CHAPTER V

BACKEND LINE CONTAMINATION REDUCTION

5.1 Introduction

5.1.2 Problem Description

Problem statement: 44% of HGA at Backend line need to be cleaned and cause lower line efficiency and capacity constraint.

Goal and Objective Statement: Reduce the rework percentage to be 13%.

5.1.3 Process Description

Cheetah18 product had 44% fast rework for contamination defect which it caused lower manufacturing line efficiency and capacity constraint. The fast rework was found on 4 major areas.

1. ET operation as known as "G1" which the percentage was equal to 2.8%
2. FOI operation as known as "G2" and the parts have to be routed back to test arm loading operation so that the units can be passed to spot clean for rework which the percentage was equal to 14%
3. FOI operation as "Touch up" parts. This was to clean on other area except "Gimbal" which was not allowed to clean because of RSA/PSA change reason. The percentage was equal to 10%
4. OQA lot rejection was about 10%

5.2 Measure Phase

5.2.1 Process Mapping

Process Map started at the backend of HGA process and details to operations which affect to contamination. Hidden factory or rework loop is concerned as a primary, G1 and G2. G1 is the rework process that operators at ET operation need to inspect contamination on ABS before test. If they found, parts should be returned to spot cleaning operation. G2 is the rework loop process that operators at FOI found the contamination on any areas of HGA. It needs to be returned to Spot cleaning operation. The details of flow are provided as below.

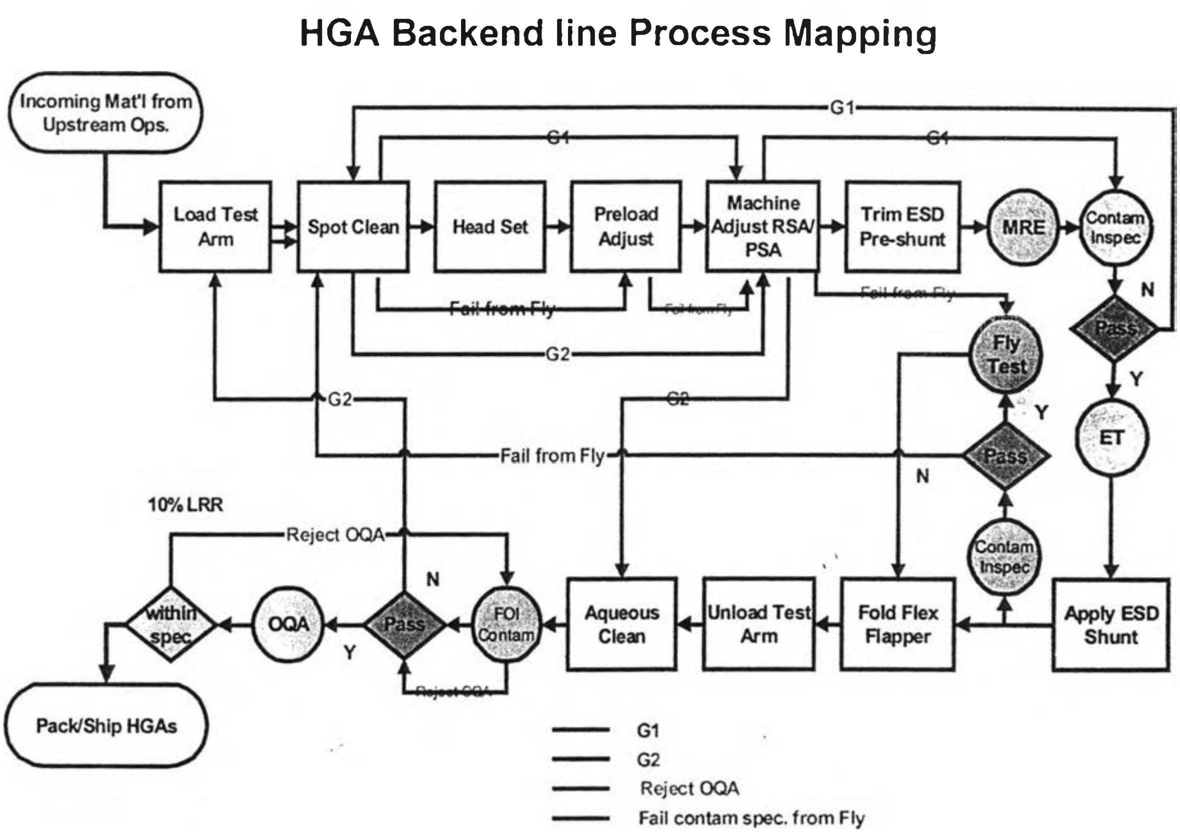

Figure 5.1 HGA backend line process mapping

5.2.2 Cause & Effect Diagram

Cause & Effect Diagram is to identify, explore, graphically display and in increasing detail of all the possible causes related to a problem or condition to discover the root causes. Cause & Effect of backend line contamination is provided as below.

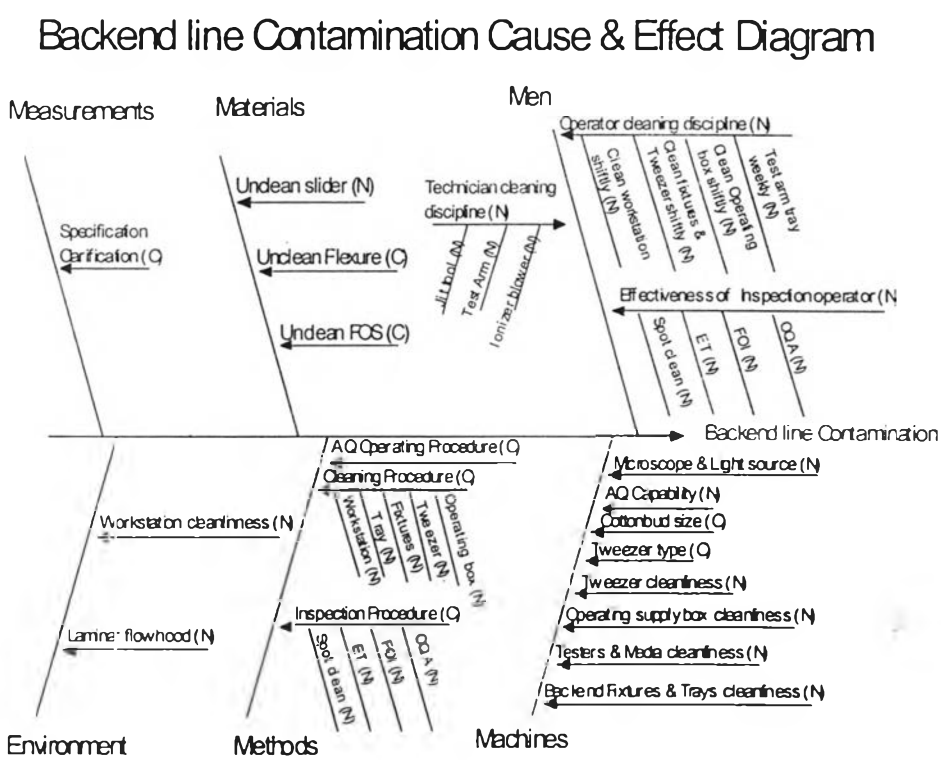

Figure 5.2 Backend line contamination Cause & Effect Diagram

5.2.3 Cause & Effect Matrix

Cause & Effect Matrix is used to relate and prioritize X's, scored as to relationship to outputs, to customer and Y's, scored as importance to customer, through numerical ranking by using the process map as a primary source. For contamination Cause & Effect Matrix is illustrated as below.

Rating Of Important to Customer		10	10	10	8	6	4	
		1	2	3	4	5	6	
Process Input		O% Particle on ABS	O% Particle on ABS	Less cleaning on side of the slider	Less lot rejection	Less cleaning at FOS and Flexure	Less cleaning on FOS and Sturt at gimbal Area	Total
1	Clean slider	10	10	10	10	10	10	480
2	Clean Workstation	10	10	10	10	10	10	480
3	Clean Fixtures	10	10	10	10	10	10	480
4	Clean Ionizer Blower	10	10	10	10	10	10	480
5	Clean Tweezer	10	10	10	10	10	10	480
6	Proper cotton buds size at Spot clean& FOI.	10	10	10	10	10	10	480
7	Clean C/S tray & Cover	8	8	8	8	8	8	384
8	Clean Test arm tray	8	10	10		10	10	380
9	AQ Capability		10	10	10	10	10	380
10	Inspection procedure clarification		10	10	10	10	10	380
11	Proper tweezer type at FOI		10	10	10	10	10	380
12	Clean Jit tool	10	5	10		10	10	350
13	Specification Clarification	4	5	10	8	8	5	322
14	Clean Operating supply box	7	7	7		7	7	280
15	Laminar flowhood Capability	5	5	5	5	5	5	240
16	Clean media	10	10					200
17	Spot clean operator effectiveness	10	10					200
18	Autogrammer load cell cleanliness	10	10					200
19	Clean Test arm & Wing	3	3	1		5		100
20	FOI operator effectivenes				10			80
21	Clean Inprocess tray	5						50

Table 5.1 Cause & Effect Matrix of backend line contamination[6]

[6]This score was come from brainstorming among Process Engineer, Production and Master Blackbelt by giving 10 points as a maximum and 1 point as a minimum score.

