CHAPTER VI

IMPROVE OF HGA PRELOAD FIRST YIELD

6.1 Introduction

6.1.1 Problem Description

Problem statement: 76% of Preload First Yield has been lost at autogrammer which is result in high NVA (Non-value-added) time, adjusted time.

Goal and Objective Statement: To improve HGA Preload First Yield from 24% to 50%

6.1.2 Process Description

Autogrammer is a machine/ tester that for adjusting preload of HGA to target limits before fly and electrical testing on HGA process. Every single HGA will be first measured preload and compared to 2.65+/- 0.05 grams. Any HGA preload is out of this range, that HGA will be adjusted by an autogrammer. However, any HGA preload is between this range, that HGA will be automatically passed to next operation. The measurement and adjustment process may be repeated from 1 to 9 times, depends on preload value after adjusting. Final measurement at the tenth will be last and compares to HGA preload specification at 2.65+/-0.2 grams, any HGA preload is out of this range will be scrapped.

6.2 Measure Phase

6.2.1 Process Mapping

Process Map started at the beginning of HGA process and details to operations which affect to autogrammer operation. Each operation that prior to autogrammer operation included Hidden factory, Key process input variables and Key process output variables as below.

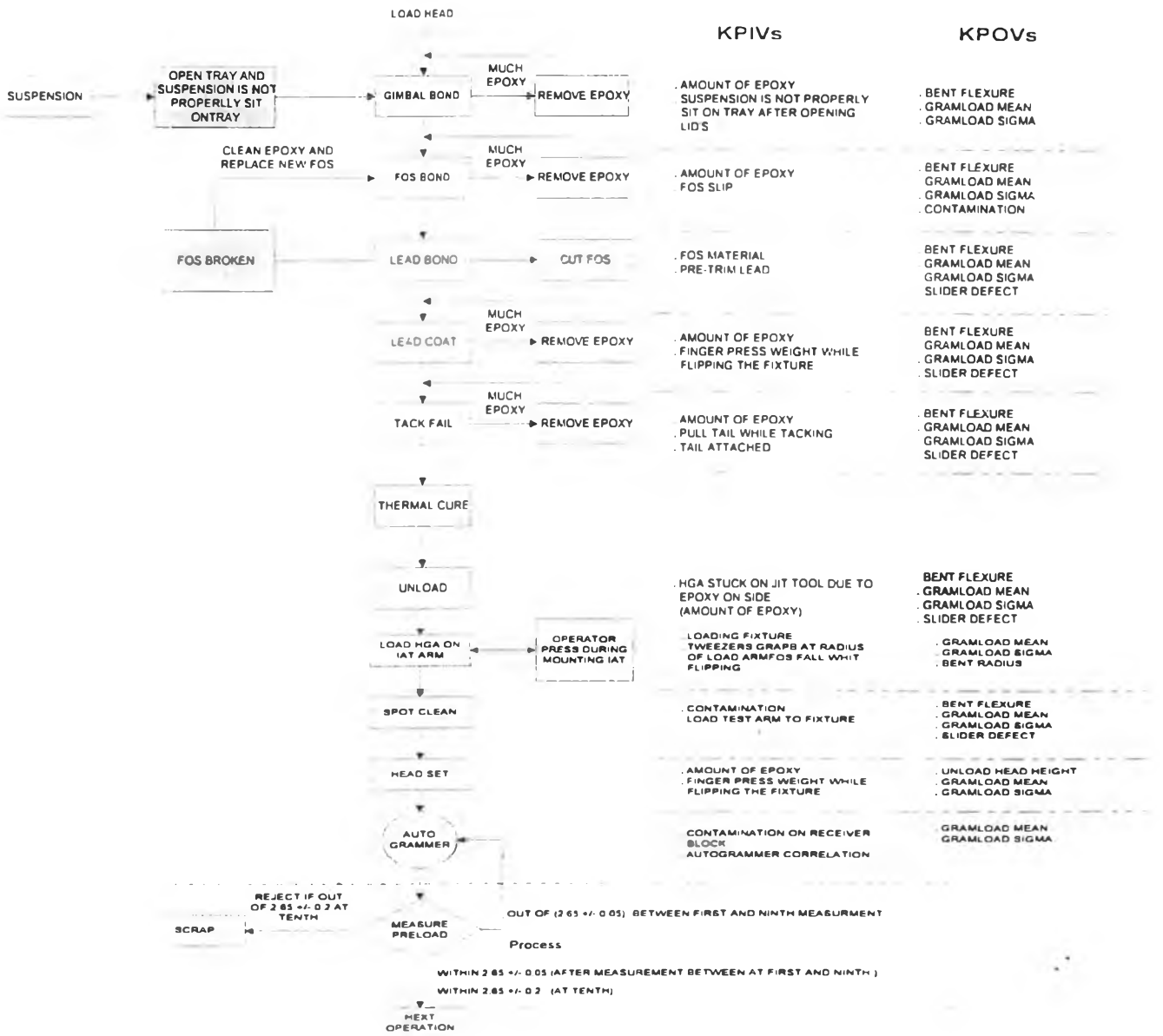

Figure 6.1 Process Mapping of Preload

6.2.2 Cause& Effect Diagram

Cause & Effect Diagram is to identify, explore and graphical display and increasing detail of all the possible causes related to a problem or condition to discover the root causes. Cause & Effect diagram of % preload reduction is illustrated as below.

