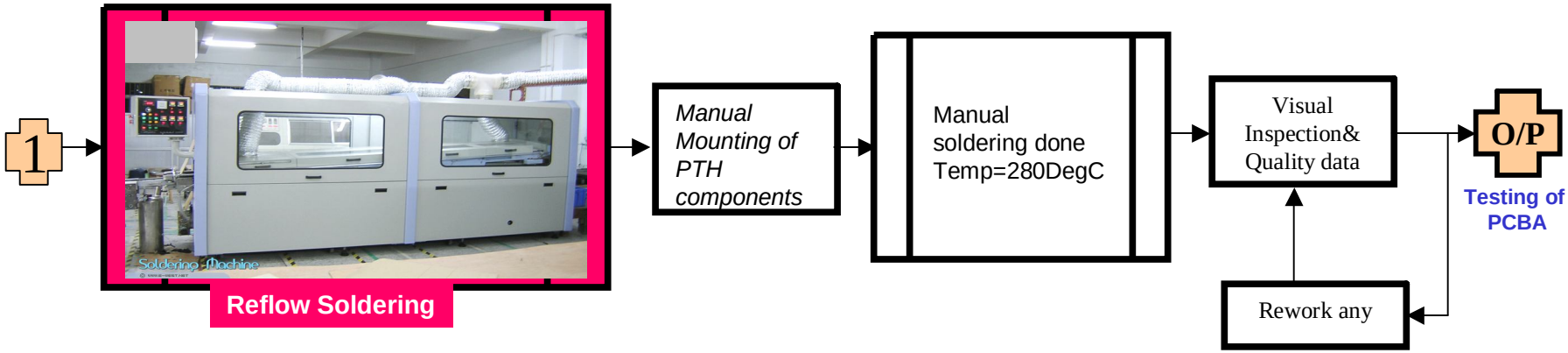


Process Mapping



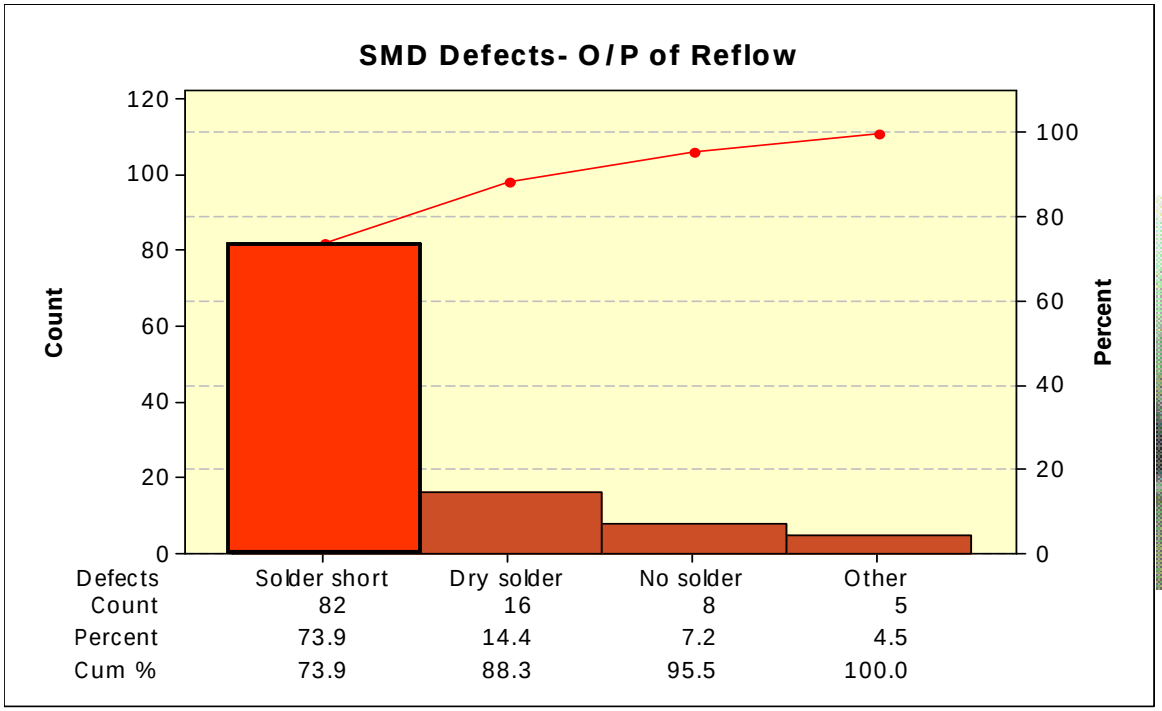
Pick & Place
Machine placement /manual placement of components based on the Quantity(cut reel/loose components)

Process Mapping

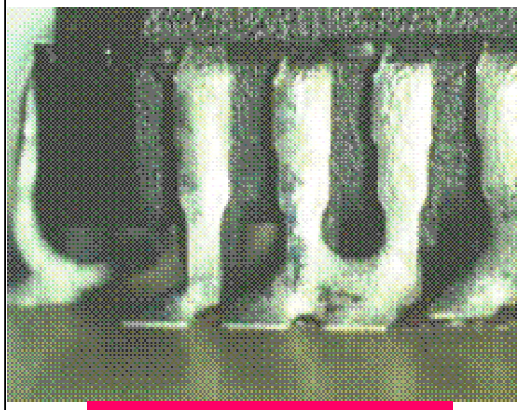


Pareto Chart

Defects at Test Jig stage related to Solderibility has been transformed to Pareto as below-



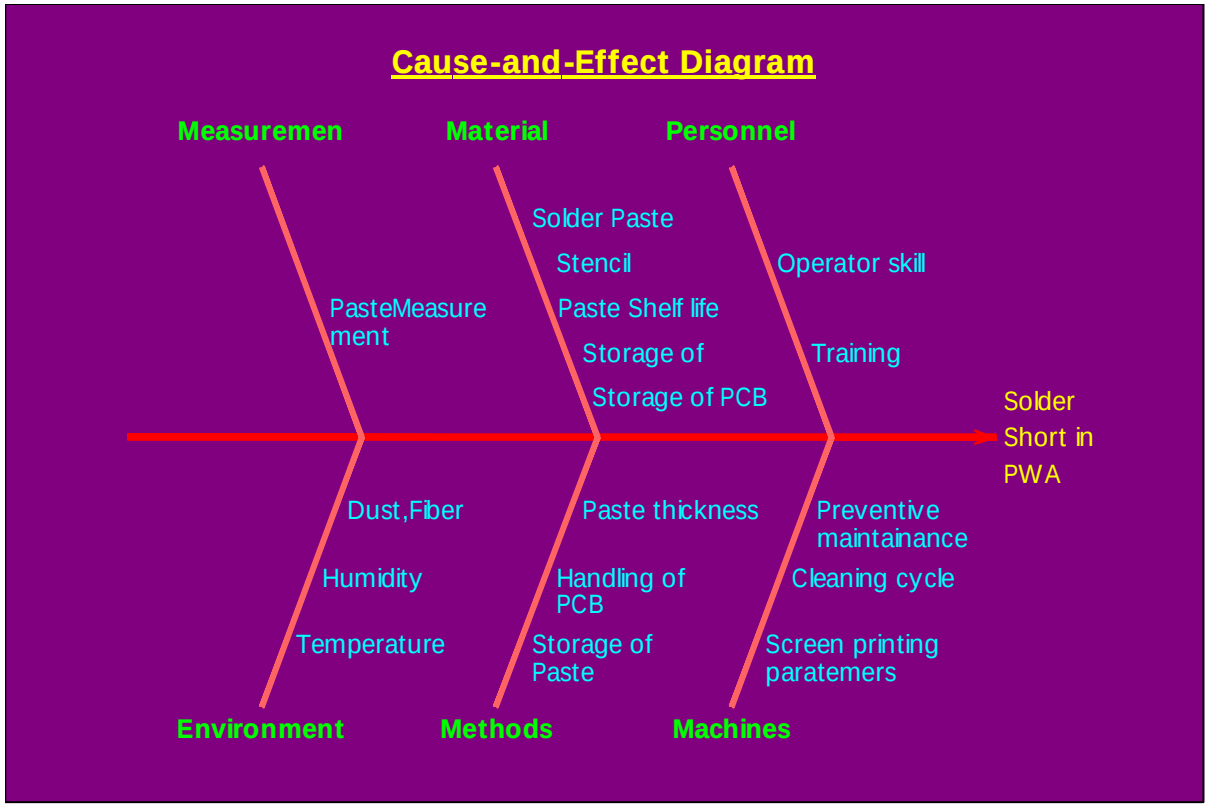
Defects	Solder short	Dry solder	No solder	Other
Count	82	16	8	5
Percent	73.9	14.4	7.2	4.5
Cum %	73.9	88.3	95.5	100.0