5.2.4 Gage R&R Study

ET Operator Gage R&R Study

Sample	Attribute	Appraiser 1	Appraiser 2	Appraiser 3	Appraiser 4	Y/N Agree
1	NG	NG	NG	NG	NG	Y
2	G	G	G	NG	G	N
3	G	G	G	G	G	Y
4	NG	NG	NG	NG	NG	Y
5	NG	NG	G	NG	NG	N
6	NG	NG	NG	NG	NG	Y
7	NG	NG	NG	G	NG	N
8	NG	NG	NG	NG	NG	Y
9	G	G	G	G	G	Y
10	NG	NG	G	NG	NG	Y
11	NG	NG	G	NG	NG	N
12	NG	NG	NG	NG	NG	Y
13	NG	NG	NG	NG	NG	Y
14	NG	NG	NG	NG	NG	Y
15	G	NG	G	G	G	N
16	NG	NG	NG	NG	NG	Y
17	NG	NG	NG	NG	NG	Y
18	G	NG	G	G	G	N
19	NG	NG	NG	NG	NG	Y
20	G	G	G	G	G	Y
21	NG	NG	NG	NG	NG	Y
22	G	NG	G	G	G	N
23	NG	NG	NG	NG	NG	Y
24	G	G	G	G	G	Y
25	G	G	G	G	G	Y
26	NG	NG	G	NG	NG	N
27	NG	NG	NG	NG	NG	Y
28	G	G	G	G	G	Y
29	G	G	G	G	G	Y
30	NG	NG	NG	NG	G	N
31	G	G	G	G	G	Y
32	NG	NG	NG	NG	NG	Y
33	NG	NG	NG	NG	NG	Y
34	NG	NG	NG	NG	NG	Y
35	NG	NG	NG	NG	NG	Y
36	NG	G	NG	NG	G	N
37	NG	NG	NG	NG	NG	Y
38	NG	NG	NG	NG	NG	Y
39	NG	NG	NG	NG	NG	Y
%Appraiser score		89.7%	92.3%	94.9%	95%	
						74.4%

Note : * = answer with wrong criteria

OQA Operator Gage R&R Study

Sample	Attribute	Appraiser 1	Appraiser 2	Appraiser 3	Appraiser 4	Y/N Agree
1	G	G	G	G	G	Y
2	NG	NG	NG	NG	NG	Y
3	NG	NG	NG	NG	NG	Y
4	G	G	G	G	G	Y
5	NG	NG	NG	NG	NG	Y
6	G	G	G	G	G	Y
7	NG	NG	NG	NG	NG	Y
8	NG	NG	NG	NG	NG	Y
9	NG	NG	NG	NG	NG	Y
10	NG	NG	NG	NG	NG	Y
11	NG	NG	NG	NG	NG	Y
12	NG	NG	NG	NG	NG	Y
13	G	G	NG	G	G	N
14	NG	NG	NG	NG	NG	Y
15	NG	NG	NG	NG	NG	Y
16	G	G	G	G	G	Y
17	NG	NG	NG	NG	NG	Y
18	NG	NG	NG	NG	NG	Y
19	NG	NG	NG	G	NG	N
20	NG	NG	NG*	NG	NG	N
21	G	G	NG	G	G	N
22	NG	NG	NG	NG	NG	Y
23	NG	NG	NG	NG	NG	Y
24	G	G	G	G	G	Y
25	NG	NG	NG	NG	NG	Y
26	NG	NG	NG	G	NG	N
27	NG	NG	NG	NG	NG	Y
28	NG	NG	NG	NG	NG	Y
29	NG	NG	NG	NG	G	N
30	G	G	G	G	G	Y
31	NG	NG	NG	NG	NG	Y
32	NG	NG	NG	NG*	NG	N
33	G	G	G	G	G	Y
34	NG	NG	NG	NG	NG	Y
35	G	G	NG	G	G	N
36	NG	NG	NG	NG	NG	Y
37	NG	NG*	NG	NG	G	N
38	G	G	G	G	G	Y
39	NG	NG	NG	NG	NG	Y
40	G	G	G	G	G	Y
%Appraiser score		87.5%	90.0%	92.5%	95%	
						77.6%

Note : * = answer with wrong criteria.

FOI Operator Gage R&R Study

Sample	Attribute	Appraiser 1	Appraiser 2	Appraiser 3	Appraiser 4	Appraiser 5	Appraiser 6	Appraiser 7	Appraiser 8	Y/N Agree
1	G	G	G	G	G	G	G	G	G	Y
2	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
3	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
4	G	G	G	G	G	G	G	G	G	Y
5	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
6	G	G	G	NG	NG	G	G	G	G	N
7	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
8	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
9	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
10	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
11	NG	G	NG	NG	NG	NG	NG	NG	NG	N
12	NG	NG	G	NG	NG	NG	NG	NG	G	N
13	G	G	G	G	G	G	G	NG	G	N
14	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
15	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
16	G	G	G	G	G	G	NG	G	G	N
17	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
18	NG	NG	NG	NG	NG	NG	G	NG	NG	N
19	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
20	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
21	G	G	G	G	G	G	G	G	G	Y
22	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
23	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
24	G	NG	NG	G	NG	G	G	G	G	N
25	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
26	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
27	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
28	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
29	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
30	G	G	NG	G	G	G	G	NG	G	N
31	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
32	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
33	G	G	G	G	G	G	G	G	G	Y
34	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
35	G	G	G	G	G	G	G	G	G	Y
36	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
37	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
38	G	G	G	G	G	G	G	G	G	Y
39	NG	NG	NG	NG	NG	NG	NG	NG	NG	Y
40	G	G	G	G	G	G	G	G	G	Y
% Appraiser score		95%	92.5%	87.5%	85%	87.5%	85%	85.0%	87.5%	
						Overall score				80.0%

Note : * = answer with wrong criteria.

Table 5.2 Gage R&R of ET, FOI and OQA operation

Gage R&R is poor due to the operator was unclear about the specification. Corrective action has been taken by clarifying the specification and re-training operators. After re-establish the gage has been improved from 80% to 92% at FOI. 77.5% to 90% at OQA and 74.4 % to 92.5% at ET.

5.2.5 Capability Analysis & Roll throughput Yield

Process Baseline - HGA Backend line Contamination Project

Based on 0 ABS particle specification

	Long Term	Entitlement
Units Submitted	500	100
Units Passed	500	100
Units Repaired	800	44
Units Scrapped	0	0
Classical Yield	1.00	1.00
First Time Yield	0.09	0.60
Observed Defects	1104	47
Opportunities per Unit	19	19
Opportunities Submitted	9500	1900
Defects per Unit	2.208	0.47
Rolled Thruput Yield	0.11	0.63
Defects per Opportunity	0.116210526	0.024736842
Defects per Million Opportunities	116211	24737
Yield per Opportuntiy	0.89	0.98
Sigma Score Long Term	1.2281	
Sigma Score Short Term	2.7281	1.9697
Process Capability Long Term	0.41	
Process Capability Short Term		0.66

Process Baseline - HGA Backend line Contamination Project

Based on 4 ABS particles specification

	Long Term	Entitlement
Units Submitted	500	500
Units Passed	500	500
Units Repaired	261	101
Units Scrapped	0	0
Classical Yield	1.00	1.00
First Time Yield	0.54	0.81
Observed Defects	338	136
Opportunities per Unit	19	19
Opportunities Submitted	9500	9500
Defects per Unit	0.676	0.272
Rolled Thruput Yield	50.8%	76.2%
Defects per Opportunity	0.035579	0.014315789
Defects per Million Opportunities	35579	14316
Yield per Opportuntiy	0.97	0.99
Sigma Score Long Term	1.8125	
Sigma Score Short Term		2.1913
Process Capability Long Term	0.60	
Process Capability Short Term		0.73

5.2.6 FMEA

FMEA is the systematic design evaluation procedure that to identify potential failure modes and rate the severity of the effects. Moreover, it is also used to identify critical characteristics and significant characteristics. FMEA of backend contamination problem is illustrated as below.

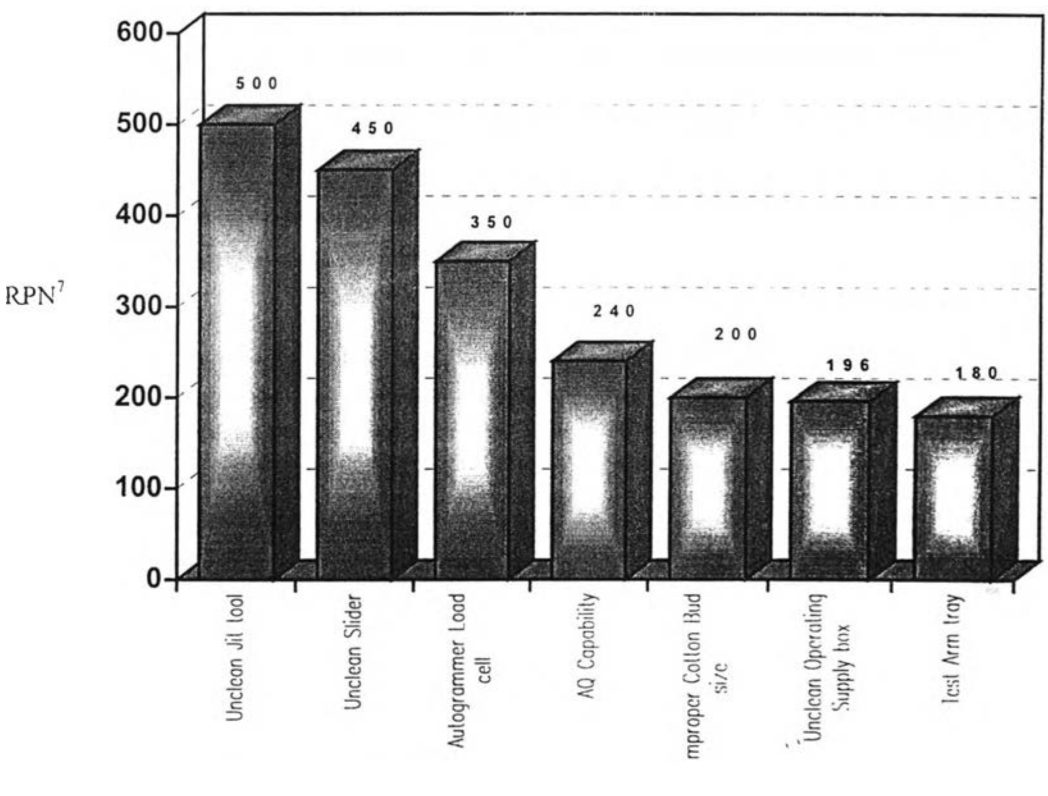

Figure 5.3 Backend line contamination FMEA

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[7]RPN is standing for Risk Priority Number which calculate from Occurrence x Severity x Detection. The score of each category is ranging from 1 to 10 and coming from a brainstorming among team, including Process Engineer, Supervisor and Master Blackbelt.