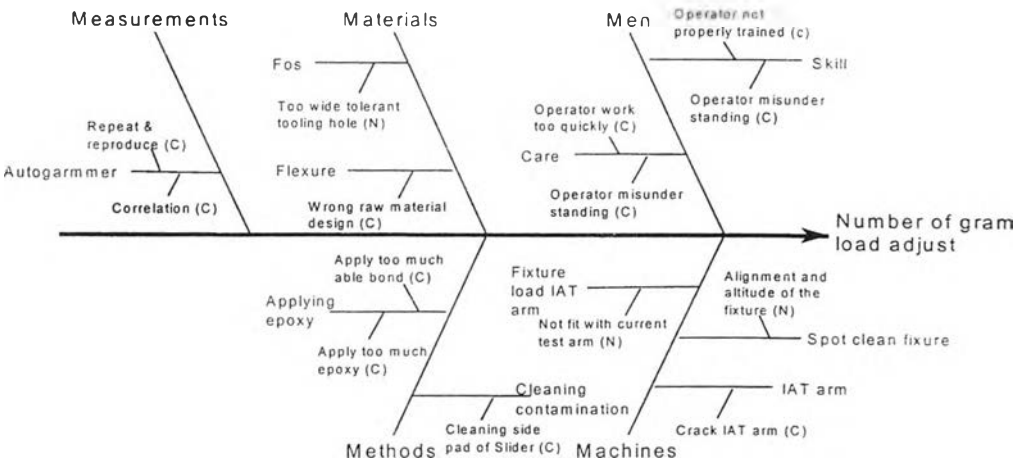

Figure 6.2 Cause & Effect Diagram of Preload.

6.2.3 Rolled Throughput Yield

Rolled Throughput Yield = 24% (Out = 702/ In = 2897)

	Count	Pass
First Measurement	2897	702
Bend 1	2195	1198
Bend 2	997	636
Bend 3	361	280
Bend 4	81	61
Bend 5	20	8
Bend 6	12	6
Bend 7	6	1
Bend 8	5	5
Bend 9	0	0

Table 6.1 Number of adjustments at autogrammer

6.2.4 Cause and 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 preload Cause & Effect Matrix is illustrated as below.

Process step	Process input	Preload mean (10)	Preload sigma (40)	Total (50)
Tail attached	Tail attached	9	16	25
Autogrammer	Correlation	2	20	22
Spot clean	Clean contamination	5	16	21
Autogrammer	R&R	3	16	19
Lead bond	Lead bond	5	12	17
Load IAT	IAT mounting	3	8	11
Unload HGA	HGA stuck on Jit tool	1	8	9
Fos bond	Fos slip	5	4	9
Gimbals bond	Open flexure tray's lid	1	4	5
Gimbals bond	Amount of epoxy	1	4	5
Load IAT	Hold HGA at radius	1	2	3
Head set	Load HGA	1	2	3

6.2.5 Gage R&R

Gage R&R did on autogrammer that was already confirmed on Correlation and Calibration. Operators who measured to parts were well trained as well. One autogrammer and two operators measured the preload of 10 HGAs, repeated 2 times/HGA. The procedure is as below:

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[9]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.

1. Sample 10 HGAs (on IAT) and measure preload by operator #1 and record preload.
2. Measure preload the same 10 HGAs by operators #2 and record preload.
3. Re-measure preload the same 10 HGAs by operators #1 and record preload.
4. Re-measure preload the same 10 HGAs by operators #2 and record preload.

Result in 27% of P/T ratio, 1.37% of contribution, 12.05% of Disc Inx and 2.50% of Process. 27% of P/T ratio was very high and this was the best of P/T ratio we used to get when compared with preload adjustment limits at target +/-0.05. The graphical result is illustrated as below:

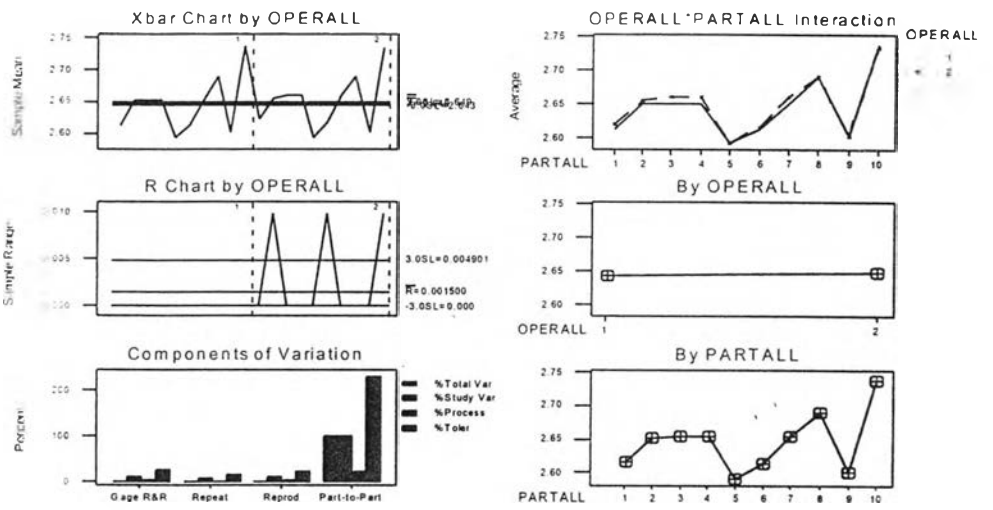


Figure 6.3 Graphical result of Preload Gage R&R

6.2.6 Process Capability Analysis

Process Capability was first analyzed and observed @ 700,000 DPMO and preload first yield was equal to 24% as the baseline on Cheetah 18 product. In addition, the special causes were observed at the high end of distribution. These special causes were suspected due to the amount of epoxy at FOS bond operation, autogrammer correlation and raw flexure material lot to lot variation. Normal distribution observed an DPMO reducing to 665,760 after suggesting operators to apply an epoxy at FOS bond operation, building material only one shipment and ensuring autogrammers were in good condition.