Solder short in IC leads

CTQ Specification Table

NEED	DRIVERS	CTQs	DEFECT DEFINITION	MEASURE FOR DEFECT	KANO STATUS
Reduce Solderibility Defect in PCBA	Reflow process	Good Solderibility As per IPC610	Any incidence solder short in Soldering of SMD component	No.of solder short after reflow In Video microscope inspection	Less the Better
	Screen Printing Process	Paste thickness Consistency	Any incidence solder short in Soldering of SMD component	No.of solder short after reflow In Video microscope inspection	Less the Better



Vital Brainstorming output-

1. Stencil Design
2. Printing Parameters
3. Reflow Profile
4. Solder paste Storage,Type, height,slump
5. PCB Gerber Design

Data collection plan

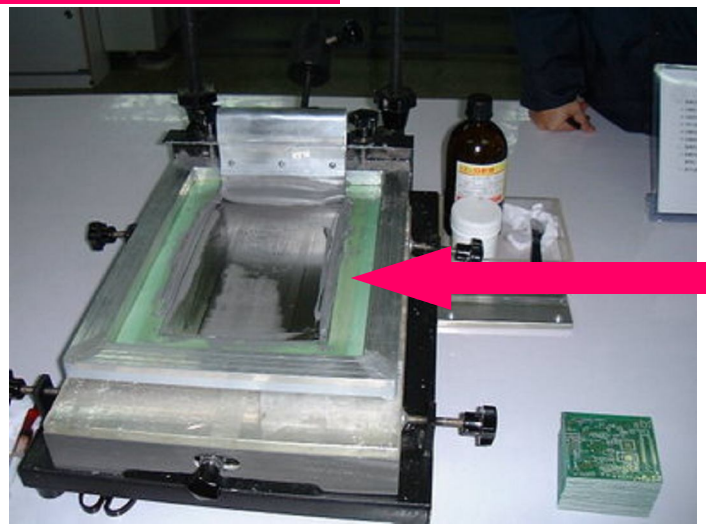
Data collection plan for	Project	Date
PCBA Solderibility failures in shop floor	Reduction of Solderibility problem in PCBA	10.10.2009
1. What is the need of this data collection?	2. Who will collect the data?	3. Location of data collection
To find out the present status of PCBA failures & to validate it's causes	SP	Reflow M/C- Vendor Programming/Testing- Screen printing machine

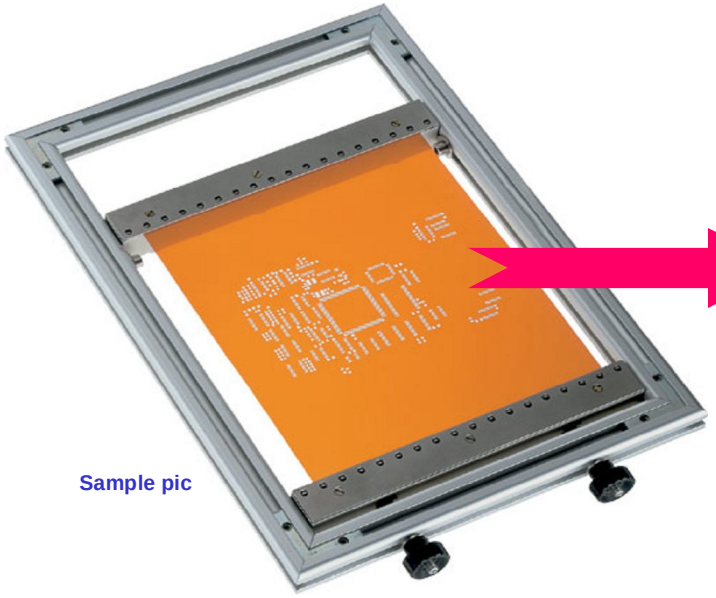
DATA				
What	Measure type / data type	How measured	Sampling	Purpose
Temperature	Continuous	Thermocouple reader Reflow	20 samples	Check Process capability
PCBA Failed	Discrete	At Test Jig stage	100 samples	Check failure rate before and after Implementation of solution
Solder Paste thickness	Continuous	Manufacturer Machine	30 samples	Paste Type may be factor in Solderibility