5.2.7 Phase Conclusion

1. Contamination specification is unclear. The specification among slider & HGA & HSA are confusing. Slider specification is looser than HGA.
2. The correct specification requires zero particles on HGA and allows only 10% of part can be shipped out with 4 particles. The specification is not practical to be used in the manufacturing line and somewhat unclear. The wrong interpretation happened on all HGA products. They are using the specification of 4 particles instead of zero on ABS. HSA specification requires 10 particles. There is no impact to HSA assembly process. The current HGA assembly process is not capable to meet zero particle contamination.
3. Gage R&R for operators is not capable due to the unclear specification. After clarify the specification, the gage is improved to be 90%.

5.3 Analysis Phase

5.3.1 Demographic Matrix

The baseline data is the **passive data from the database**. The yield is based on the 5-ABS particles on ABS (G1) and 4 ABS particles at FOI (G2). The correct specification at FOI is 0 particles that allow only 10% of the parts to be shipped with 4 particles.

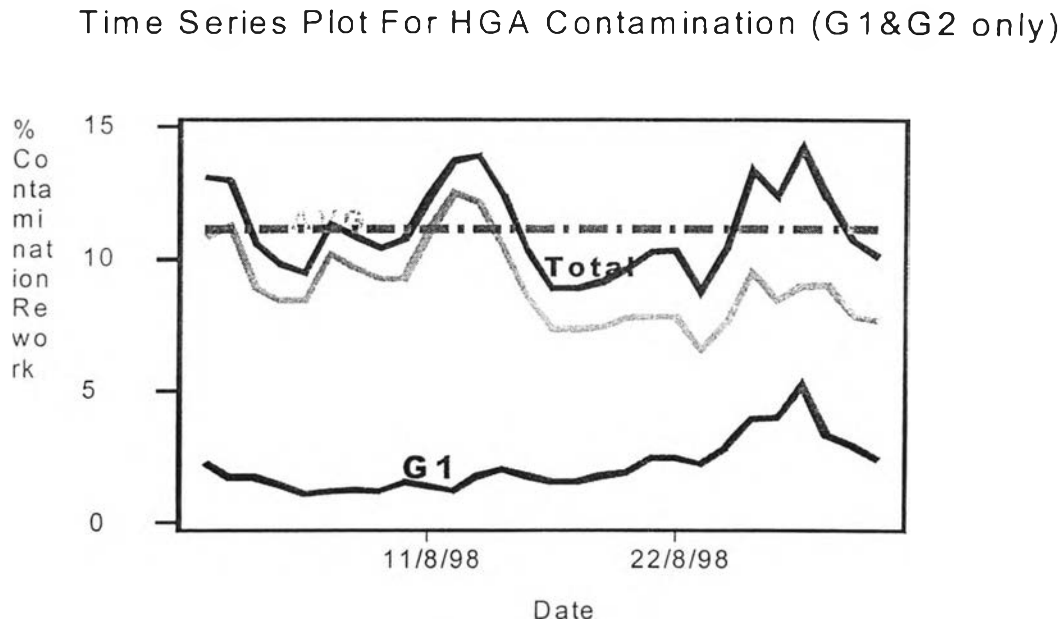


Figure 5.4 Time Series Plot For HGA Contamination (G1 & G2 only)

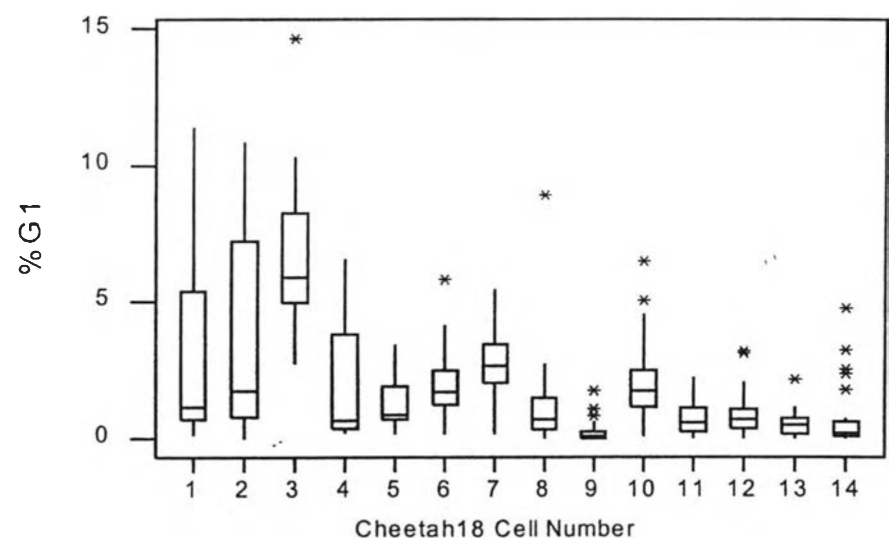


Figure 5.5 Percent Contamination (% G1) by cell

[8]* is an outliner which is calculated from, Min{highest data point, Q3+1.5(Q3-Q1) and Max{lowest data point,Q1-1.5(Q3-Q1)}.

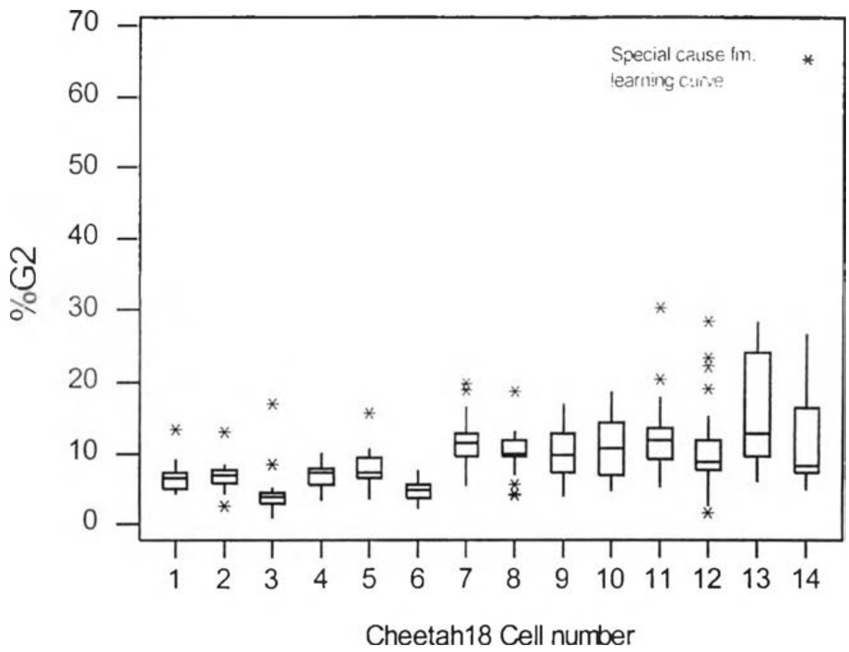


Figure 5.6 Percent Contamination (% G2) by cell

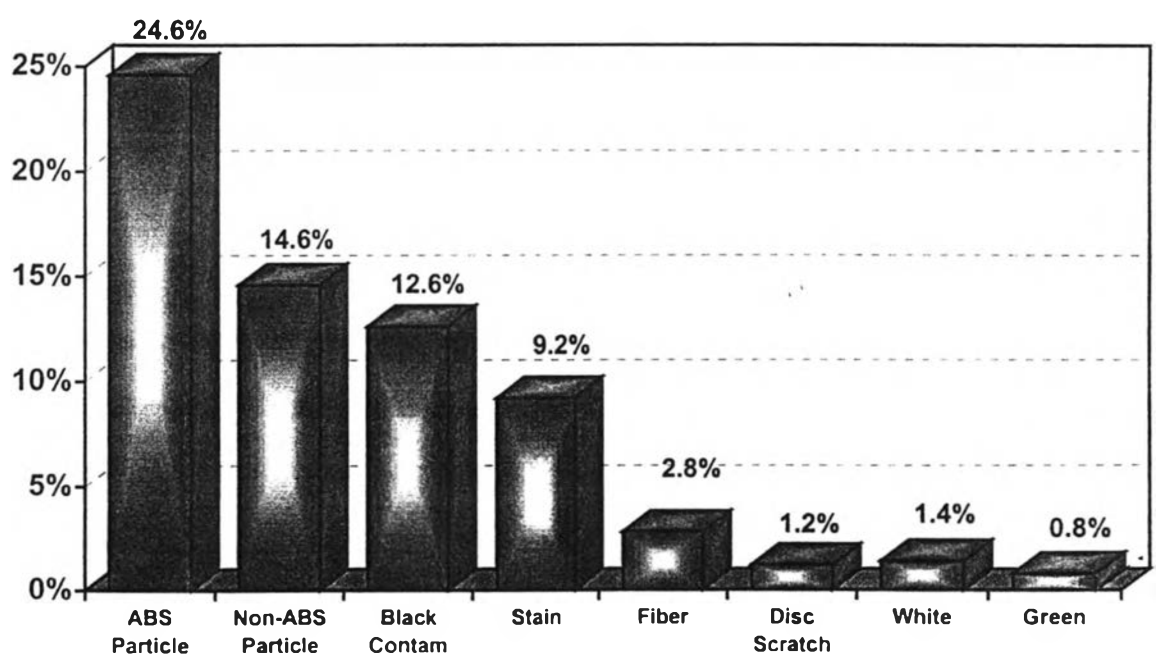


Figure 5.7 HGA Contamination Defect at FOI (zero particles on ABS)