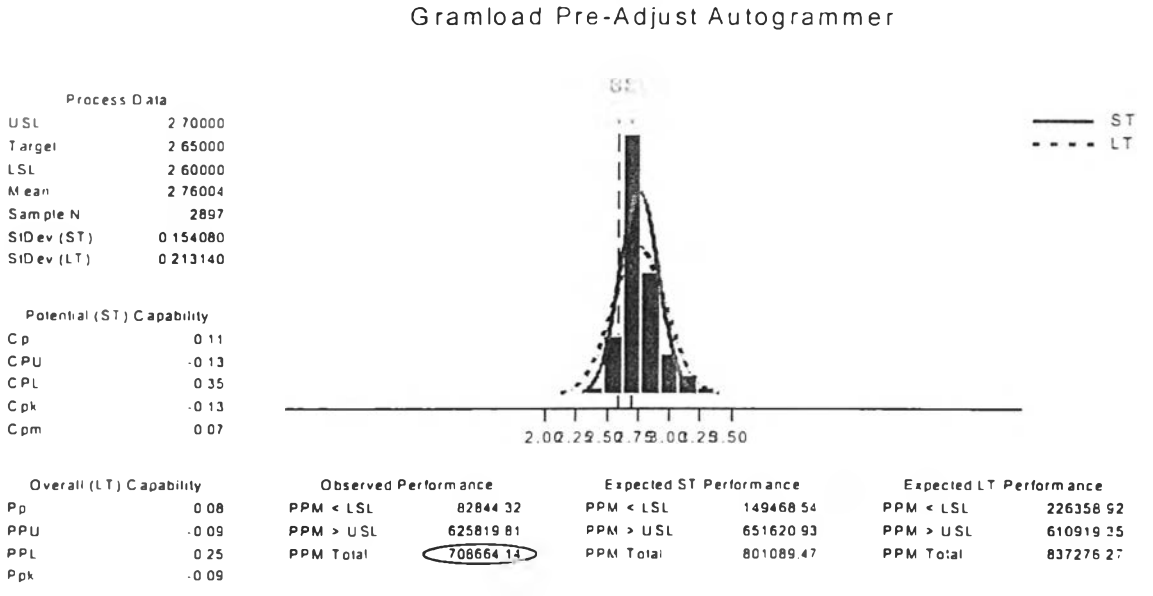


Figure 6.4 Preload Process Capability analysis

6.2.7 Phase Conclusion

According to Gage R&R showed 27% of P/T ratio, it means that the current preload window adjustment is too tight when compares to current Process gage standard deviation, which it is the best that we can achieve. So, in order to improve preload first yield, the appropriate preload adjustment window is taken into account.

6.3 Analysis Phase

6.3.1 Demographics matrix for KPIV's

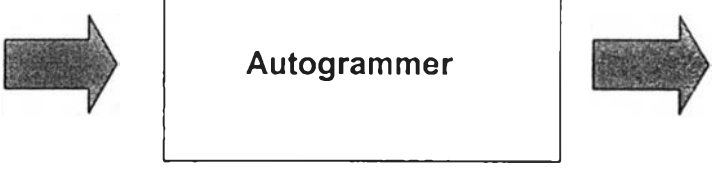
KPIV'S

1 Preload at raw suspension
2 Front line HGA process
(FOS bond, Lead bond and Tail tacking)
3 FOS vendor

4 Autogrammer

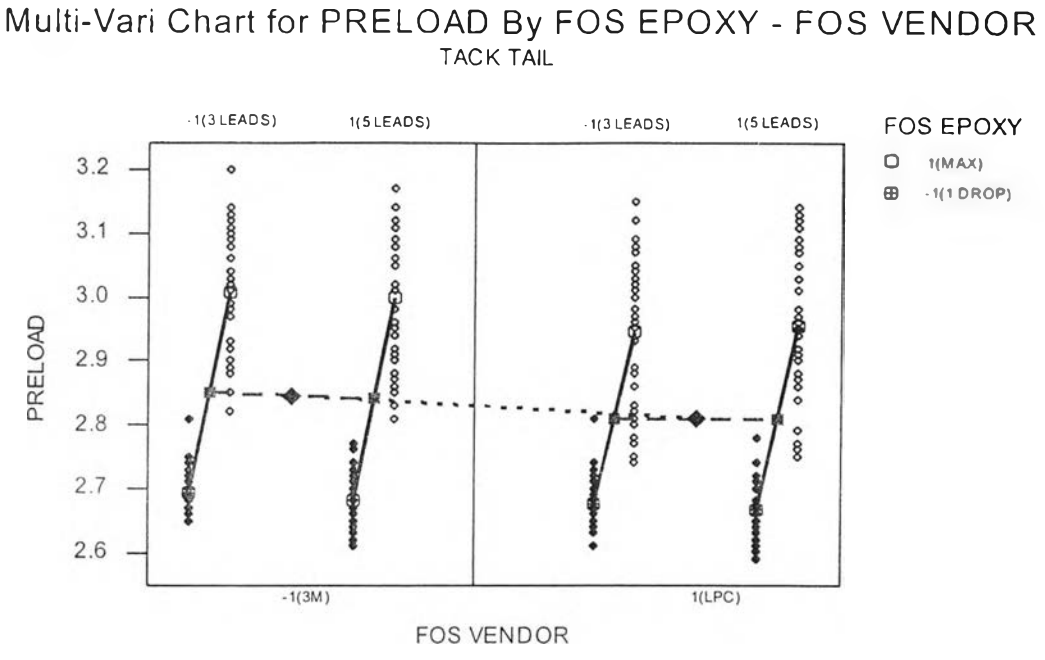
KPOV'S

1 HGA Preload



6.3.2 Multi- Vari Analysis

Multi-Vari chart was analysis by comparing among FOS bond application, FOS vendor and Tail Tack epoxy application. The result is as below.



According to this analysis, we can obtain that

- High standard deviation of preload was observed at high epoxy level at FOS bond operation.
- Mean of preload was higher at high epoxy level at FOS bond operation.
- Preload is slightly different between FOS vendors.
- No difference observed of preload between tail tack on 3 leads and 5 leads.

6.3.3 Hypothesis Testing

An evaluation was analyzed in order to understand what operation that effect to preload by building HGA and measuring preload on each operation. Hypothesis testing had reported that FOS bond and Tail Tacking operation do impact to preload value which is illustrated as below.