Vendor Visit

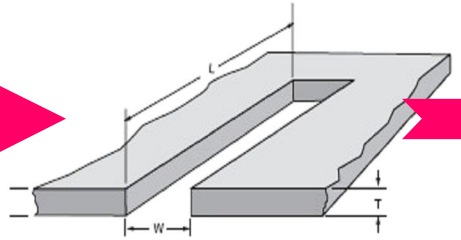
Measure

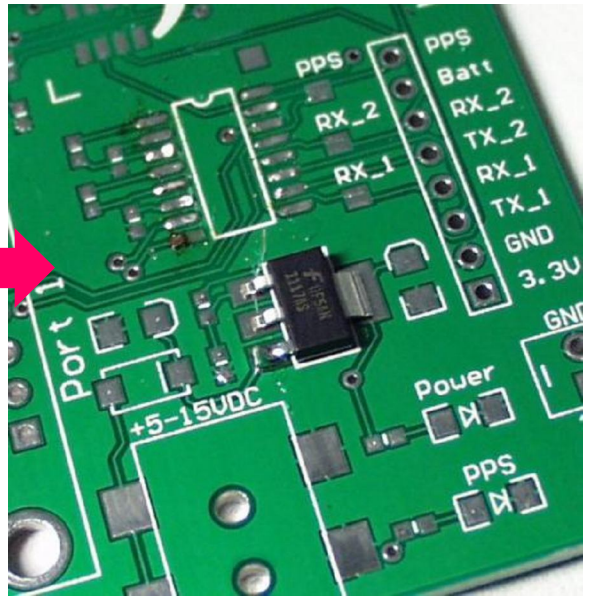
Screen Printing process





Sample pic

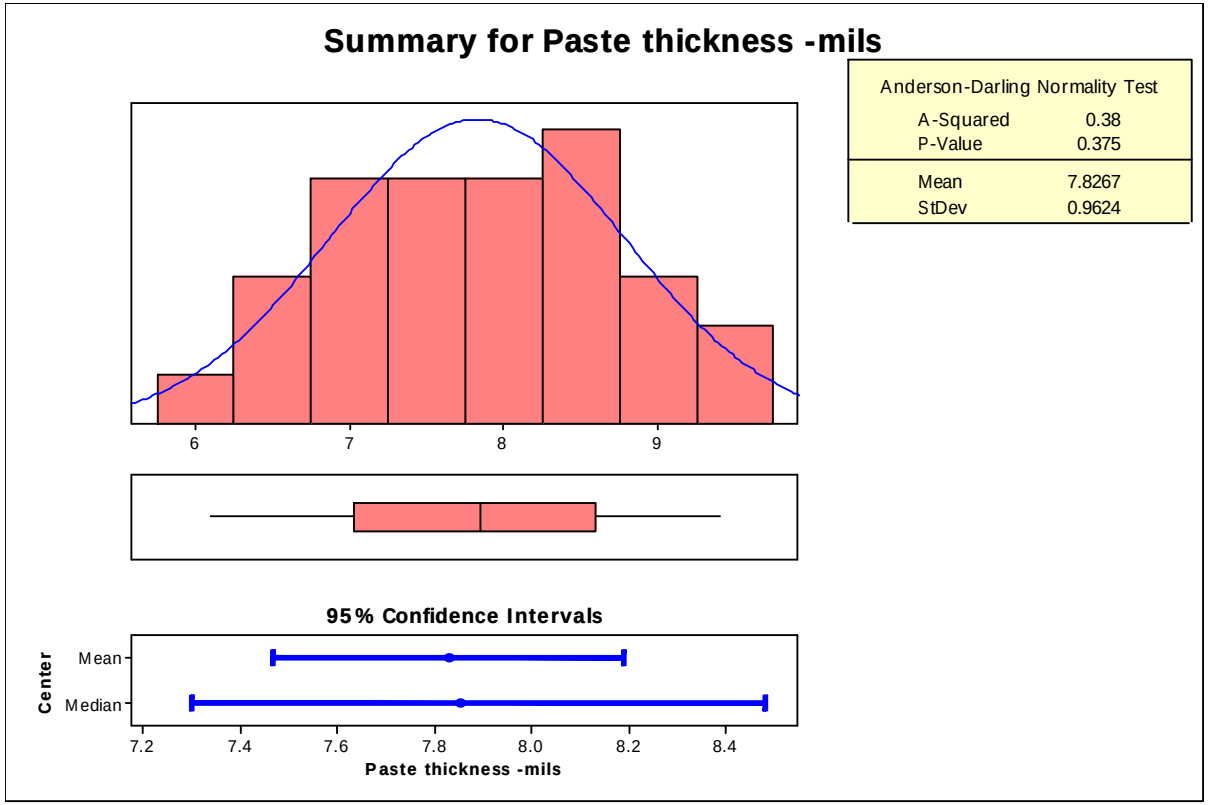




Data Plotting- Solder Paste Height measurement

Screen Printing process

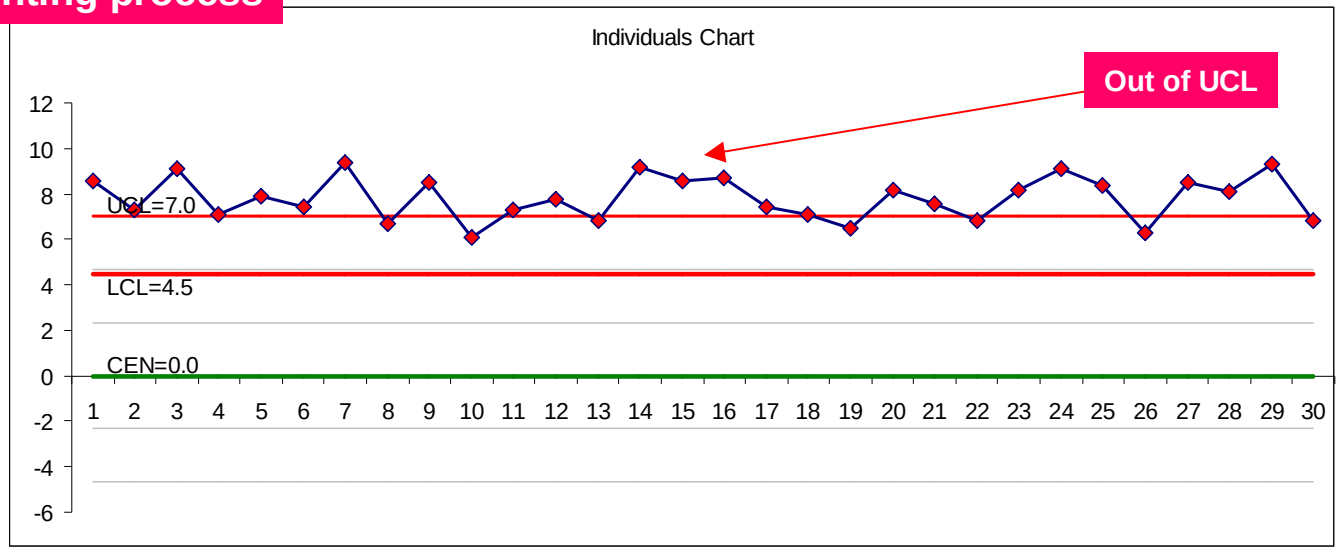
Anderson Darling Normality test

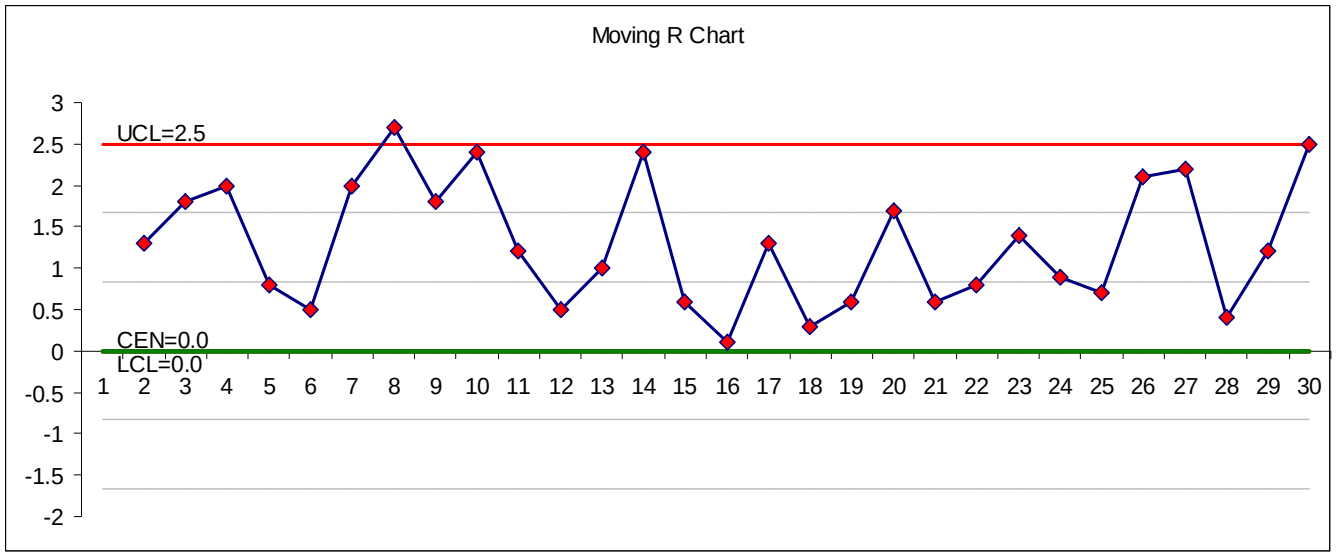


Observation : From Normal Distribution Summary shows Mean of Paste thickness observed is 7.8 mil (198 micron).

