IEEE SW Test Workshop

Semiconductor Wafer Test Workshop

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Statistical Process Control for the Sort Area

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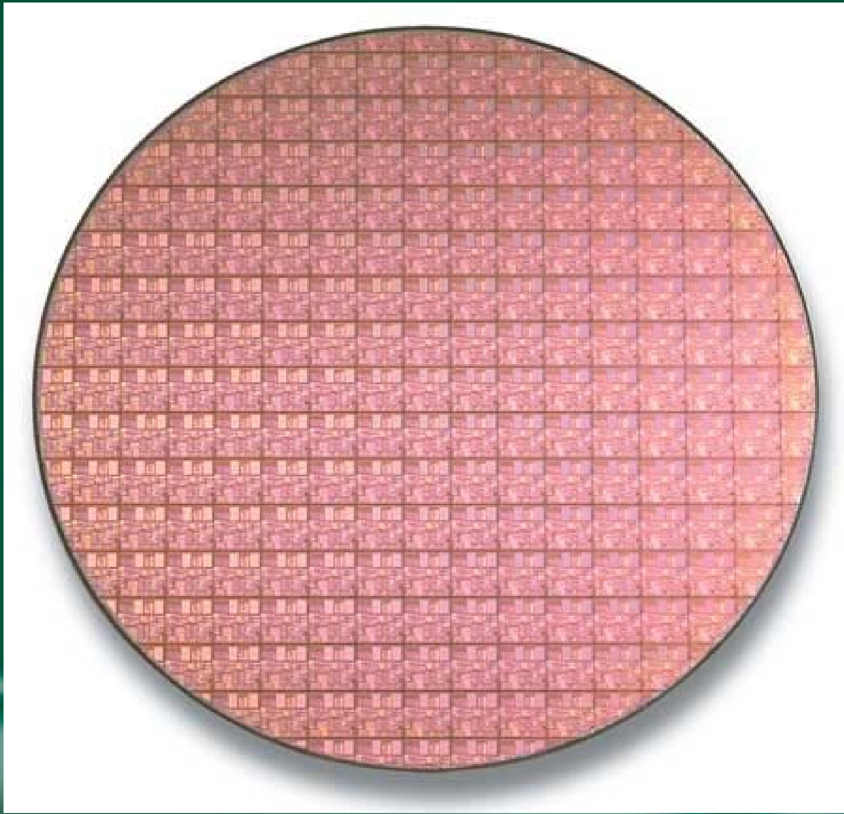
Overview of Presentation

- Probed wafers – a source of forensic evidence of probing process performance
- High-level review of Statistical Process Control (SPC)
- What you can learn through SPC of sort area data
- Key parameters to monitor
- Sort area SPC you can do today
- Sort area SPC – the Next Generation
- Summary

A probed wafer contains a huge amount of forensic evidence of probing process performance.



- Probe card performance
  - Probe tip alignment
  - Probe tip size
  - Probe tip wear
- Prober performance
  - Stepping errors
  - Probe-to-pad alignment
- Sort Bin Data

A Brief Overview of SPC

- SPC monitors the average value and range of values that are produced by a process.
- Monitoring and minimizing the variation produces a repeatable process.
- Repeating known good processes provides the best results.

SPC Charts: Average sample value, range of sample values

- X-chart
  - Chart of individual values
  - The guys at the machine shop would plot lot sample average shaft diameter here
- mR chart
  - Chart of moving ranges
  - The guys at the machine shop would plot the range of shaft diameters here

With SPC,
Data Becomes Knowledge

Probe Scrub Major Length

28.66
24.57
20.48
16.38
12.29
8.190
4.095
0.0000
-4.095

SPC UCL(L) = 24.57
Target High(L) = 17.43
SPC LCL(L) = 10.29

08:27:02 12:27:45 13:27:56 14:17:50 15:21:46 14:24:06 12:05:30 09:06:22 10:11:07 06:27:49 06:06:48 09:19:17 10:01:19 09:09:39 09:05:16 13:11:18 14:15:08 07:21:58 15:21:27 10:22:17 08:02:44 09:16:52 10:19:54 13:22:47 15:22:05 09:29:32 08:04:09 09:04:29 12:20:34 13:20:31 11:27:17 11:27:54 14:27:23 07:29:54 12:09:09 14:10:43 15:10:59 14:08:12 14:08:39 15:08:09 15:08:09 15:08:37 16:08:03 16:08:28 17:08:00 17:08:26 17:08:57 18:08:24