One-way Analysis of Variance

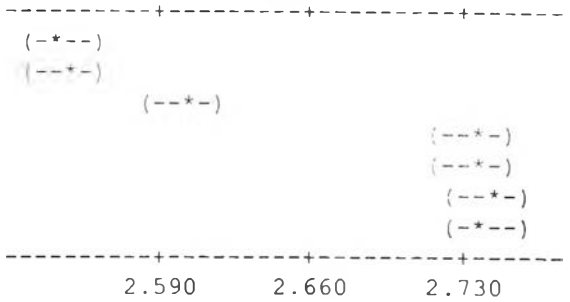
Analysis of Variance for Gramload

Source	DF	SS	MS	F	P
Operation	6	3.23824	0.53971	114.70	0.000
Error	413	1.94332	0.00471		
Total	419	5.18156			

Level	N	Mean	StDev
1RAW FLE	60	2.5418	0.0539
2GIMBAL	60	2.5470	0.0518
3FOS BON	60	2.6033	0.0900
4COAT/TA	60	2.7348	0.0740
5UNLOAD	60	2.7358	0.0697
6LOAD IA	60	2.7408	0.0688
7SPOT CLEAN	60	2.7388	0.0647

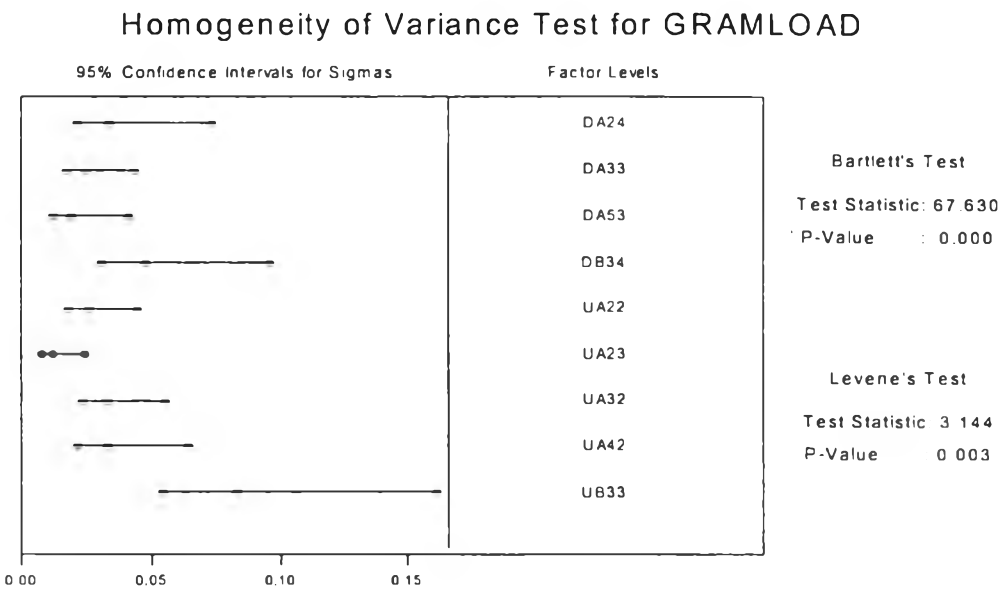
Pooled StDev = 0.0686

Individual 95% CIs For Mean
Based on Pooled StDev



In addition, there were several evaluations on preload Hypothesis testing on cell to cell, shift to shift, between up and down tab which will be illustrated as below.

- Hypothesis testing of preload among cells



One-way Analysis of Variance

Analysis of Variance for Gramload

Source	DF	SS	MS	F	P
Operation	6	3.23824	0.53971	114.70	0.000
Error	413	1.94332	0.00471		
Total	419	5.18156			

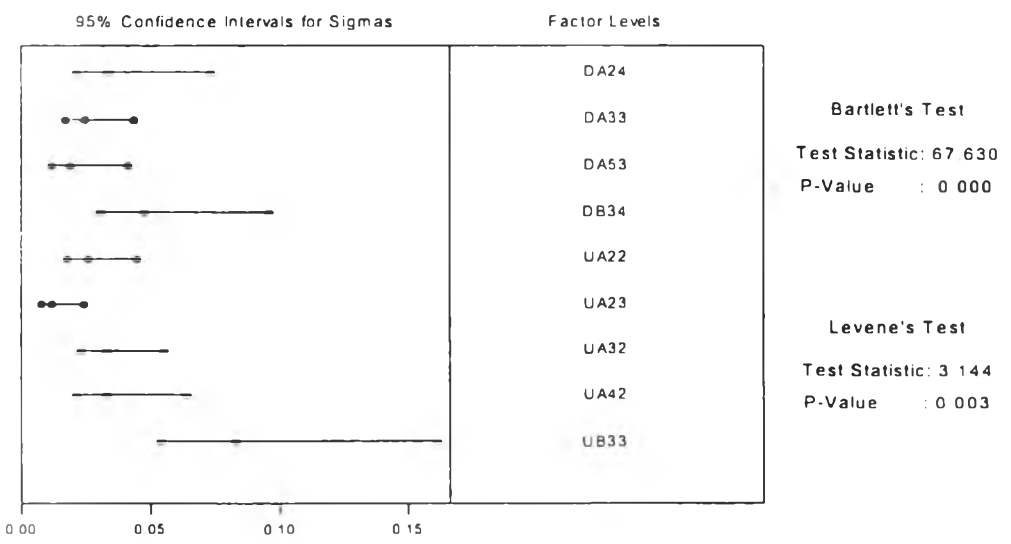
Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
1RAW FLE	60	2.5418	0.0539	(-*--)
2GIMBAL	60	2.5470	0.0518	(--*-)
3FCS BON	60	2.6033	0.0900	(--*-)
4COAT/TA	60	2.7348	0.0740	(--*-)
5UNLOAD	60	2.7358	0.0697	(--*-)
6LOAD IA	60	2.7408	0.0688	(--*-)
7SPOT CLEAN	60	2.7388	0.0647	(-*--)

Pooled StDev = 0.0686

2.590 2.660 2.730

In addition, there were several evaluations on preload Hypothesis testing on cell to cell, shift to shift, between up and down tab which will be illustrated as below.