I-mR/ Paste Thickness

Screen Printing process



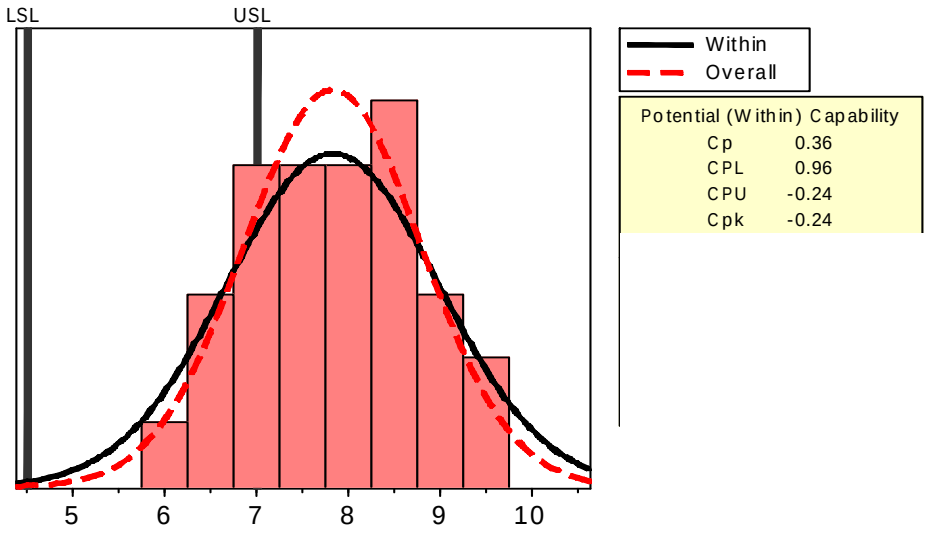


Cpk Analysis of Solder Paste Thickness

Screen Printing process

Process Capability Analysis of Paste Thickness

Process Data	
LSL	4.50000
Target	*
USL	7.00000
Sample Mean	7.82667
Sample N	30
StDev(Within)	1.15554
StDev(Overall)	0.97070



Data confirms Normality

Cpk = - 0.24

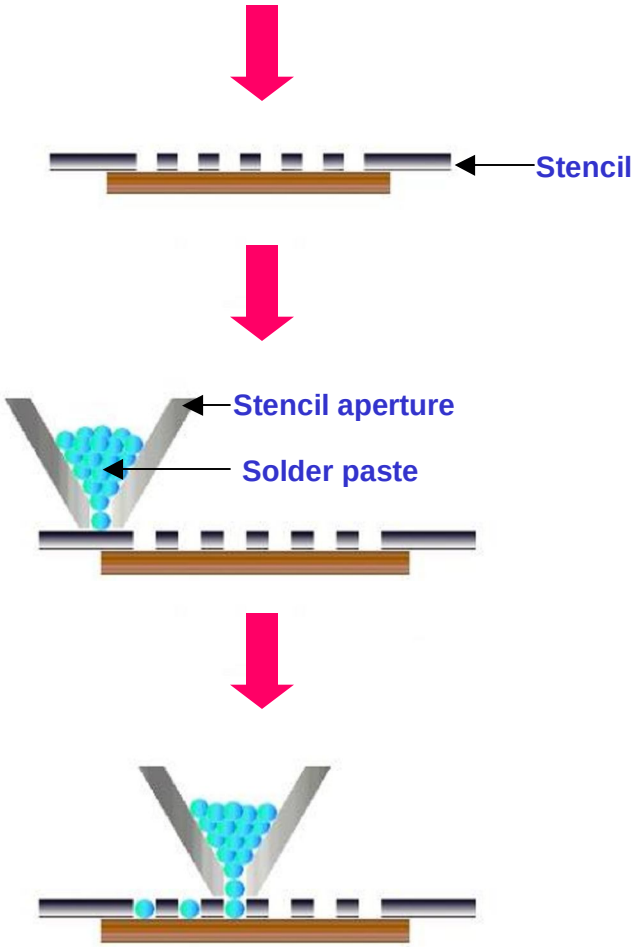
As Stencil thickness is 5mil, Paste thickness = Stencil thickness + 2/ - 0.5 mil (ie; 4.5 – 7.0 mil Or 114-178 micron)as per common industry Standard.

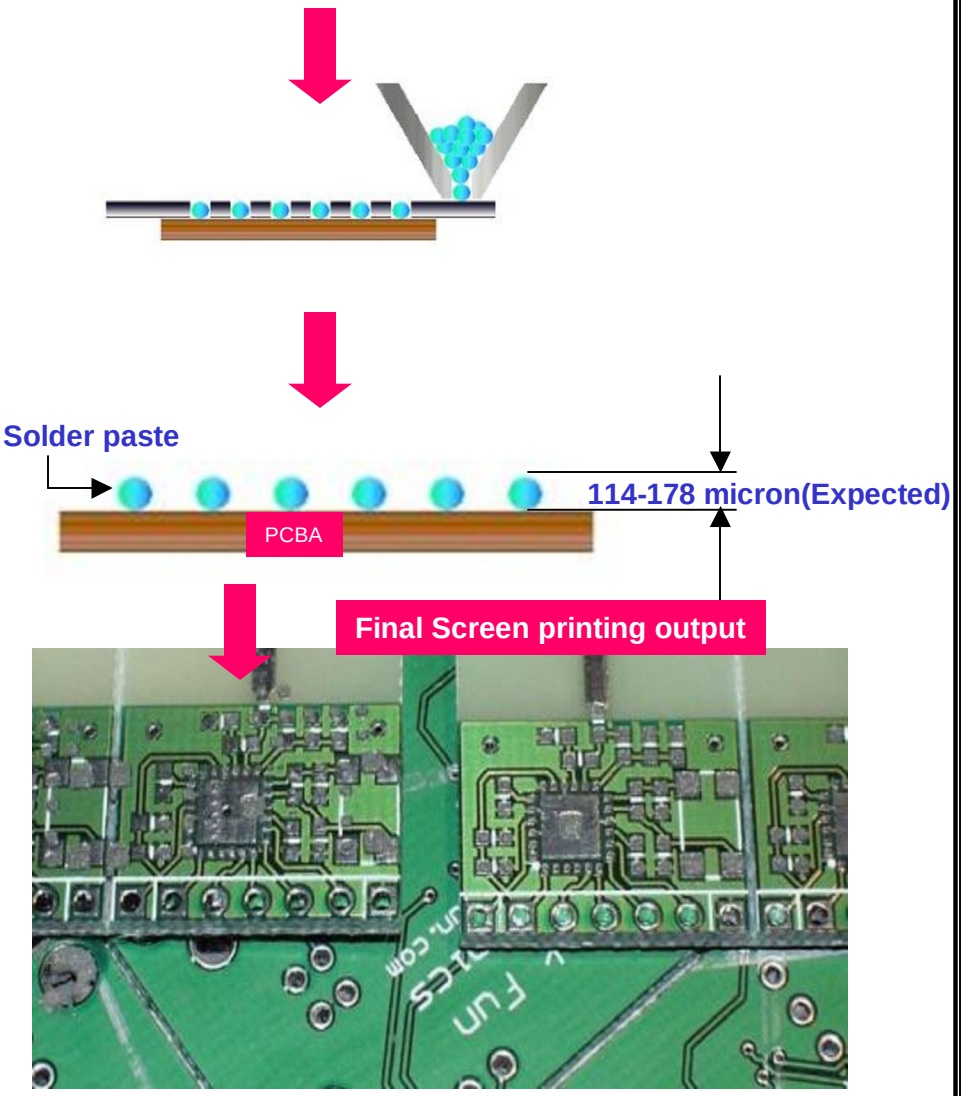
Concludes 80% of process is running outside USL, with Cpk= - 0.24