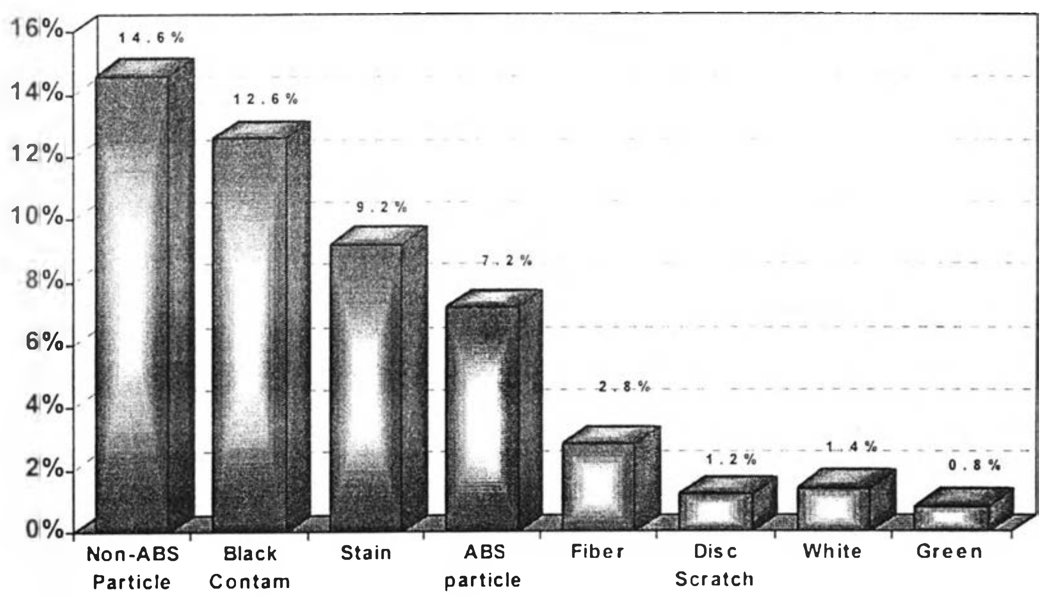
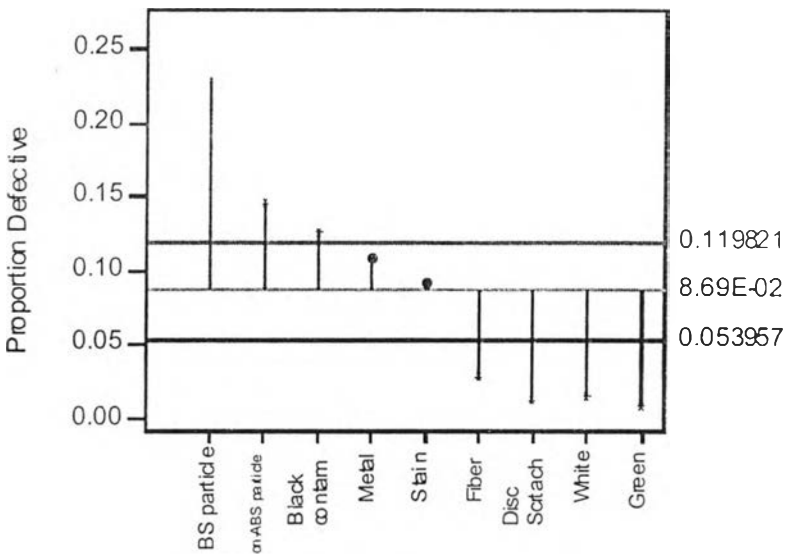


Figure 5.8 HGA Contamination Defect at FOI (four particles on ABS)

5.3.2 Multi-Vari Analysis

Below is the total picture for the contamination defects. The analysis will be concentrated on ABS particles as the primary. Moreover, all analysis is leaning towards the zero contamination on ABS specification.

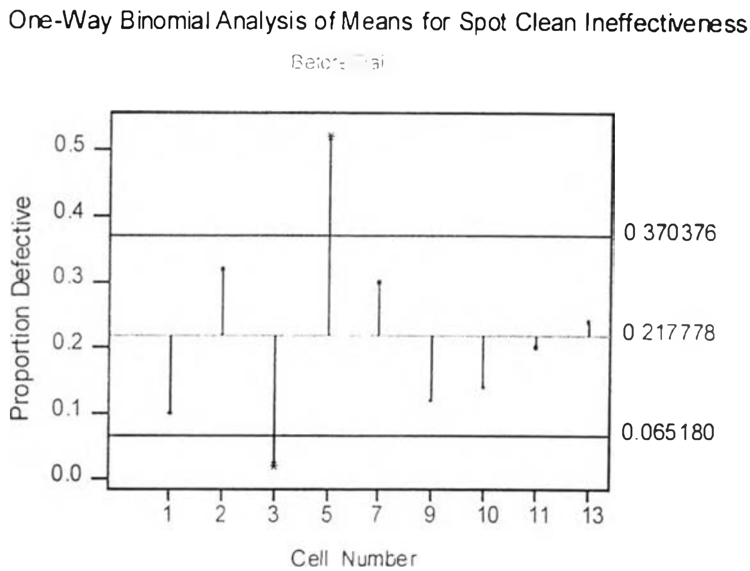
- One way Binomial Analysis of Mean for HGA contamination at FOI

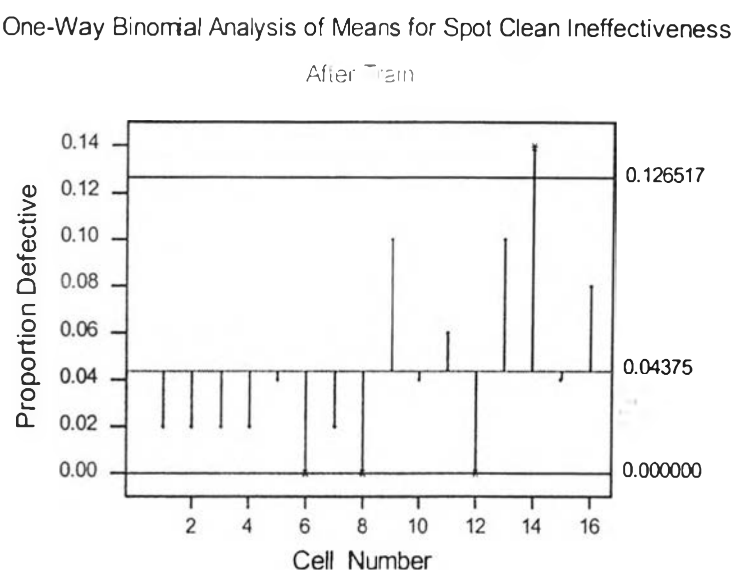


Evaluation 1: Spot clean effectiveness, Attribute tool, (ANOVA – Analysis of mean), (Appendix A: Table A.1)

<u>Procedure</u>

1. Let Spot clean operator clean and inspect parts as normal procedure.
2. Parts have re-inspected by technician.
3. Train operators about cleaning procedure and specification.
4. Let Spot clean operator clean and inspect parts with new instruction.
5. Parts have re-inspected by technician.



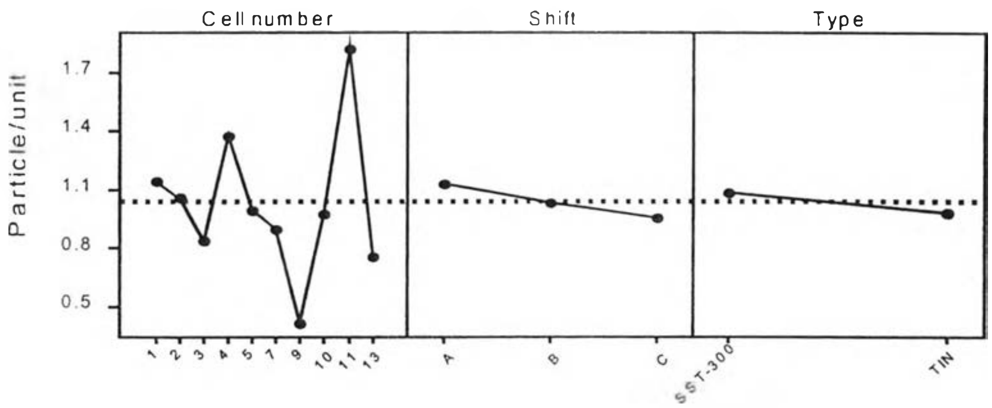


Conclusion: The evaluation result showed significant different of Spot clean effectiveness among Cheetha18 cells but it gets better after training.

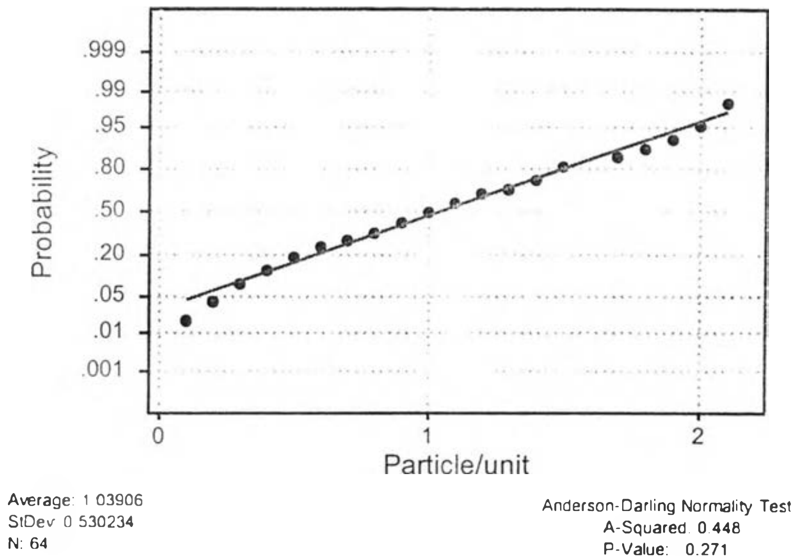
- *Evaluation 2:* Investigate Autogram receiver type, including operator performance among cells and shifts. (Appendix A: Table A.2)

According to there are two types of receivers at autogrammer, SST-300 and TIN, that ABS of slider is required to contact directly to these materials during measure and adjust mode. So, there is high opportunity that contamination on receivers or residual of both receiver types would be contaminated on ABS surface. So, the investigation of these has been taken into account that is as below.