- Hypothesis testing of preload among cells



One-way Analysis of Variance (Cell)

Source	DF	SS	MS	F	P
LOCATION	8	0.08496	0.01062	6.99	0.000
Error	134	0.20366	0.00152		
Total	142	0.28862			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
DA24	12	2.7252	0.0335	(------*-------)
DA33	19	2.7470	0.0245	(-----*-----)
DA53	12	2.7793	0.0187	(------*-------)
DB34	14	2.7201	0.0474	(------*------)
UA22	20	2.7869	0.0256	(-----*-----)
UA23	14	2.7554	0.0119	(-----*------)
UA32	22	2.7270	0.0328	(----*----)
UA42	15	2.7307	0.0326	(-----*------)
UB33	15	2.7182	0.0827	(------*------)

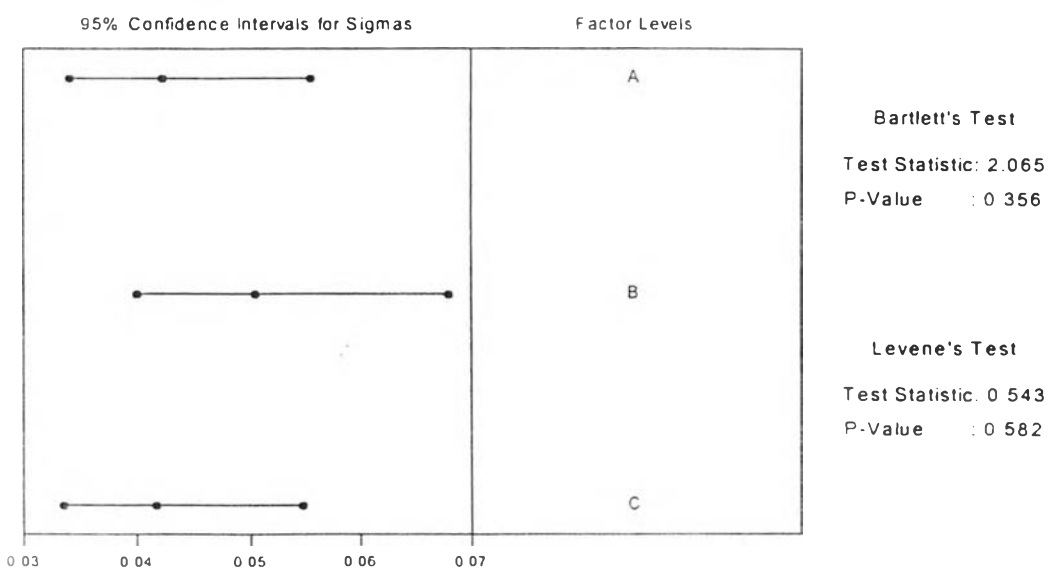
n = 140

Pooled StDev = 0.0390

2.700 2.730 2.760 2.790

According to these analysis, we can conclude that there are significant different of mean and sigma of preload among cells.

- Hypothesis testing of preload among shifts



One-way Analysis of Variance (Shift)

Analysis of Variance for GRAMLOAD

Source	DF	SS	MS	F	P
SHIFT	2	0.00875	0.00438	2.19	0.116
Error	140	0.27986	0.00200		
Total	142	0.28862			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
A	50	2.7387	0.0423	(---------*---------)
B	43	2.7558	0.0505	(---------*---------)
C	50	2.7387	0.0417	(---------*---------)

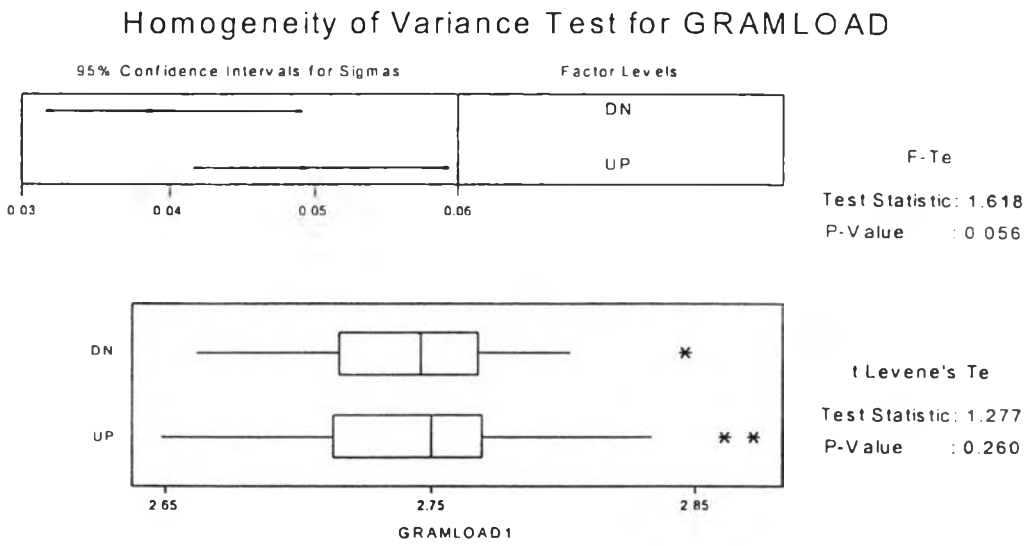
n = 100

Pooled StDev = 0.0447

2.736 2.748 2.760

Base on these analysis, we can conclude that there are no significant different of mean and sigma of preload between each shift.

- Hypothesis testing of preload between up and down tab



[10] * 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)}.