Mean Paste thickness = 7.8

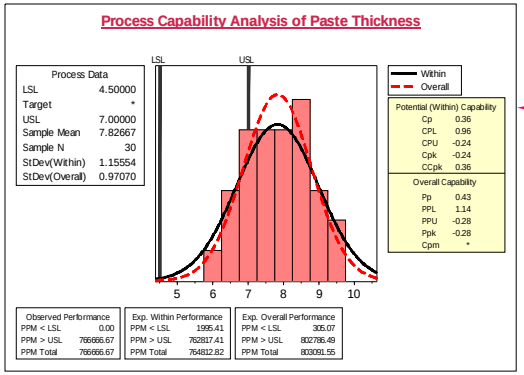
Paste Thickness running out of Specification

Screen Printing process





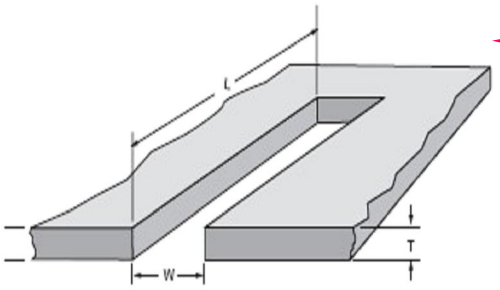
Vital cause



Vital cause identified After Brainstorming

1. **Present** Stencil opening is 1:1 (PCB Pad vs Stencil aperture ratio) leading to excess amount of solder paste deposition, and solder short after reflow.

2. Presently using Solder Paste Type-3 of 25-45 micron granule size, in PCBA having IC of 15 mil pitch.
   As per 5 ball rule,this can be cut-off point.
   Decided to use Type-4 (20-38 micron) solder paste in order to get better solder paste transfer efficiency in 15mil pitch IC through DOE



Stencil

Reduced Aperture width‘W’ by 5% in IC having Pitch =<20mil, to reduce paste volume on Pad hence reduce chance of solder short after reflow.

Paste T3 vs T4 Hypothesis Testing

Chi-Square Test: Solder Paste T-3 Vs T-4

	Good	Bad	Total
T4	57	15	72
	51.51	20.49	
	0.586	1.472	
T3	36	22	58
	41.49	16.51	
	0.727	1.827	
Total	93	37	130

Chi-Sq = 4.612, DF = 1, **P-Value = 0.032**

P-value shows Solder Paste T3/T4 has effect in Solderibility (solder short) in 15 Mil pitch IC

Reflow temperature effect on BGA soldering

Chi-Square Test:Reflow Temperature

	Good	Bad	
1	56	32	88
	64.60	23.40	
	1.144	3.157	
2	82	18	100
	73.40	26.60	
	1.007	2.778	
Total	138	50	188

Chi-Sq = 8.086, DF = 1, **P-Value = 0.004**

P-value shows Reflow Temperature T_{Peak} At 220 & 235 has effect in BGA soldering

Test:

BGA Pull Test conducted as below-
Soldered BGA(at Tpeak=220:NonROHS profile) has been pulled up by BGA Rework Station at 190 DegC (As planned).

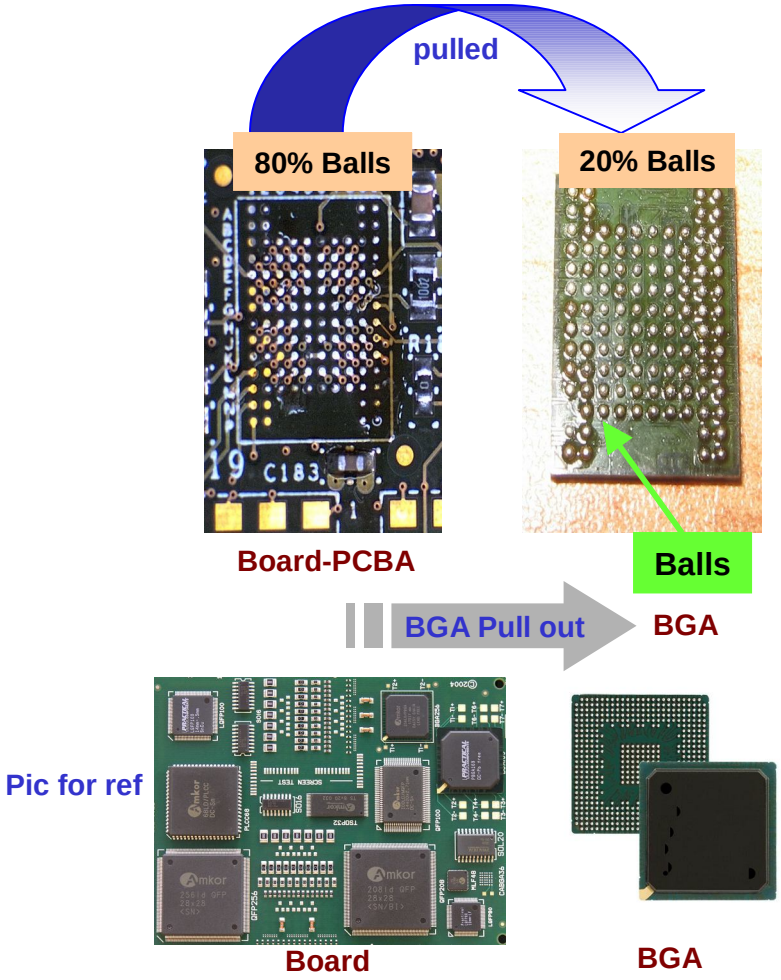
Observation:

Found 20% BGA Balls Came out in BGA & remaining 80% BGA Balls remain in Board.

Conclusion:

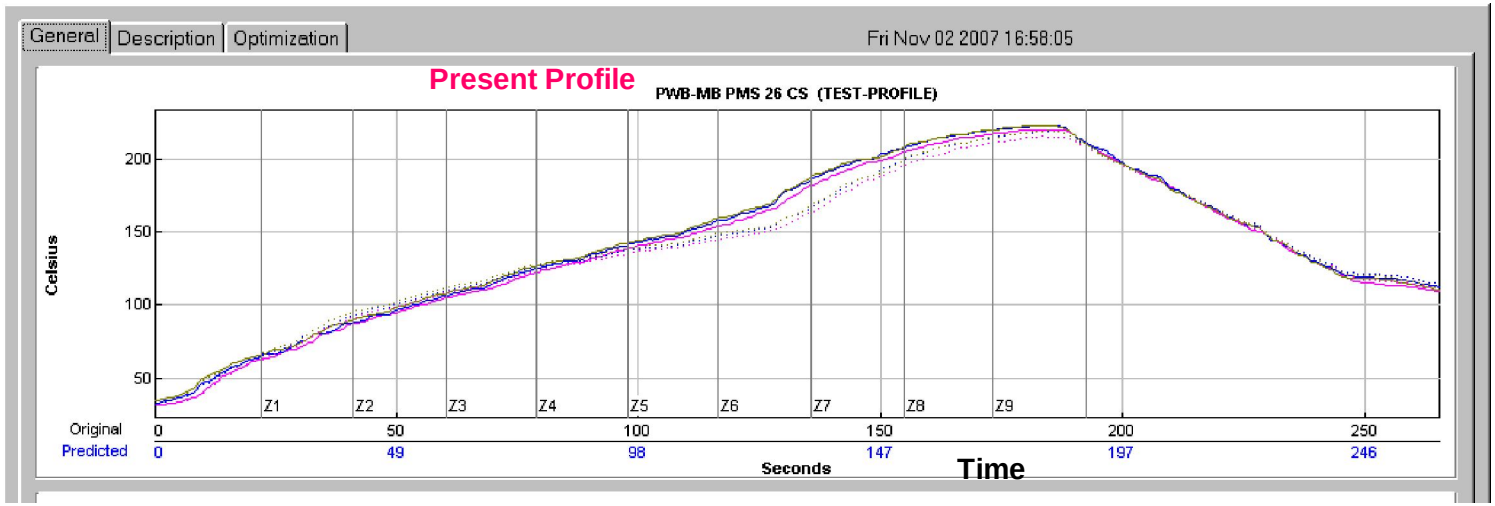
Good soldering Balls remain on Board after Pull Test.
Bad Soldering Balls came out with BGA package.
Shows BGA Balls are not melting on Board At 220 DegC.