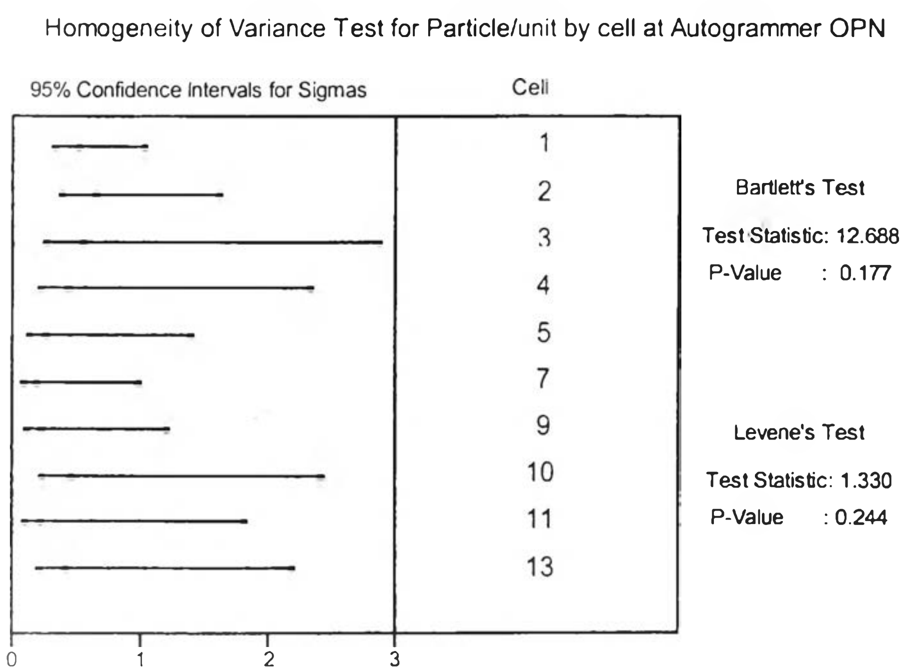
- Main effect Plot – Data Means for Particles/unit at Autogrammer Opn.



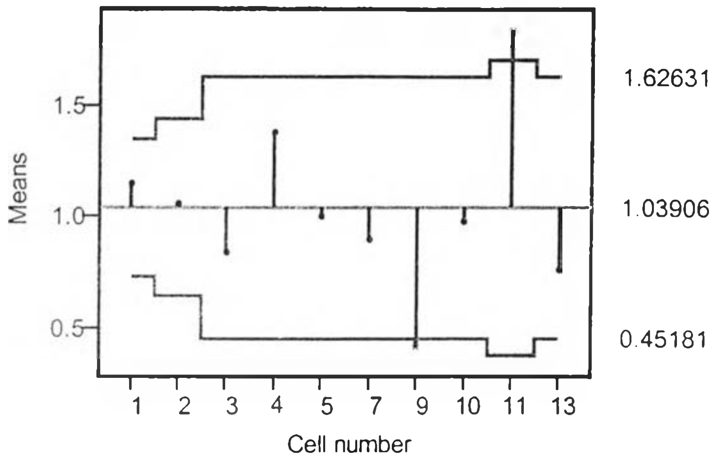
Use variable tool since it contains more information than attribute. Sample has been increased in order to approximate to normal distribution. The data has been qualified to pass normality as well.



- Homogeneity of Variance Test for Particle/unit by cell at Autogrammer Opn.



- One-way ANOM for Particle/unit by cell at Autogrammer Operation.

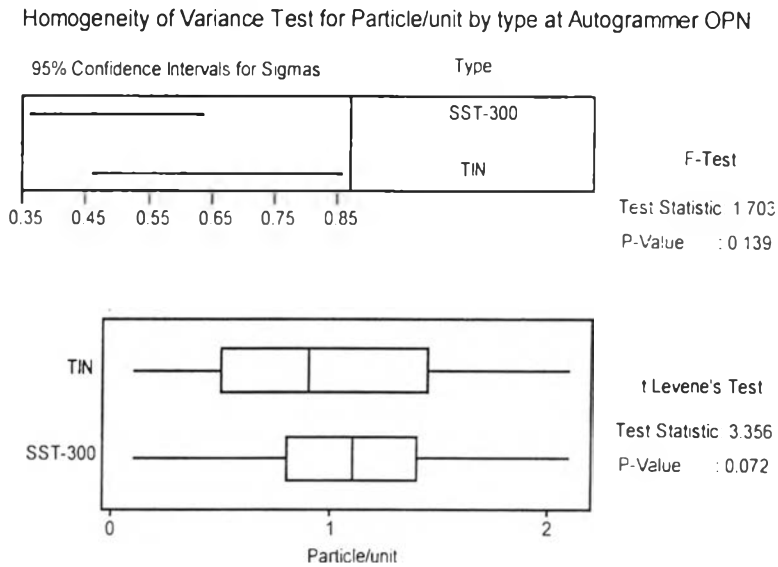


One-way Analysis of Variance

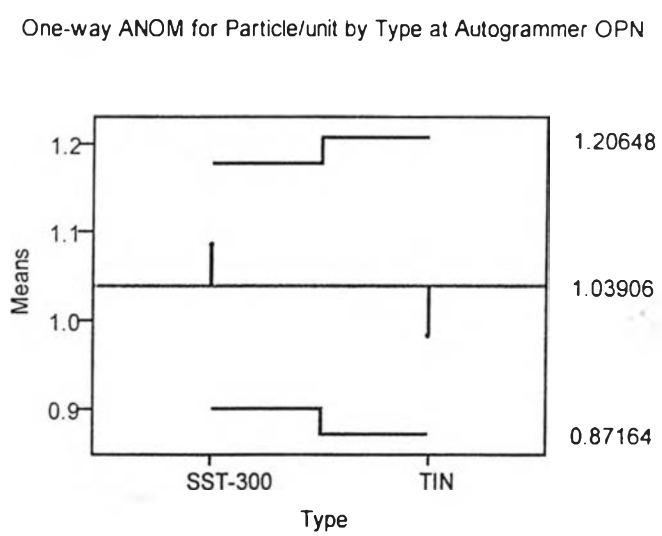
```
Analysis of Variance for Particle/unit by cell at   Autogrammer OPN
Source      DF        SS        MS        F        P
Cell num     9     5.856     0.651     2.96    0.006
Error       54    11.857     0.220
Total       63    17.712
                                   Individual 95%   CIs For Mean
                                   Based on Pooled   StDev
Level        N      Mean     StDev  -+---------+---------+---------+-----
 1          15    1.1467    0.5194                (--*---)
 2          10    1.0600    0.6484              (---*---)
 3           5    0.8400    0.5459          (-----*-----)
 4           5    1.3800    0.4438                 (-----*-----)
 5           5    1.0000    0.2646            (-----*-----)
 7           5    0.9000    0.1871           (-----*-----)
 9           5    0.4200    0.2280    (-----*-----)
10           5    0.9800    0.4604            (-----*-----)
11           4    1.8250    0.2217                     (------*------)
13           5    0.7600    0.4159         (-----*-----)
                                    -+---------+---------+---------+-----
Pooled StDev =    0.4686            0.00      0.70      1.40      2.10
```

Conclusion: Base on this analysis, there is a significant different of contamination mean at autogrammer among cells.

- Homogeneity of Variance Test for Particle/unit by type at Autogrammer Opn.



- One-way ANOM for Particle/unit by Type at Autogrammer Opn.

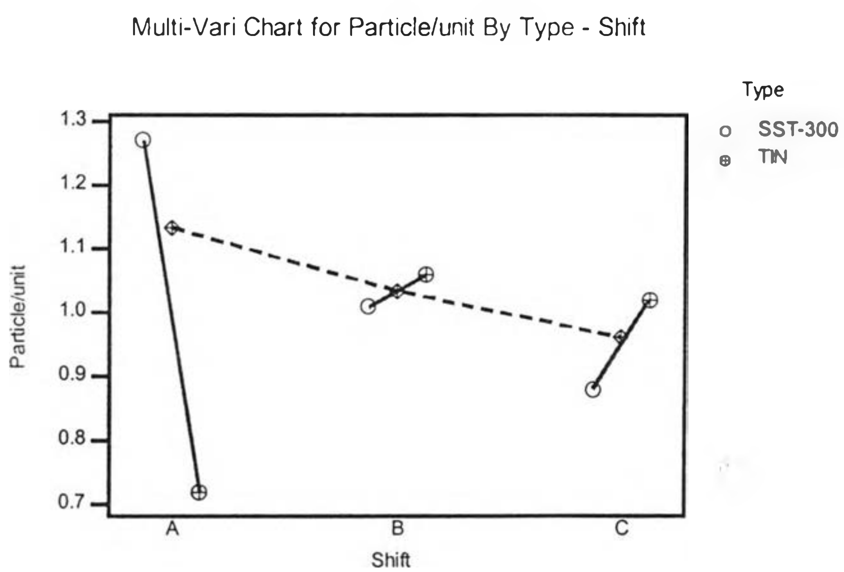


One-way Analysis of Variance

```
Analysis of Variance for Particle/unit by type at Autogrammer OPN
Source     DF      SS        MS        F       P
Type        1     0.168     0.168     0.59    0.444
Error      62    17.544     0.283
Total      63    17.712
                                    Individual 95% CIs For Mean
                                    Based on Pooled StDev
Level       N     Mean      StDev   ---------+---------+---------+------
SST-300    35    1.0857    0.4635          (-----------*-----------)
TIN        29    0.9828    0.6048   (------------*------------)
                                    ---------+---------+---------+------
Pooled StDev =   0.5320                   0.90      1.05      1.20
```

Conclusion: Base on this analysis, there is no a significant different of contamination mean between type of receivers at autogrammer operation.

- Multi-Vari Chart for Particle/unit by type- shift at Autogrammer Opn.



Conclusion: From the muti-vari chart showed that shift A has other special cause which is not due to the autogrammer type since shift B& C did not showed the same result. The suspected result of this difference may be due to the blower, its location and velocity, which will be analyzed in the next topic.

Evaluation 3: Test for turning blower on VS off at autogrammer opn, (Particle defect). (Appendix A: Table A.3)

N = 20 (with subgroup size of 100).

H_0: Number of defect is the same for turning blower on and off.

H_1: There are significant differences between these two.

<u>Two Sample T-Test and Confidence Interval for Blower- on VS Blower- off</u>

```
              N      Mean     StDev   SE Mean
Blower-on    20     1.310     0.832      0.19
Blower-off   20     0.720     0.578      0.13

95% CI for mu Blower-on - mu Blower-off: ( 0.13,  1.05)
T-Test mu Blower-on = mu Blower-off (vs not =): T = 2.60  P = 0.014  DF = 33
```

```
Conclusion :  Turning Blower on  vs off give significant mean difference.
```

Evaluation 4: Testing for maintaining Blower at the same VS change location, (Particle defects).