Valuable Sort Area Parameters

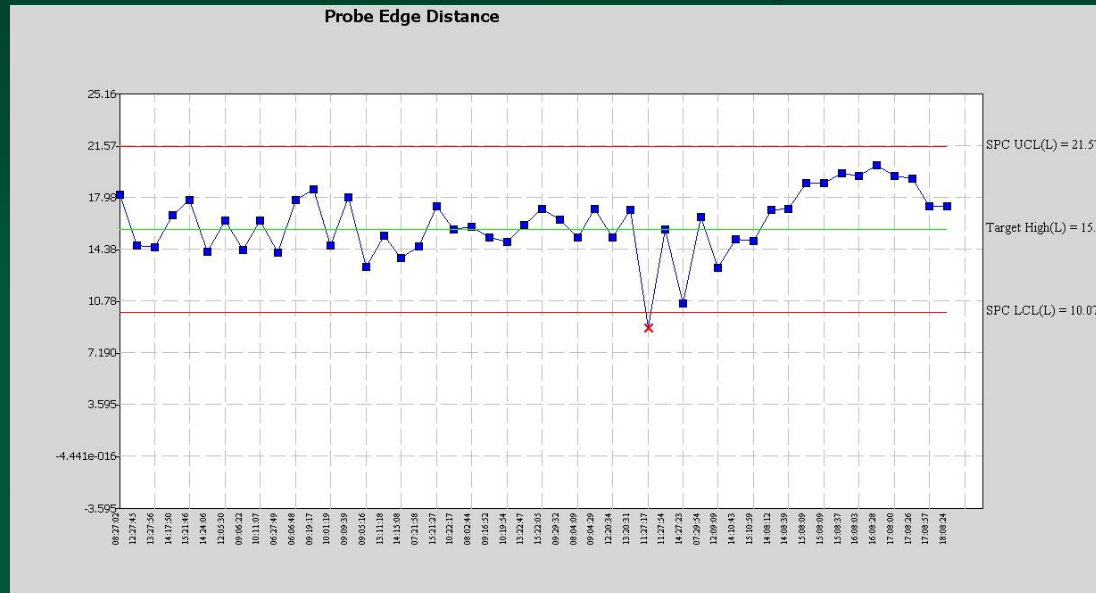
- Scrub Edge Distance(s)
- Scrub Major Length
- Scrub Minor Length
- Scrub Size(s)
- Pad Size
- Probe Alignment Error(s)
- Prober Alignment Errors(s)
- Sort Bin Data

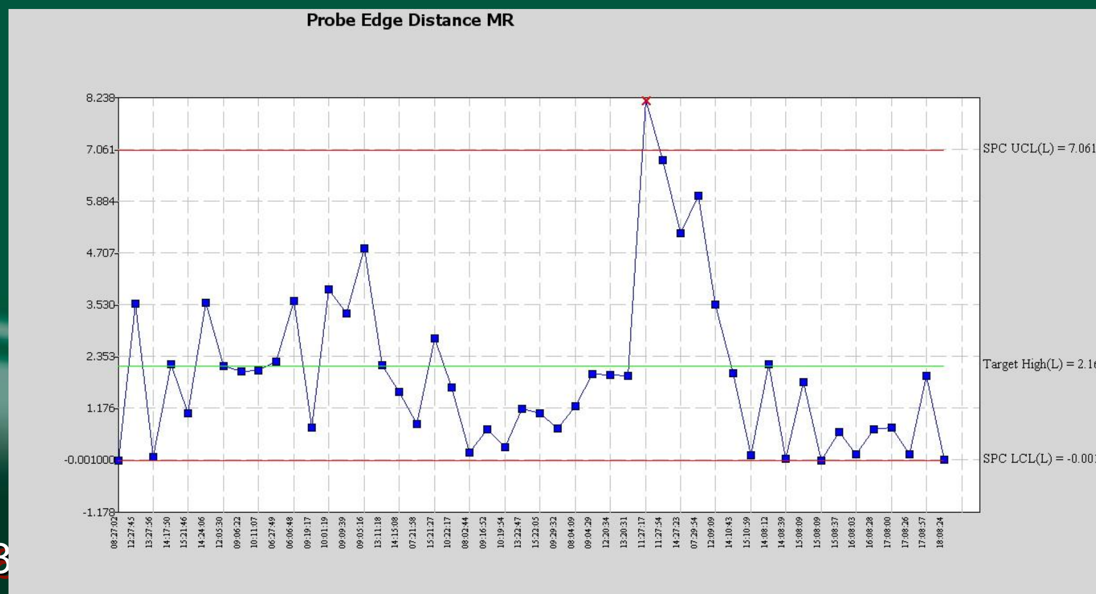
Scrub Edge Distance(s)

- The minimum distance of a scrub mark from the top, bottom, left, or right edge of a pad.
- Indicates probing process capability index (Cpk).
- Low variation indicates probing process stability.
- Can be used to guide pad size reduction decisions.