One-way Analysis of Variance (Tab)

Analysis of Variance for GRAMLOAD

Source	DF	SS	MS	F	P
TAB	1	0.00014	0.00014	0.07	0.792
Error	141	0.28847	0.00205		
Total	142	0.28862			

Level	N	Mean	StDev
DN	57	2.7426	0.0386
UP	86	2.7446	0.0491
n = 100			
Pooled StDev =		0.0452	

Individual 95% CIs For Mean
Based on Pooled StDev

```
---------+---------+---------+---------
(----------------*----------------)
       (-------------*-------------)
---------+---------+---------+---------
      2.7370    2.7440    2.7510
```

Base on these analysis, we can conclude that there are no significant different of mean and sigma of preload between tabs.

6.3.4 Phase Conclusion

The results showed variation at raw suspension, FOS bond and Tail Tacking operation in testing of ANOM and Homogeneity on the same HGAs. Moreover, the variation among cells and shifts were observed as well.

6.4 Improve Phase

6.4.1 DOE Planing Sheet

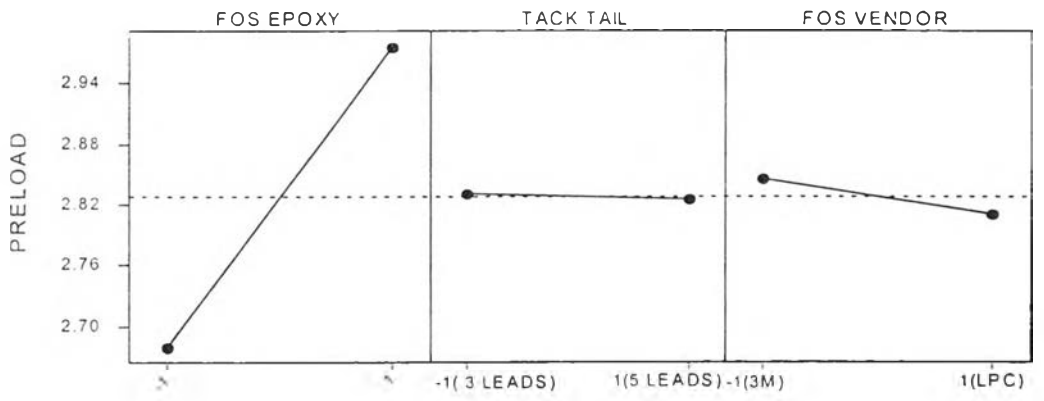
The DOE was designed for 3 factors, 2 levels, 10 repetitions and 4 replications which the details are provided as below.

Control variables	Level -1	Level+1
1 Amount of epoxy at FOS bond	1drop of needle tip and smear to 75%	Release epoxy all time and smear to 75%
2 Amount of epoxy at Tail Tack	Cover 3 leads	Cover 5 leads
3 FOS Materail Vendors	3M	LPC