This evaluation is the consequent of evaluation 3 since blower can not be off according to ESD reason. This evaluation is to investigate if the changing location has impacted or not. Also N = 20 (subgroup size of 100)

H_0: Number of defect is the same for the same and changes blower location.

H_1: There are significant differences between these two.

Two Sample T-Test and Confidence Interval for Blower- same location VS Blower- change location

```
                          N    StDev   SE Mean
Blower-same location     20    1.310     0.832
Blower-change Location   20    0.460     0.319
0.071
95% CI for mu Blower-same mu Change Location: ( 0.44,  1.261)
T-Test mu Blower-same mu Change Location (vs not =): T = 4.27  P = 0.0003  DF = 24
```

Conclusion: Turning Blower same vs changing location give significant mean difference.

This is the big finding of contamination root cause. The ionizer blower current location is pulling the air from outside laminar flow hood to be inside and cause the dirty working environment. The flow direction was proved and demonstrated by using a fog testing (an equipment that testing the air velocity flow).

☯ ***Evaluation 5:*** Testing for AQ after ET VS AQ before ET, (Particle defects).

H_0: Number of defect is the same for both process flow.

H_1: There are significant differences between these two.

Test and Confidence Interval for Two Proportions

```
Sample        X       N  Sample p
1            37     100  0.370000
2             4     100  0.040000

Estimate for p(1) - p(2):  0.33
95% CI for p(1) - p(2):  (0.227875, 0.432125)
Test for p(1) - p(2) = 0 (vs not = 0):  Z = 6.33  P-Value = 0.000
```

Conclusion: Moving AQ to before ET gives different proportion defect than AQ after ET.

Evaluation 6: Testing for Clean Jit tool & Normal Slider VS Clean Jit tool & Clean slider, (Side-Particle defect).

H_0: Number of defect is the same for both cases

H_1: There are significant differences between these two.

Test and Confidence Interval for Two Proportions

```
Sample        X       N  Sample p
1            24     100  0.240000
2            10     100  0.100000

Estimate for p(1) - p(2):  0.14
95% CI for p(1) - p(2):  (0.0377057, 0.242294)
Test for p(1) - p(2) = 0 (vs not = 0):  Z = 2.6[illegible]  P-Value = 0.007
```

Conclusion: Clean Jit tool & Clean Slider gives different proportion defect than Clean Jit tool & Normal Slider.

Evaluation 7: Testing for Normal Jit tool & Normal Slider VS Unclean Jit tool & Normal slider, (Side-Particle defect).

H_0: Number of defect is the same for both cases

H_1: There are significant differences between these two.

Test and Confidence Interval for Two Proportions

```
Sample        X      N  Sample p
1            49    100  0.490000
2            24    100  0.240000

Estimate for p(1) - p(2):  0.25
95% CI for p(1) - p(2):  (0.121133, 0.378867)
Test for p(1) - p(2) = 0 (vs not = 0):  Z = 3.80  P-Value = 0.000
```

Conclusion: Clean jit tool & Normal slider gives different proportion defect than Normal Jit tool & Normal Slider.

☯ ***Evaluation 8:*** Testing for Used VS New Rubber Tip at FOS bond operation, (Black contamination defect).

H_0: Number of defect is the same for Used and New Rubber Tip.

H_1: There are significant differences between these two.

Test and Confidence Interval for Two Proportions

```
Sample        X      N  Sample p
1            33    200  0.165000
2             1    200  0.005000

Estimate for p(1) - p(2):  0.16
95% CI for p(1) - p(2):  (0.107637, 0.212363)
Test for p(1) - p(2) = 0 (vs not = 0):  Z = 5.99  P-Value = 0.000
```

Conclusion: New Rubber Tip gives different proportion from Used Rubber Tip.

- *Evaluation 9:* Testing for Foil VS Stainless cover tray at AQ operation, (Particle defect).

H_0: Number of defect is the same for Foil and Stainless cover tray.

H_1: There are significant differences between these two.

Test and Confidence Interval for Two Proportions

```
Sample        X      N  Sample p
1            15    100  0.150000
2             4    100  0.040000

Estimate for p(1) - p(2):  0.11
95% CI for p(1) - p(2):  (0.0301691, 0.189831)
Test for p(1) - p(2) = 0 (vs not = 0):  Z = 2.70  P-Value = 0.007
```

Conclusion: Stainless cover tray gives different proportion from Foil cover tray.

- *Evaluation 10:* Testing for New VS Used HGA In-process tray, (Black Contamination defect).

H_0: Number of defect is the same for New and Used In-process tray.

H_1: There are significant differences between these two.

Test and Confidence Interval for Two Proportions

```
Sample        X      N  Sample p
1            12    100  0.120000
2             3    100  0.030000

Estimate for p(1) - p(2):  0.09
95% CI for p(1) - p(2):  (0.0180664, 0.161934)
Test for p(1) - p(2) = 0 (vs not = 0):  Z = 2.45  P-Value = 0.014
```

Conclusion New HGA In-process tray gives different proportion from used tray.

5.3.3 Phase conclusion

1. The major key input variables are unclear specification which impact significantly to the Gage R&R, Spot clean operator effectiveness, Ionizer blower location, C/S tray cover cleanliness (from AQ to assembly line).
2. The validation for all those key input variables have been done on one cell and seen the significant improvement. The rework percentage went down to 3% level with no touch up at all at FOI operation. Further investigation has been done on the control cell. After 2 weeks. the contamination level has gone down to be less than 1% for in process. The OQA lot rejection was improved significantly from 10% to 2%.

Variables	Operation	Defect	Hypothesis result	
			Significant	Not significant
1) Spot clean operator	Spot clean	ABS particle	X	
2) Load cell type	Autogrammer	ABS particle		X
3) Cell	Autogrammer	ABS particle	X	
4) Shift	Autogrammer	ABS particle		X
5) Blower on VS off	Autogrammer	ABS particle	X	
6) Blower-relocation	Autogrammer	ABS particle	X	
7) Clean Slider	Head load	Non-ABS particle	X	
8) Change Process Flow	AQ	ABS particle	X	
9) Clean Jit tool (new)	Head load	Non-ABS particle	X	
10) Cover tray	AQ	ABS particle	X	
11) In-process tray (new)	-	ABS particle	X	
11) New rubber tip	FOS bond	Black contam.	X	

Table 5.3 Key Input Variables Summary.

3. Took out the cotton buds completely from this control cell and the contamination level is still maintained.
4. The other minor activities have implemented such as cleaning test arm and test arm tray and focusing on cleaning working area by shiftly, changing silo design. Those activities will help eliminate the opportunity of fast rework.

5.4 Improve Phase

After analysis phase, the improvement has shown significant lower than the target. The Laminar DOE was performed to find the further room of improvement. (Appendix A: Table A.4)

5.4.1 Laminar DOE Procedure

1. Design of Experiment was picked for 4 factors, 2 replicates, and full factorial design. Those 4 factors are ionizer blower on/off, ionizer blower angle, ESD partition and laminar velocity.

	Hi	Lo
Ionizer blower condition	On	Off
Ionizer blower angle	60	0
Partition	1.5ft	0ft
Velocity (1ft from filter)	110	70

2. Measure two KPOVs, One is the particle/cu.ft which was the cumulative data for 1 hour. The other one is the workstation velocity.
3. The measurement was done at 6 location on one site of workstation. This work station is a Microscope operation (FOI)

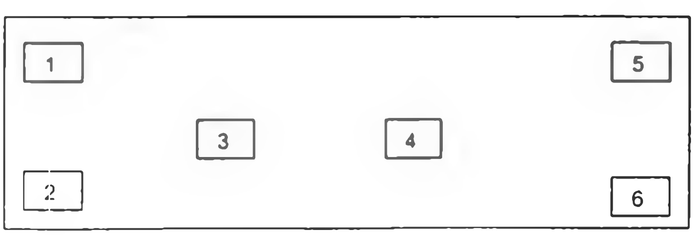
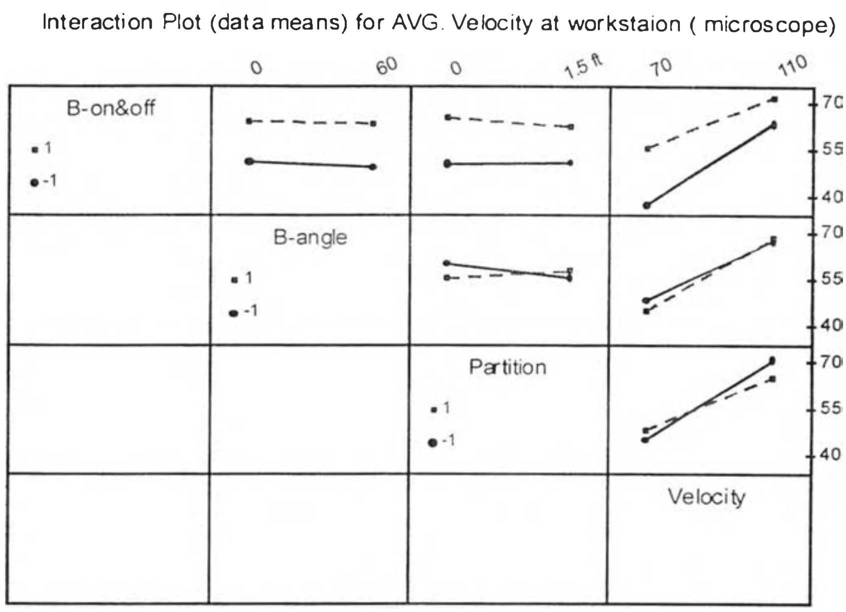
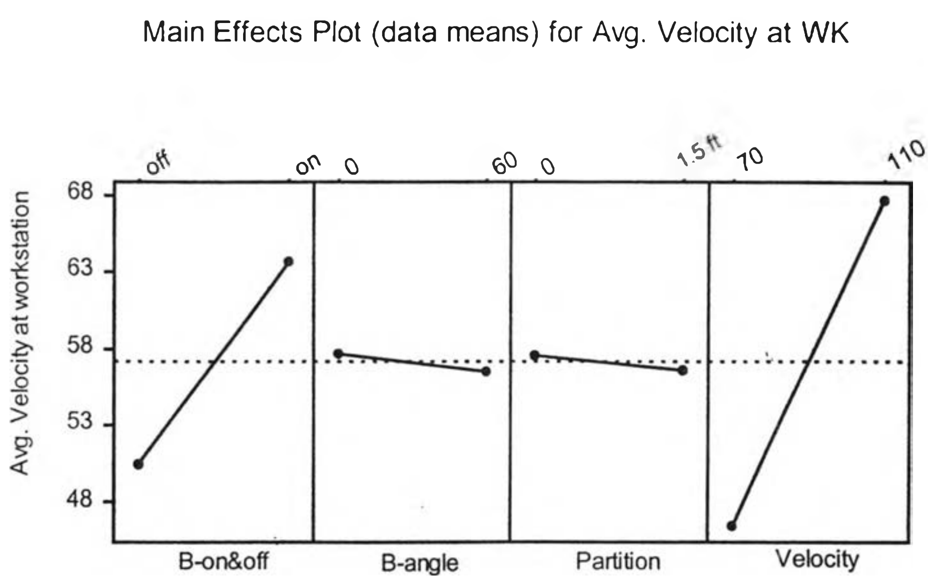