Scrub ID	Scrub Minor Length (µm)	Scrub Major Length (µm)	Edge Distance (µm)	Left Distance (µm)	Right Distance (µm)	Top Distance (µm)	Bottom Distance (µm)	Pad X Size (µm)	Pad Y Size (µm)
Pass	6711	6711	6707	6711	6711	6711	6711	6954	6954
Fail	0	0	4	0	0	0	0	0	0
Near Fail	0	0	0	0	0	0	0	0	0
Not Found	243	243	243	243	243	243	243	0	0
Min	4.354	6.291	0.778	2.276	7.960	0.778	7.852	84.943	84.254
Max	30.436	77.417	41.212	51.719	87.670	54.447	68.244	97.440	94.375
Average	12.840	15.001	33.351	38.526	34.494	35.511	37.602	87.005	87.078
Std Deviation	1.597	2.078	2.064	2.697	2.749	2.253	2.382	0.930	0.760
1	12.538	14.171	32.615	41.039	32.615	36.312	37.061	86.602	87.040

XmR Charts for Edge Distance





Scrub Major Axis Length

- Indicates planarity of probe card contact.
- Low variation indicates uniform scrub length.

Scrub ID	Scrub Minor Length (µm)	Scrub Major Length (µm)	Edge Distance (µm)	Left Distance (µm)	Right Distance (µm)	Top Distance (µm)	Bottom Distance (µm)	Pad X Size (µm)	Pad Y Size (µm)
Pass	6711	6711	6707	6711	6711	6711	6711	6954	6954
Fail	0	0	4	0	0	0	0	0	0
Near Fail	0	0	0	0	0	0	0	0	0
Not Found	243	243	243	243	243	243	243	0	0
Min	4.354	6.291	0.778	2.276	7.960	0.778	7.852	84.943	84.254
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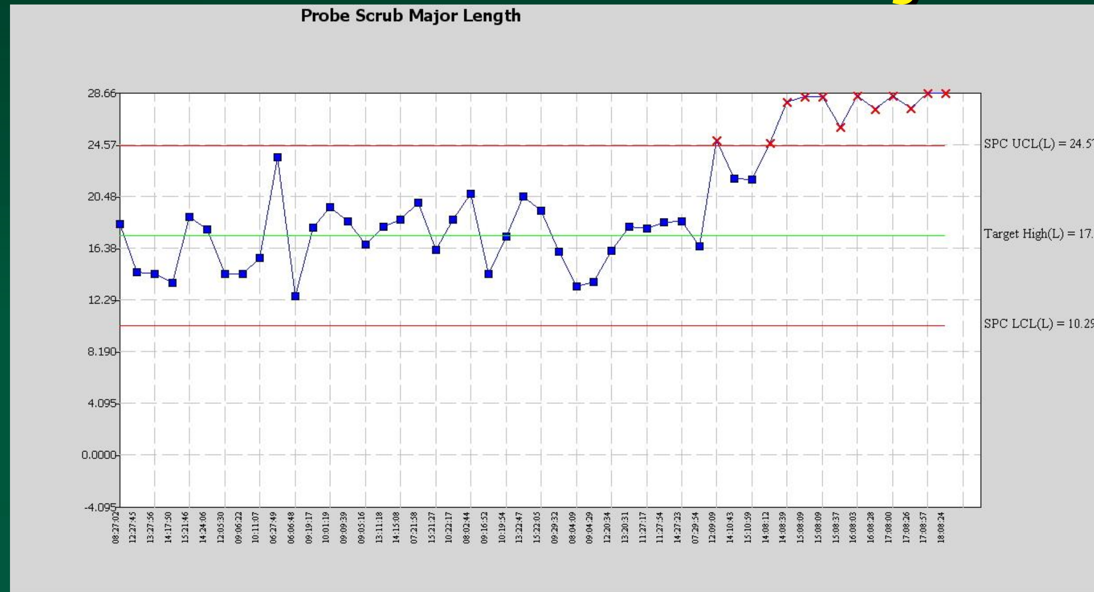
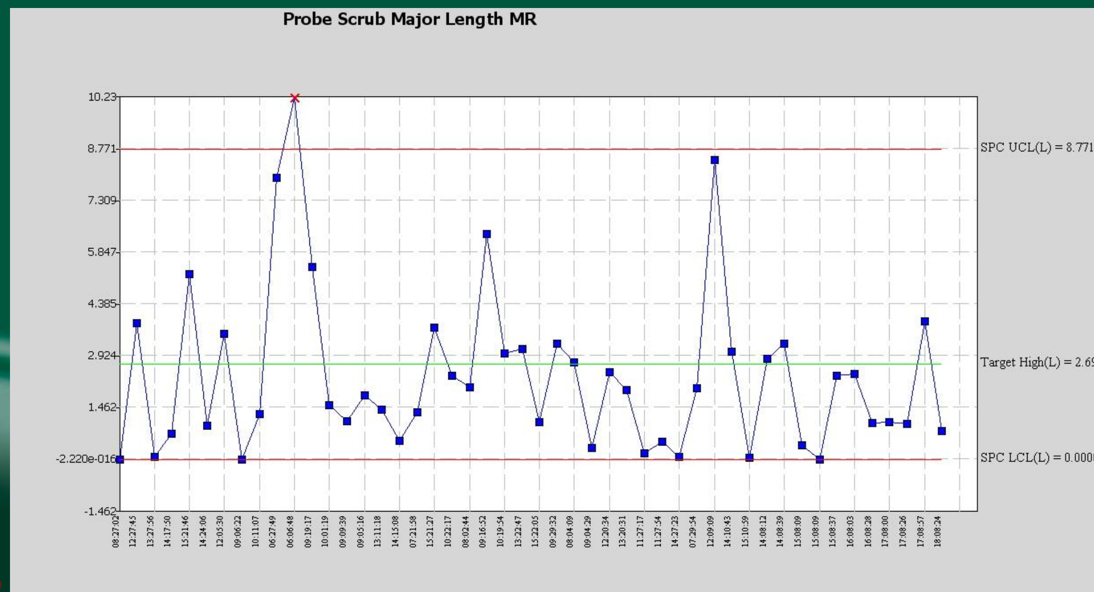
1	12.538	14.171	32.615	41.039	32.615	36.312	37.061	86.602	87.040