BGA manufacturer recommends 235 Peak Body Temperature, will not be suitable to my PCBA having non-ROHS parts.



Reflow process

Reflow Profile running at Vendor – [RTS – Ramp to Spike Profile]

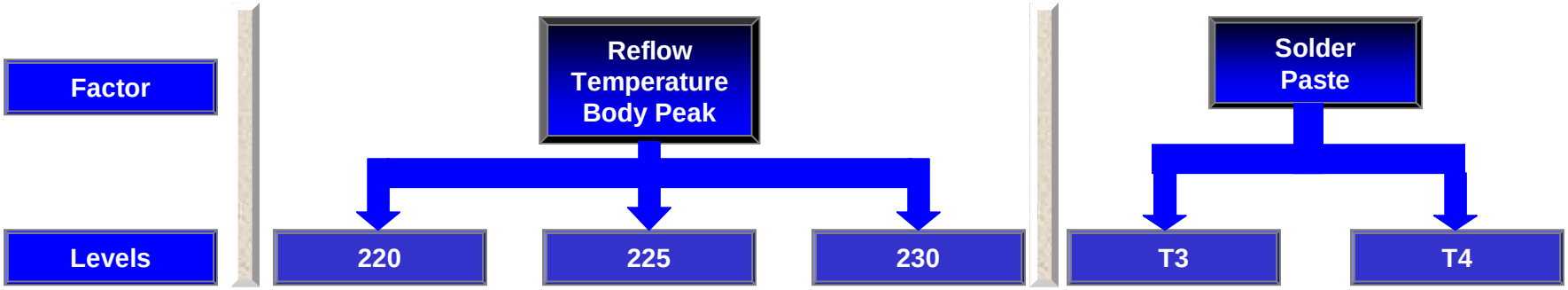


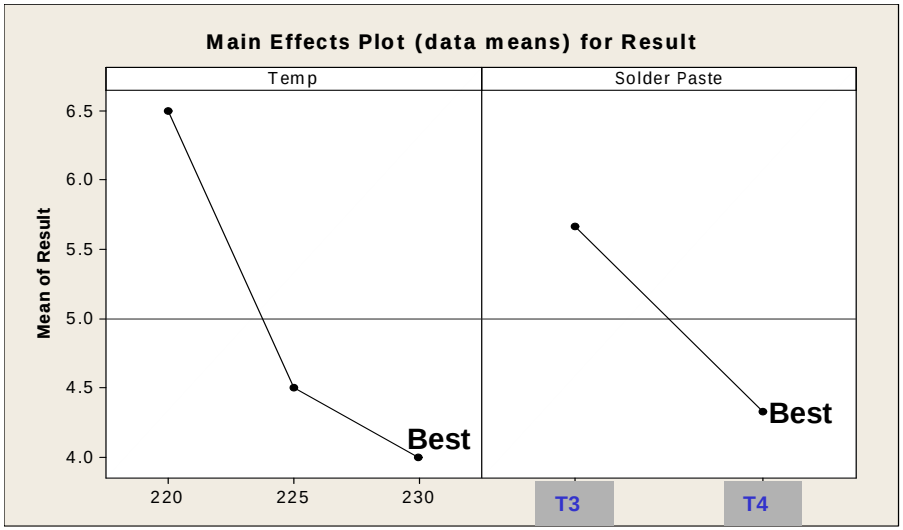
Above RTS Profile to be Looked at for stable soldering of PCBA as well as BGA(ROHS Device) soldering in Non-ROHS environment.

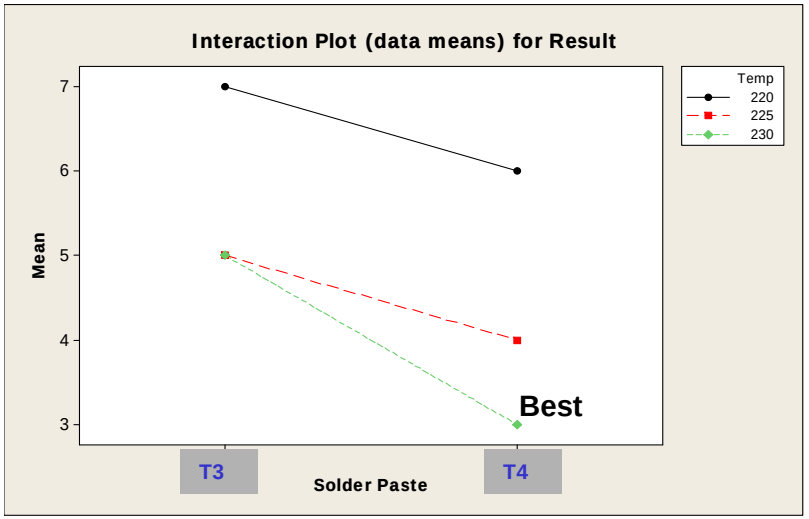
Cause Solution Matrix Planned

Effect	Cause	Solution	Implementation Risk	Risk Addressed	Risk Closed	Responsibility
Solder Short	Screen printing Paste Thickness variation	Machine Parameters Optimized	Solder short may increase	To be run in Pilot lot of 30 no PCBA for monitoring	Parameters Freeze	Machine Supervisor
		Cleaning of ON-line Stencil reduced from 10 PCBA to 5 PCBA	Cycle time can increase	Cycle time to be monitored	Cycle time no change as Pick-place machine is having high cycle time than screen printing	Machine operator
		Measurement of Paste Thickness Process Deployed	No Risk	No Risk	System Deployed	Quality Manager
		Stencil Initiated with 5% reduction in aperture width in order to reduce paste Volume in IC<20mil pitch	May induce less solder problem	New stencil to be run in Pilot Lot of 30 numbers PCBA before deploying in production lot	Monitoring	Design/ Process Dept -
	Reflow Profile	Profile Changed from Ramp to Spike(RTS) to Ramp Soak Spike(RSS) from DOE	RSS may need more fine tuning for good Solderibility	To be monitored	Monitoring	Process Engineering