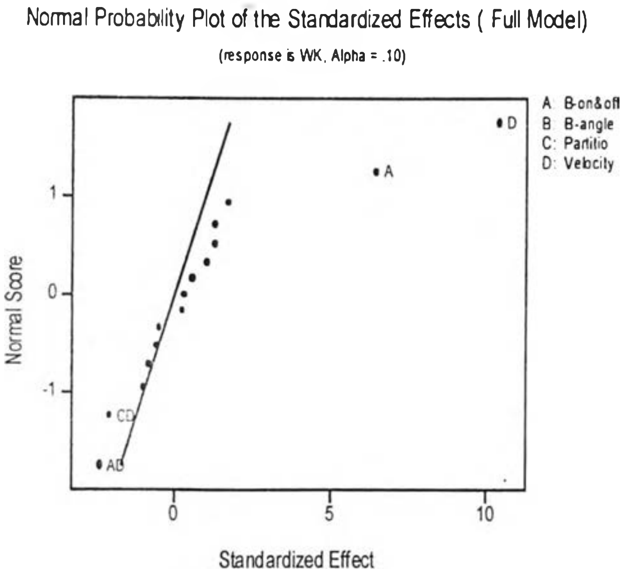
Figure 5.9 Velocity Measurement Location on Workstation.

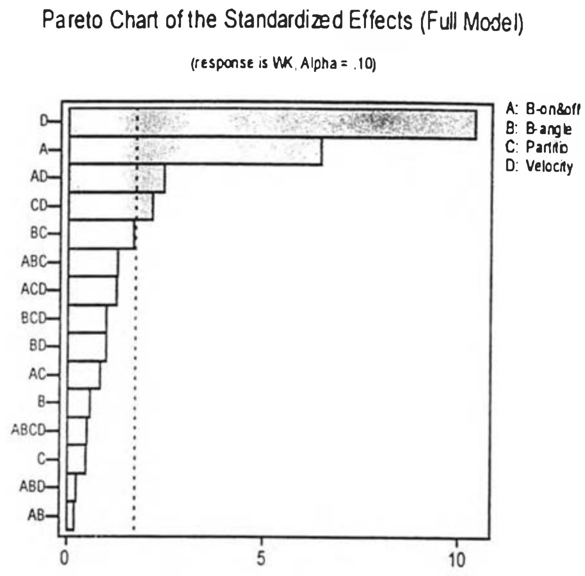
5.4.2 DOE Results

- ***Velocity on workbench***









Fractional Factorial Fit (Reduce Model)

Estimated Effects and Coefficients for WK (coded units)

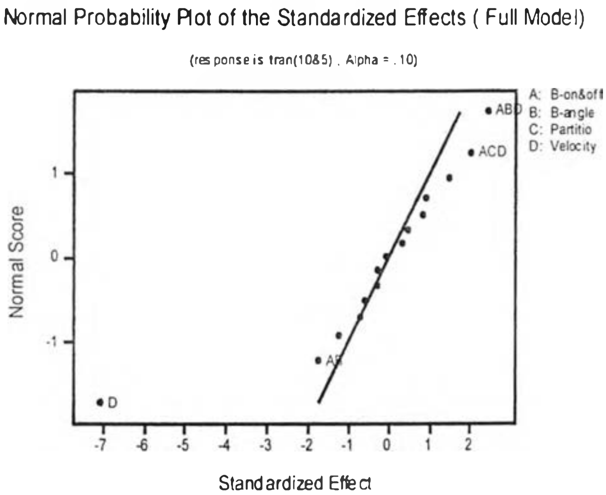
Term	Effect	Coef	StDev Coef	T	P
Constant		57.134	1.066	53.61	0.000
B-on&off	13.194	6.597	1.066	6.19	0.000
Velocity	21.256	10.628	1.066	9.97	0.000
B-on&off*Velocity	-5.019	-2.509	1.066	-2.35	0.026

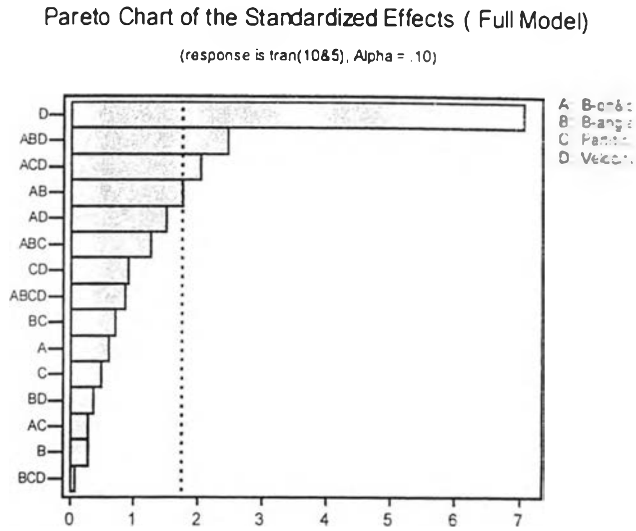
Analysis of Variance for WK (coded units)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	2	5007.23	5007.23	2503.61	68.87	0.000
2-Way Interactions	1	201.50	201.50	201.50	5.54	0.026
Residual Error	28	1017.86	1017.86	36.35		
Pure Error	28	1017.86	1017.86	36.35		
Total	31	6226.59				

Conclusion: The DOE result showed the velocity is the big contributor for the velocity on workbench. This DOE contained 2 responses. One is the velocity on workbench and the other is the number of particle on workbench which will be shown on the next page.

- ***The number of particle on workbench***





Fractional Factorial Fit

Estimated Effects and Coefficients for tran(10& (coded units)

Term	Effect	Coef	StDev Coef	T	P
Constant		2.875	0.2560	11.23	0.000
B-on&off	-0.308	-0.154	0.2560	-0.60	0.553
B-angle	-0.142	-0.071	0.2560	-0.28	0.784
Velocity	-3.607	-1.803	0.2560	-7.04	0.000
B-on&off*B-angle	-0.901	-0.451	0.2560	-1.76	0.091
B-on&off*Velocity	0.769	0.384	0.2560	1.50	0.146
B-angle*Velocity	0.181	0.091	0.2560	0.35	0.726
B-on&off*B-angle*Velocity	1.258	0.629	0.2560	2.46	0.022

Analysis of Variance for tran(10& (coded units)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Main Effects	3	104.998	104.998	34.999	16.69	0.000
2-Way Interactions	3	11.489	11.489	3.830	1.83	0.169
3-Way Interactions	1	12.662	12.662	12.662	6.04	0.022
Residual Error	24	50.338	50.338	2.097		
Pure Error	24	50.338	50.338	2.097		
Total	31	179.485				

Regression Analysis

```
                 The regression equation is
Particle(tran10&5) = 2.88 - 0.154 B-on&off - 0.071 B-angle - 1.80
                   Velocity + 0.629 B/o&f/an/ve
```

Predictor	Coef	StDev	T	P
Constant	2.8751	0.2675	10.75	0.000
B-on&off	-0.1542	0.2675	-0.58	0.569
B-angle	-0.0708	0.2675	-0.26	0.793
Velocity	-1.8034	0.2675	-6.74	0.000
B/o&f/an	0.6290	0.2675	2.35	0.026

S = 1.513   R-Sq = 65.6%   R-Sq(adj) = 60.5%

Conclusion: The result showed that the velocity is the biggest contributor for the number of particle on the workbench.

5.4.3 Phase Conclusion

1. Air velocity from Laminar is an important factor for contamination on workbench. Found R-square of 93% after the second DOE running. Current specification is called for 70-150 ft/min velocity by 1 ft below filter. There is no specification on workbench. The DOE conclusion is that we can improve the air velocity on workbench by increasing the air velocity to be 110 ft/min.
2. Facility group took an action to investigate if the 110 ft/min specification can be obtained. The difficulty is the Teparuk has a lot of older type of motor inside the Laminar flow hood which is limiting factor for velocity increment. The agreement has been made to buy the new motor for replacement. Facility will take action on the new purchase order of Laminar flow hood.

5.5 Control Phase

5.5.1 Metrics to be reported and interval

The key metrics is available as G1&G2 percentage on Web site. Shift&cell and product can also break down the detail. The benefit from project is to increase the line loading since the hidden factory factors have been reduces. The line loading is also available daily on Web site. Shift&cell and product break down the details as well.