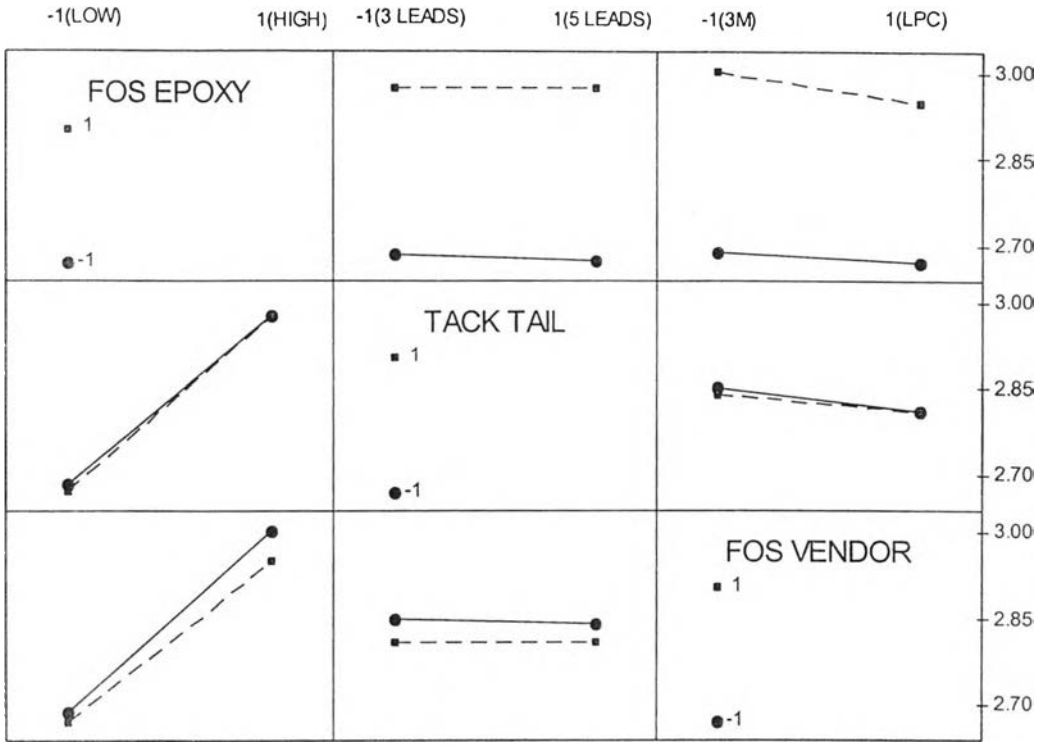
Table 6.2 Preload DOE

6.4.2 DOE Result

- *Main Effect Plot: Data mean of preload*



- *Interaction plot: Data mean of preload*



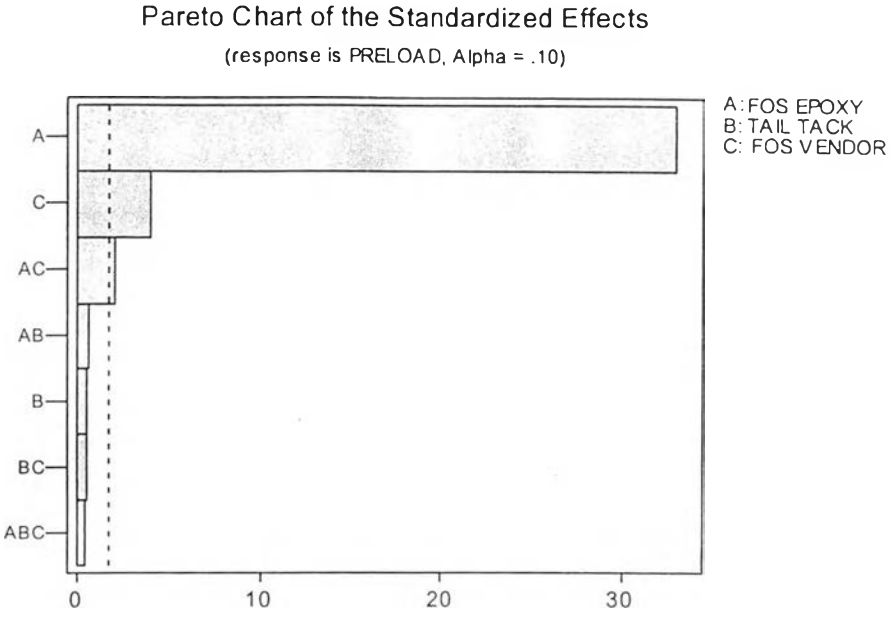
- *Fractional factorial*

```
Fractional Factorial Fit

Estimated Effects and Coefficients for PRELOAD (coded units)
Term                              Effect      Coef  StDev Coef       T      P
Constant                                   2.82788    0.004492  629.58  0.000
FOS EPOXY                         0.29650  0.14825    0.004492   33.01  0.000
TAIL TACK                        -0.00525 -0.00262    0.004492   -0.58  0.559
FOS VENDOR                       -0.03575 -0.01787    0.004492   -3.98  0.000
FOS EPOXY*TAIL TACK               0.00550  0.00275    0.004492    0.61  0.541
FOS EPOXY*FOS  VENDOR            -0.01850 -0.00925    0.004492   -2.06  0.040
TAIL TACK*FOS  VENDOR             0.00500  0.00250    0.004492    0.56  0.578
FOS EPOXY*TAIL TACK*FOS VENDOR    0.00425  0.00212    0.004492    0.47  0.636

Analysis of Variance for PRELOAD (coded units)
Source                 DF       Seq SS      Adj SS      Adj MS      F      P
Main Effects            3      7.13743     7.13743     2.37914 368.52  0.000
2-Way Interactions      3      0.03180     0.03180     0.01060   1.64  0.180
3-Way Interactions      1      0.00144     0.00144     0.00144   0.22  0.636
Residual Error        312      2.01428     2.01428     0.00646
  Pure Error          312      2.01428     2.01428     0.00646
Total                 319      9.18496
```

- *Pareto chart of standardize effects*



- *Regression Analysis*

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Regression Analysis


The regression equation is
PRELOAD = 2.83 + 0.148 FOS EPOXY - 0.0179 FOS VENDOR -
0.00925 FOS EPOXY*VENDOR

Predictor             Coef       StDev          T        P
Constant           2.82787     0.00447     632.34    0.000
FOS EPOXY         0.148250    0.004472      33.15    0.000
FOS VENDOR       -0.017875    0.004472      -4.00    0.000
FOS EPOXY*VENDOR -0.009250    0.004472      -2.07    0.039

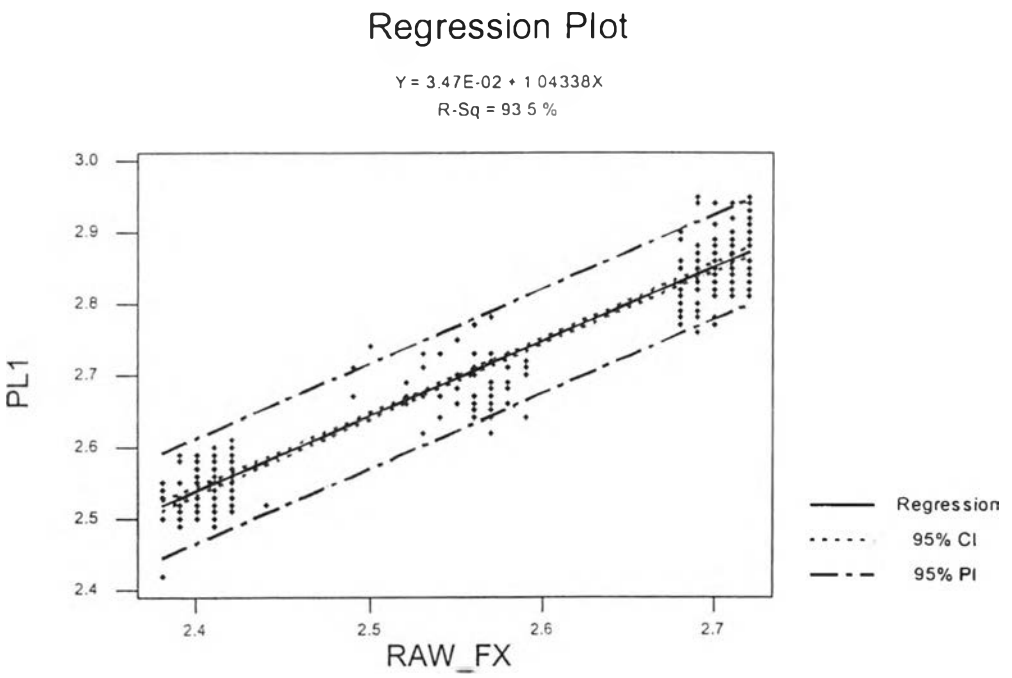
S = 0.08000     R-Sq = 78.0%     R-Sq(adj) = 77.8%