Design Of Experiment for Reflow Peak Temperature



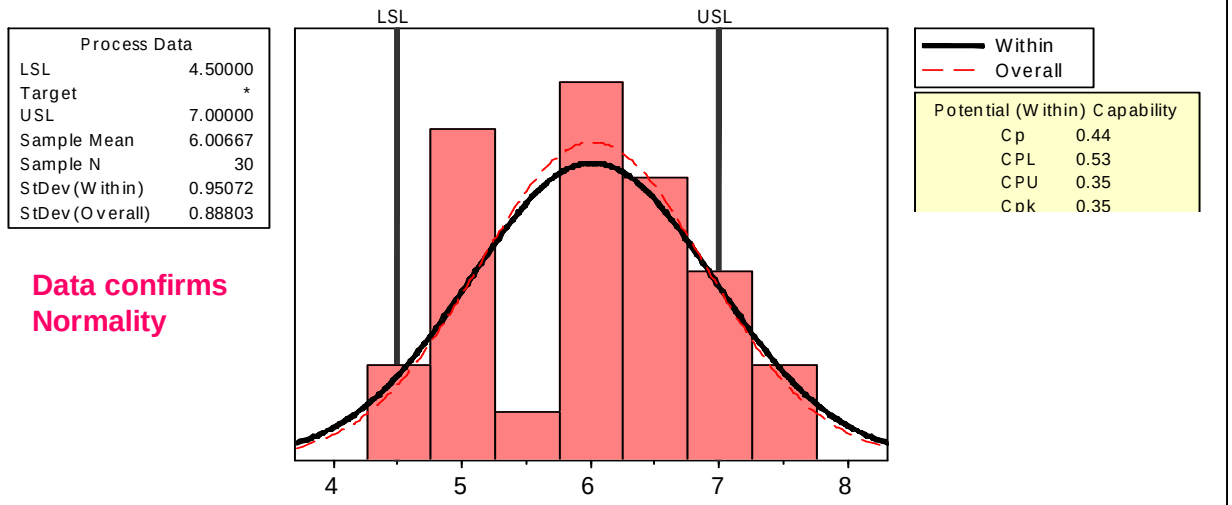




Screen Printing process

Stencil 5% reduction & Type-4

Sample Size= 30 PCBA



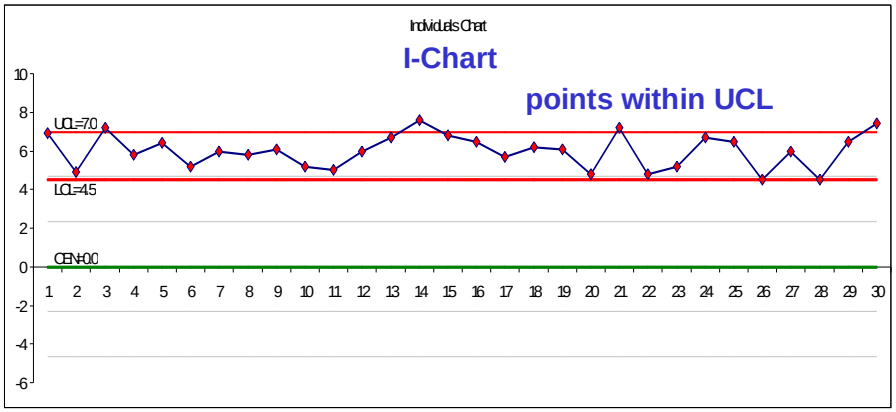
Data confirms Normality

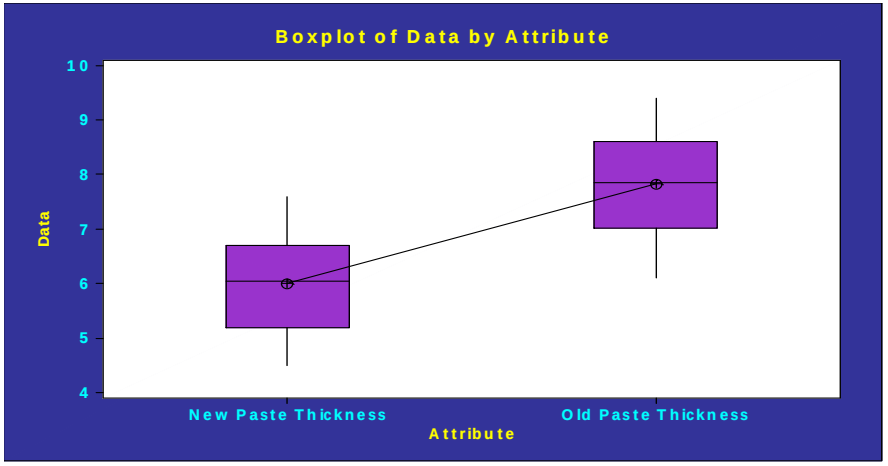
Cpk = 0.35

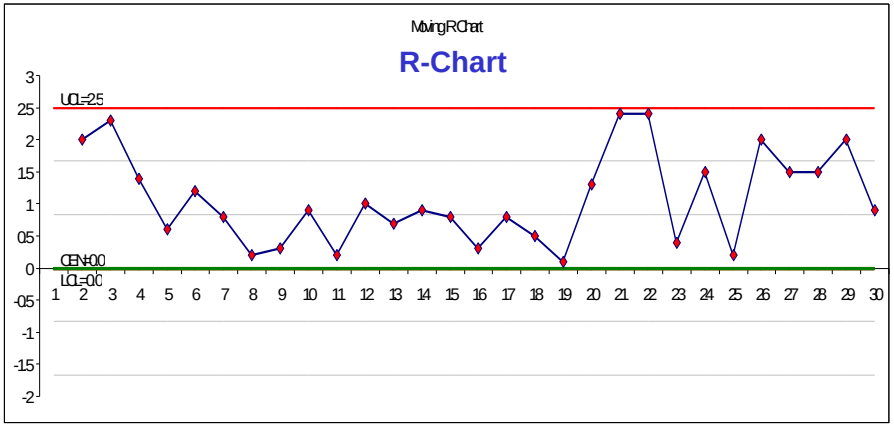
Concludes paste thickness lying outside USL reduces to 13% from 80%, with Cpk= 0.35 from -0.24

Mean Paste thickness = 6.0 from 7.8 mil

Screen Printing process







Two-Sample T-Test and CI: Data, Attribute

Two-sample T for Data

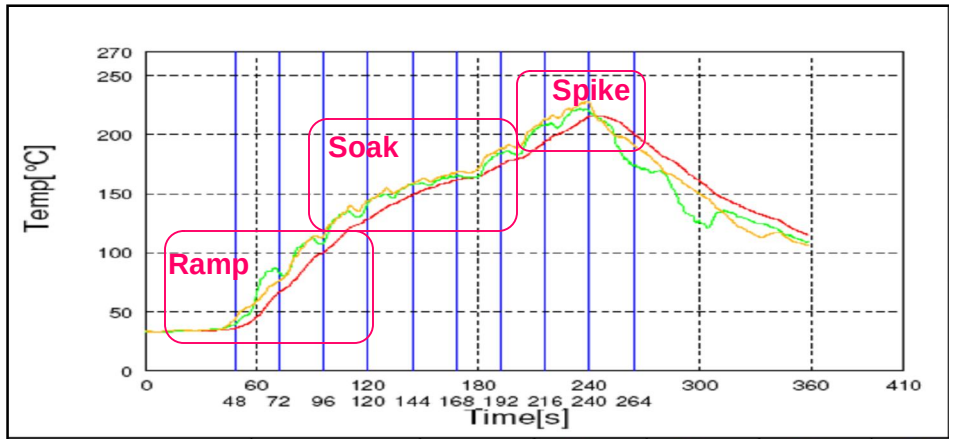
Attribute	N	Mean	**StDev**	SE Mean
New Paste Thickn	30	6.007	**0.880**	0.16
Old Paste Thickn	30	7.827	**0.962**	0.18

P-Value = 0.000

P value signifies improvement.