XmR charts for Scrub Major Length





Scrub Minor Axis Length

- Indicates probe tip diameter.
- Increases as probe tips wear.

Scrub ID	Scrub Minor Length (µm)	Scrub Major Length (µm)	Edge Distance (µm)	Left Distance (µm)	Right Distance (µm)	Top Distance (µm)	Bottom Distance (µm)	Pad X Size (µm)	Pad Y Size (µm)
Pass	6711	6711	6707	6711	6711	6711	6711	6954	6954
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Near Fail	0	0	0	0	0	0	0	0	0
Not Found	243	243	243	243	243	243	243	0	0
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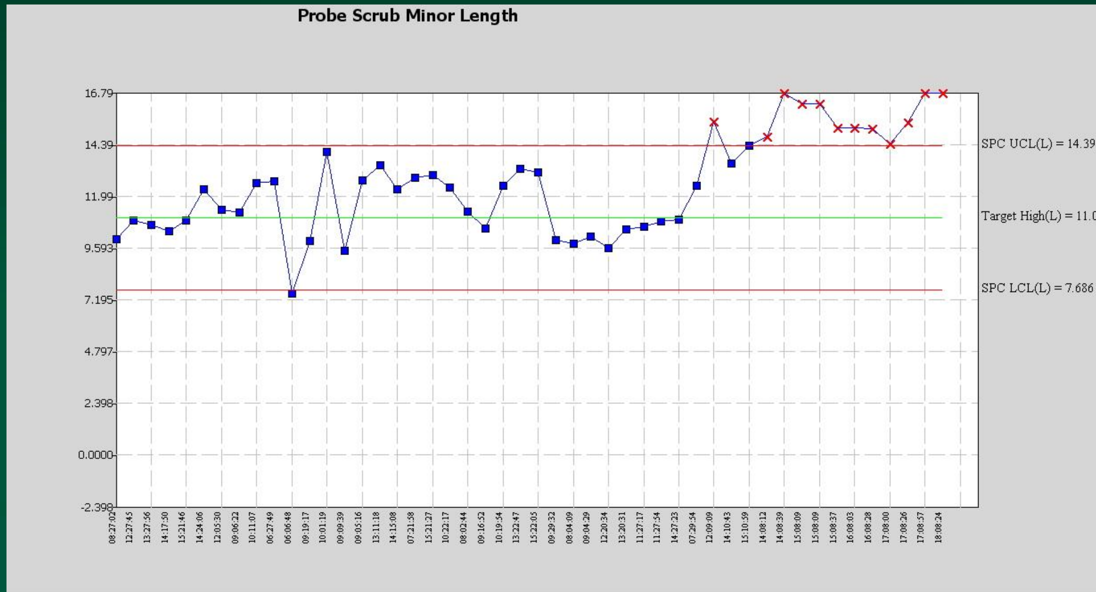
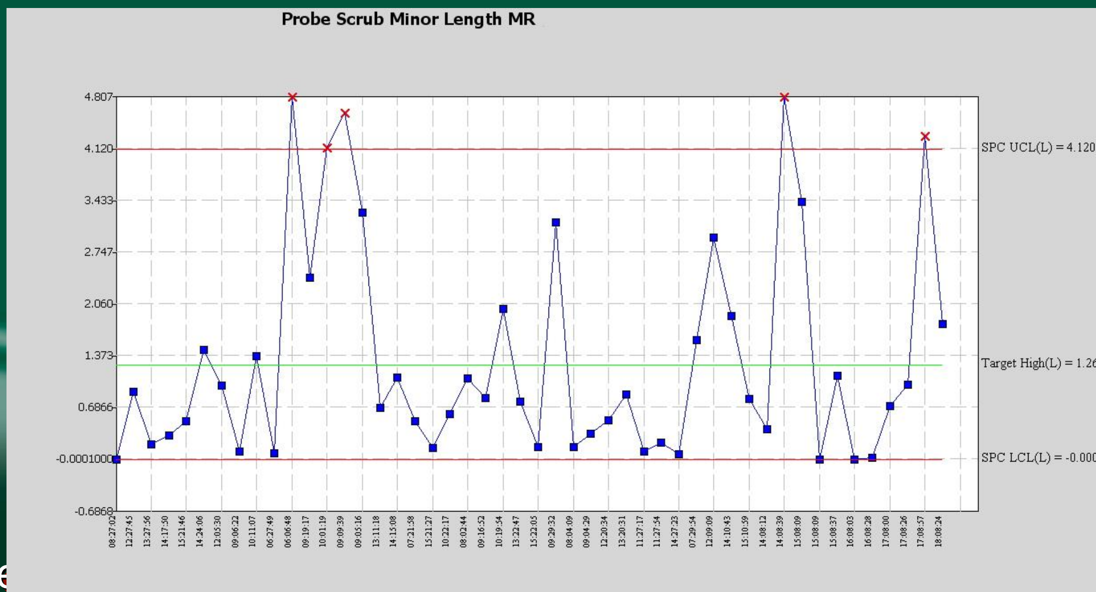
1	12.538	14.171	32.615	41.039	32.615	36.312	37.061	86.602	87.040

XmR Charts for Scrub Minor Length





Other sort area parameters…

- Pad Size(s)
  - Indicates etch process stability.
- Probe Alignment Error(s)
  - Indicates probe position deviation from its nominal position.
  - May drift over time.
- Prober Alignment Errors(s)
  - Indicates errors in prober step function.
  - May drift over time.
- Sort Bin Data
  - Changes in yield could be attributable to sort area parameters.

The Challenge is making sense of all the data

- Users have expressed interest in mining more information from sort area data.
- Users expressed concern about setup and maintenance costs.
- Users expressed concern about signal-to-noise ratio.

Probe Card Performance
Run to Fail or Run to PM?