5.5.2 Process owner responsible for monitoring

Contamination fast rework percentage can be monitored at http://eisweb.tep.thai.seagate.com/newpage/six_sigma.htm

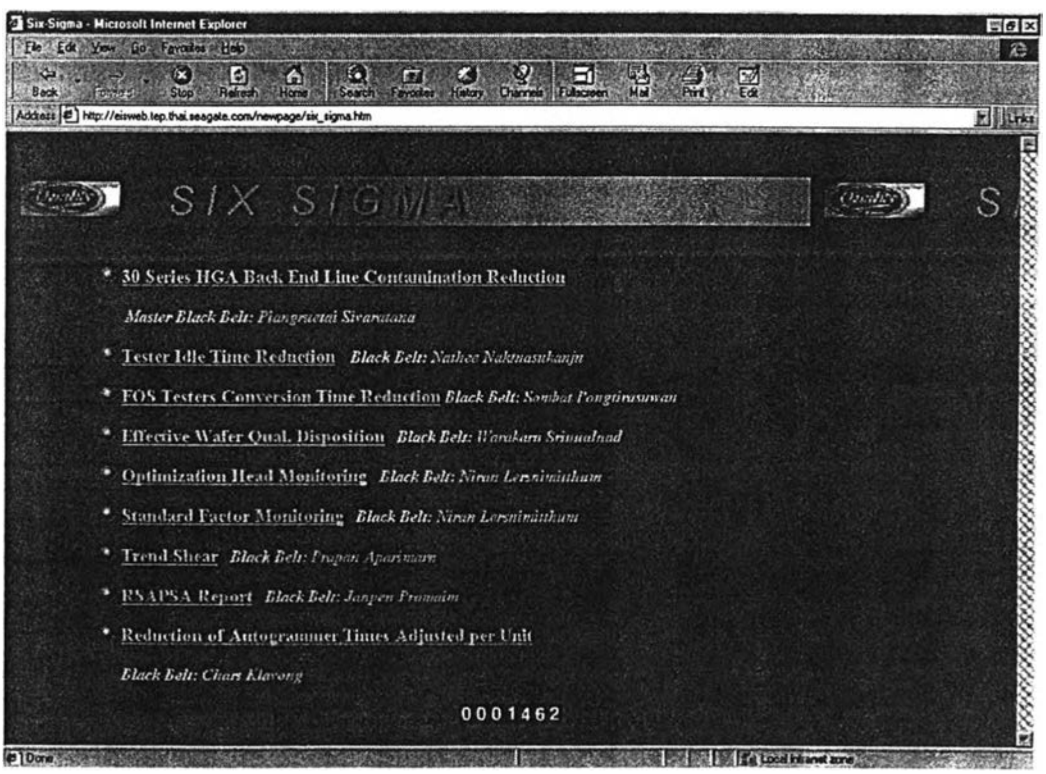


Figure 5.10 Contamination Web page

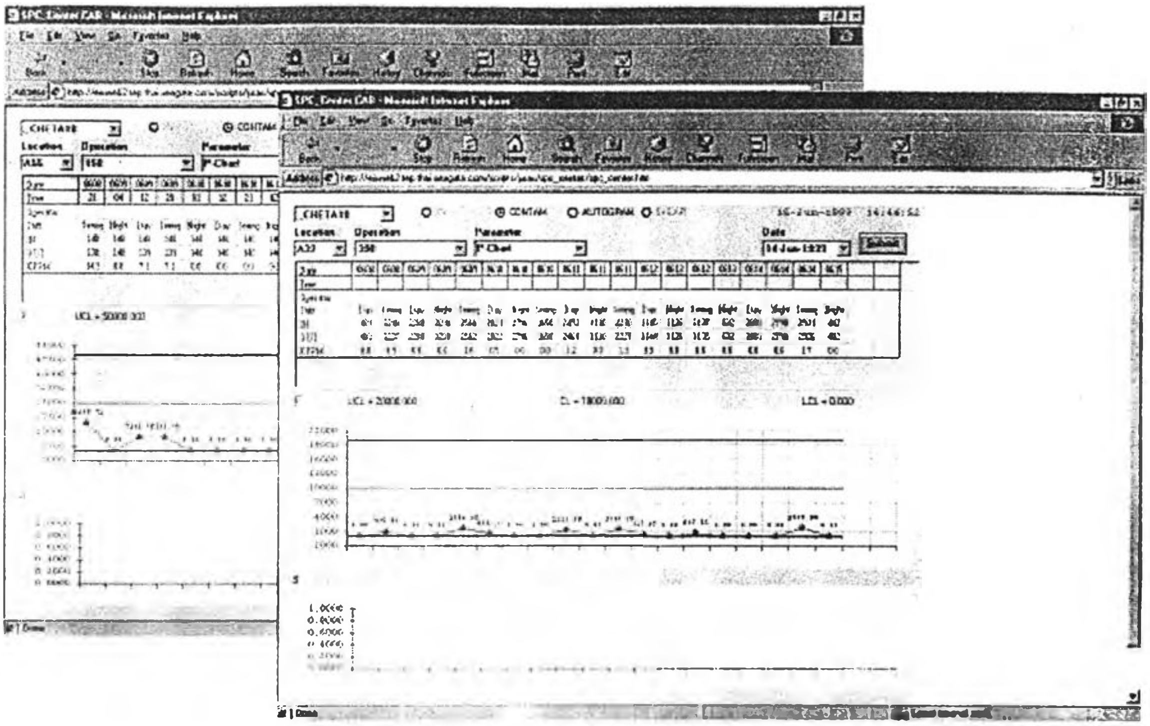


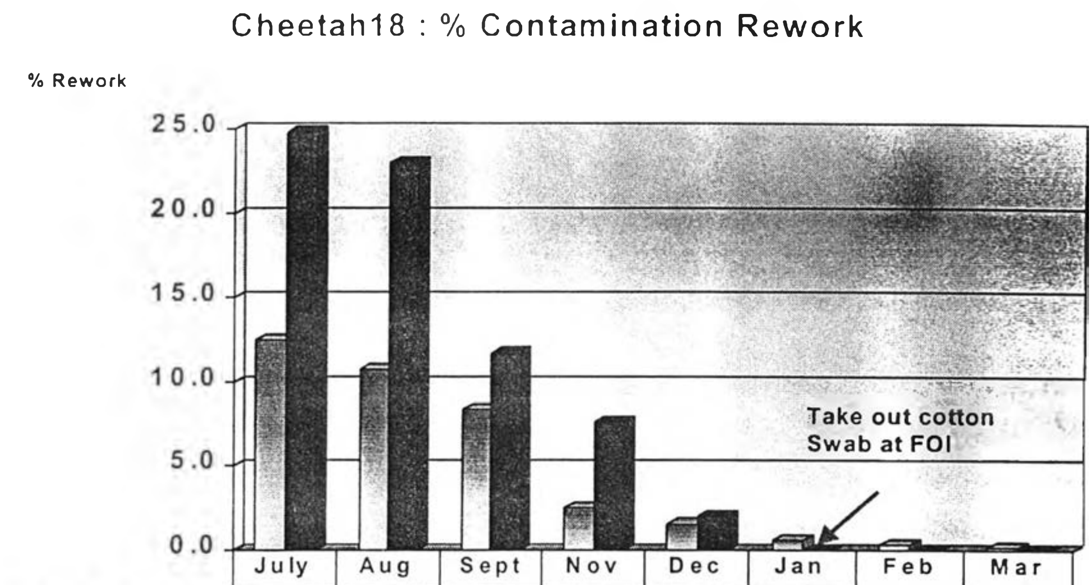
Figure 5.11 Example of automated P-Chart.

5.5.3 Phase conclusion

The P-chart has been established at Surveillance #2 and FOI operation. The control limit for Surveillance #2 operation is 0-5% and FOI control limits is 0-2%.

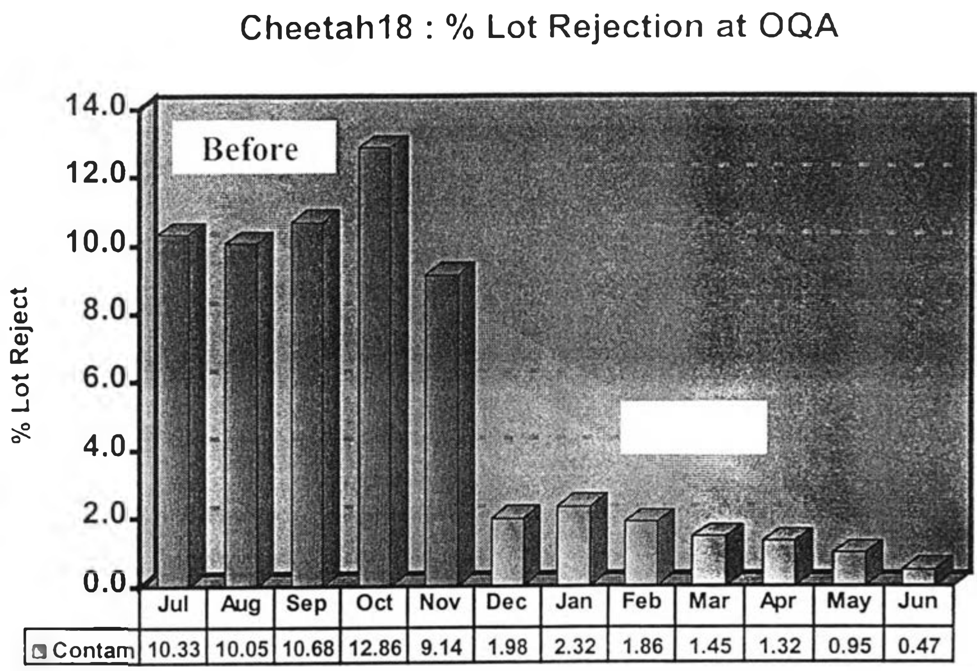
5.6 Product Performance

The product performances, including percent contamination rework and percent OQA lot rejected, have been tracking after implementing all improvement activities which are shown in Figure 5.12 and Figure 5.13, respectively.



	July	Aug	Sept	Nov	Dec	Jan	Feb	Mar
G1 & G2	12.5	10.72	8.39	2.51	1.55	0.61	0.31	0.17
Non-G2 at FOI	24.8	23.00	11.70	7.60	2.00	0.00	0.00	0.00

Figure 5.12 Percent Contamination Rework



	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Contam	10.33	10.05	10.68	12.86	9.14	1.98	2.32	1.86	1.45	1.32	0.95	0.47

Figure 5.13 Percent lot rejection at OQA