Reflow process

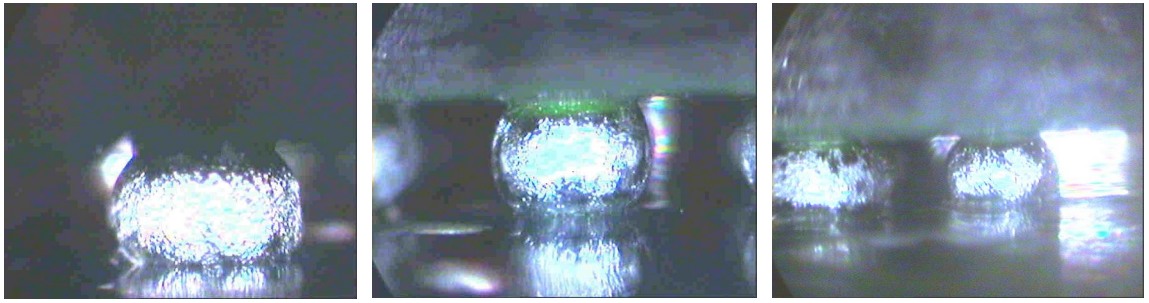
New RSS - Ramp Soak Spike Profile Deployed



Benefit: Due to Soak time it is facilitating flux to get activated which is useful for expired IC, obsolesce IC(As in our case) for getting good Solderibility.
BGA checked in X-ray/Video scope

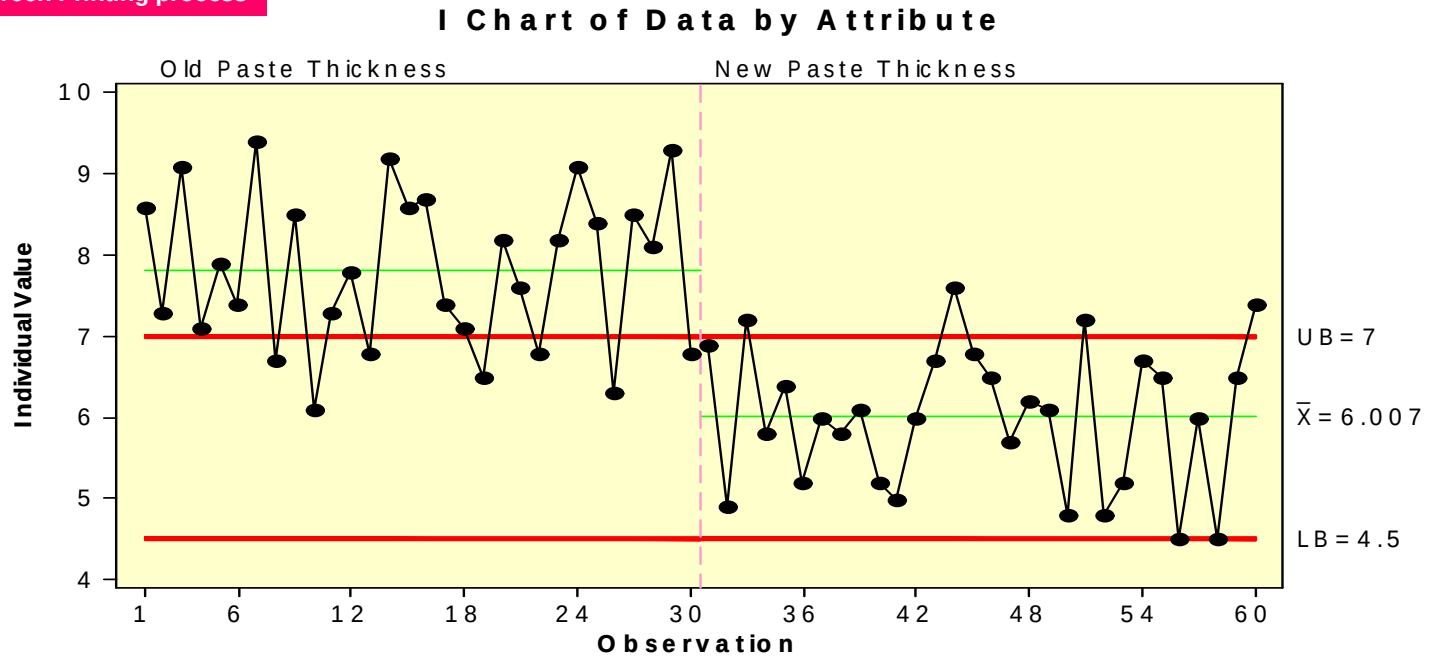
Pilot lot of 150 PCBA run and Quality confirms to IPC 610, class III.

BGA Ball Snaps shows A good wetting o/p from video scope-



Solder Paste Thickness Variation From I-Chart before and After

Screen Printing process



I-mR Chart implemented at Vendor for monitoring of Paste thickness

Paste Thickness & DPMO monitoring mechanism Implemented as a EMS Vendor Site

Requirements / Needs to ensure quality product.

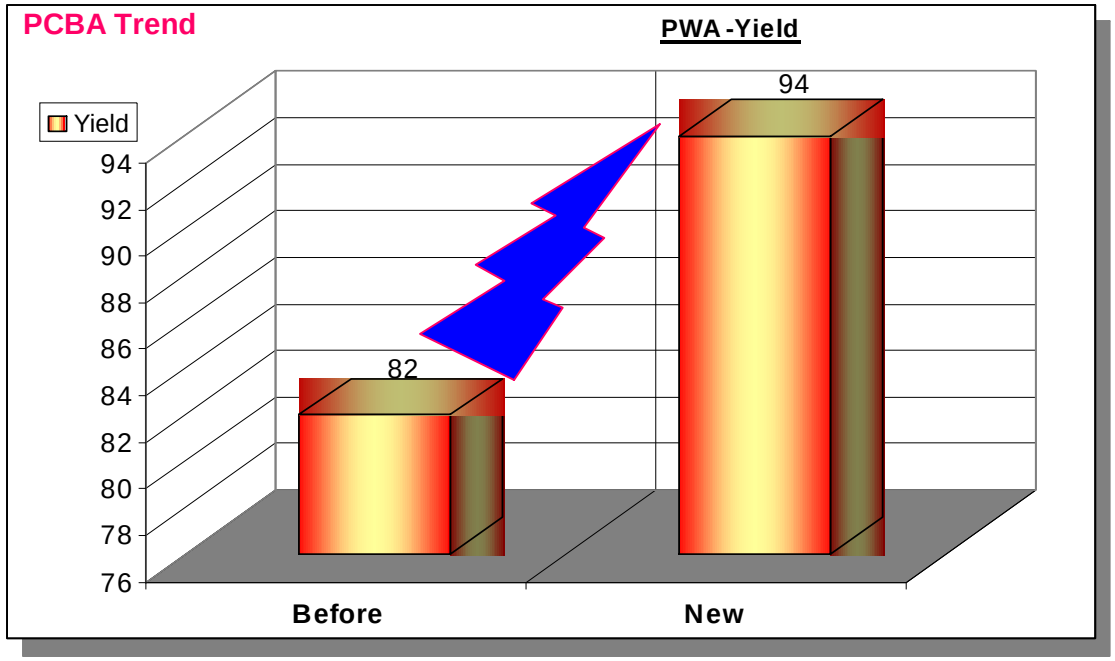
Quality Index Matrix

Process	Process Control Method	Benchmark	Actions / Responsibility
Screen Printing	Control Chart	4.5 to 7 mils.	Vendor to maintain record & display at measurement area.
Reflow	FTP	80%	We will guide for DPMO calculation for initial lot.
	DPMO	5000	Vendor to maintain record &  DPMO.xls display.
Programming / Testing	Yield	96%	Vendor to maintain records & display.
Main Unit Assembly	Yield	98%	Vendor to maintain records & display.

Note: Quality index matrix to be covered during Audit-I of ISO 9001:2000. Quality index matrix reports to be sent to us along with lot.
Above Benchmark should be re-evaluated in every quarter based on target decided with vendor.

Initial Sigma Level = 2.4

Final Sigma Level = 3.1



Thank You

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