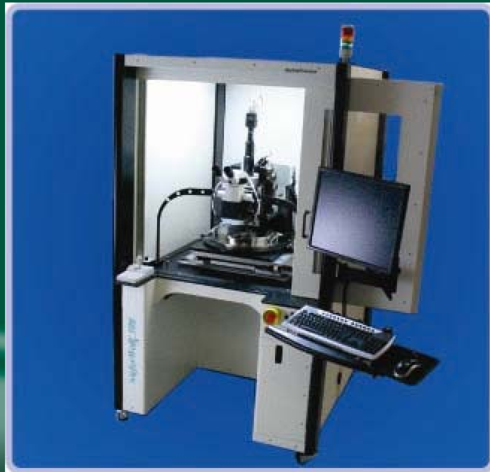
Fixed Cycle Count

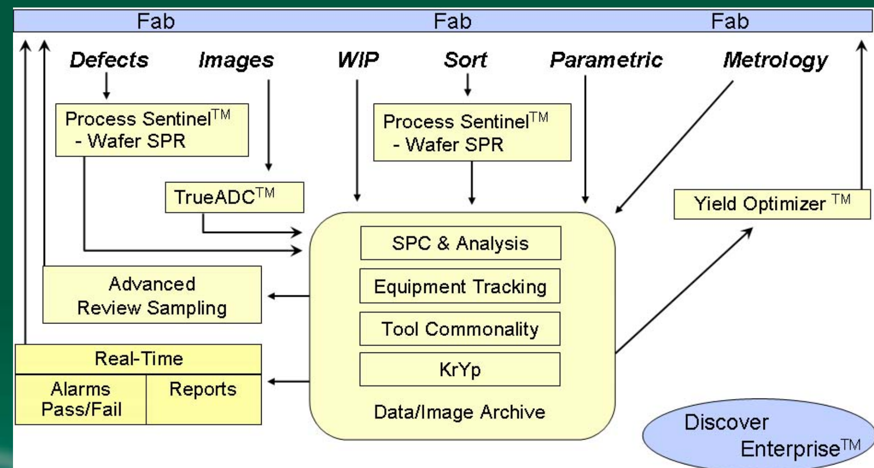
Run to Yield Fallout

waferWoRx + Discover enables identification of optimal performance scenario thru SPC

How to acquire these data?

- Working with our partners, we collected data using WaferWoRx™.
- We analyzed these data applying standard SPC rules.
- We are currently working with Rudolph's Discover™ Enterprise package to correlate these data to bin sort data to identify sort related yield loss.





Automation of Sort Area SPC

spc - [DEFECT COUNT]

File Logs Setup View Options Window Help

	LotId	XBar	Range
85	DS514	7.50	5.00
86	DS515	6.00	0.00
87	DS516	6.50	3.00
88	DS517	4.00	6.00
89	DS518	5.00	3.00
90	DS519	4.00	2.00
91	DS520	4.33	1.00
92	DS521	2.50	1.00
93	DS522	6.00	0.00
94	DS523	5.00	6.00
95	DS524	4.50	1.00
96	DS525	23.50	3.00
97	DS526	27.50	5.00
98	DS527	28.00	8.00
99	DS536	4.00	4.00
100	DS528	107.00	10.00
101	DS537	6.00	4.00
102	DS529	56.00	2.00
103	DS538	4.33	1.00
104	DS570	7.00	4.00
105	DS571	3.00	0.00
106	DS572	11.50	7.00
107	DS573	9.50	1.00
108	DS574	5.00	0.00
109	DS575	6.67	3.00

DEFECT COUNT (Last updated: 2000/04/14 20:58)

Fab: INSPEX Module: FA Device: SPC001 Step: DNL30CM

Avg. of Defect Count

197.28
159.91
122.54
85.17
47.80
10.44
-26.93
-64.30
-101.67

SPC UCL = 83.48
SPC Mean = 26.60
SPC LCL = -30.29

Range of Defect Count

23.40
20.48
17.55
14.63
11.70
8.78
5.85
2.93
0.00

SPC UCL = 18.39
SPC Mean = 5.92
SPC LCL = 0.00

Ready NUM

Other benefits that we anticipate:

- Parameters will slowly drift out of specification over time. SPC will enable users to detect problems and implement solutions before they affect process yield.
- Sort area SPC will enable process engineers to perform system maintenance on a more selective basis:
  - Perform knowledge-driven tool maintenance.
    - Do not perform maintenance based upon hours of operation.
    - Do not perform maintenance based upon cycle counts.
    - If SPC indicates no reason to implement change, let the process continue to work for you.
- Understanding sort Cpk enables successful pad shrinks.

Summary…

- We found that SPC can be applied to sort area data.
- We identified sort area parameters that are important to monitor with SPC.
- We identified the need to incorporate bin sort data into sort area data analysis.
- We are continuing to work with our partners and plan to:
  - Continue to implement synergistic connections between fab sort area tools, fab sort bin data, and Discover Enterprise™.
  - Implement sort area SPC on a trial basis, to adjust the process to maximize the signal-to-noise ratio.
- We will be back in a year to let you know what we found.