Analysis of Variance

Source            DF          SS          MS          F        P
Regression         3      7.1626      2.3875     373.06    0.000
Residual Error   316      2.0224      0.0064
Total            319      9.1850
```

- *Revise process setting*

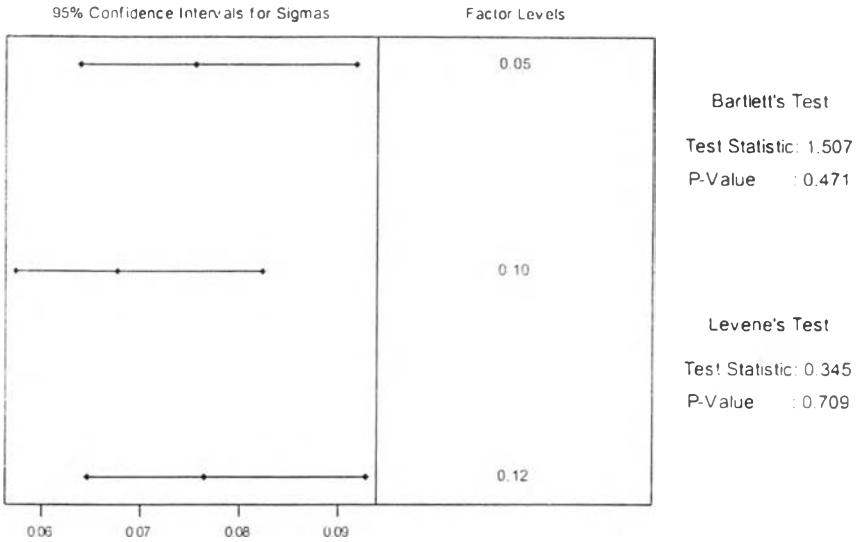
According to Multi variable analysis reported very high standard deviation of preload when apply much more amount of epoxy. So, process setting should be at low amount of epoxy. Not only the amount of epoxy which need to be adjusted but also raw flexure preload should be adjusted as well if HGA preload before adjustment is not on the target. Following graph shows preload comparing between raw suspension preload versus HGA preload before adjustment.



- *Appropriate preload window adjustment*

After studying the front line variations, the appropriate preload window adjustment has been evaluated by opening the preload window to be 3 groups, which are +/-0.05, +/-0.10 and +/-0.12. The results are provided as below.

Homogeneity of Variance Test for GRAMLOAD



One-way Analysis of Variance

Analysis of Variance for GRAMLOAD

Source	DF	SS	MS	F	P
RANGE	2	0.01561	0.00780	1.45	0.236
Error	267	1.43542	0.00538		
Total	269	1.45103			

Level	N	Mean	StDev
0.05	90	2.6592	0.0755
0.10	90	2.6409	0.0678
0.12	90	2.6529	0.0764

Pooled StDev = 0.0733

Individual 95% CIs For Mean Based on Pooled StDev

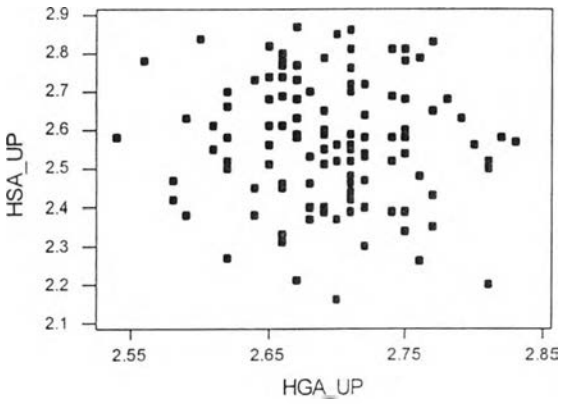
```
----------+---------+---------+---------
                (---------*---------)
(----------*---------)
          (----------*---------)
----------+---------+---------+---------
        2.640     2.655     2.670
```

Conclusion: There are no significant different of preload between these three groups. So, the preload window adjustment group +/-0.12 has been selected for the current process.

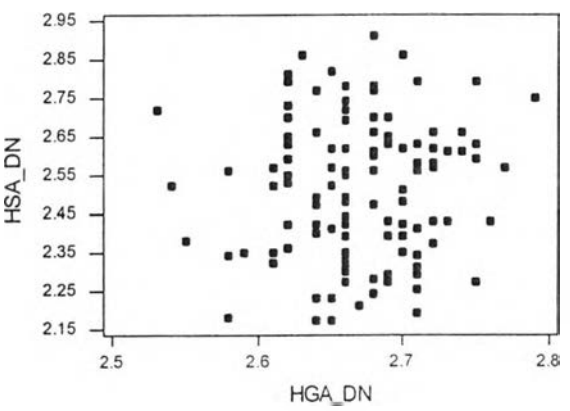
- Correlation between HGA and HSA Preload

Correlation between HGA and HSA preload has been studied by selecting HGA parts from OQA, in order to get the appropriate range of preload performance, and control build to HSA level. The result of this evaluation is illustrated as below.

CORRELATION BETWEEN HGA VS HSA (UPTAB)



CORRELATION BETWEEN HGA VS HSA (DN TAB)



Regression Analysis

The regression equation is
HSA_UP = 3.22 - 0.244 HGA_UP

Predictor	Coef	StDev	T	P
Constant	3.2220	0.7214	4.47	0.000
HGA_UP	-0.2440	0.2676	-0.91	0.364

S = 0.1633 R-Sq = 0.7% R-Sq(adj) = 0.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	0.02216	0.02216	0.83	0.364
Residual Error	118	3.14580	0.02666		
Total	119	3.16796			

Regression Analysis

The regression equation is
HSA_DN = 2.03 + 0.178 HGA_DN

Predictor	Coef	StDev	T	P
Constant	2.0301	0.9430	2.15	0.033
HGA_DN	0.1777	0.3531	0.50	0.616

S = 0.1797 R-Sq = 0.2% R-Sq(adj) = 0.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	0.00818	0.00818	0.25	0.616
Residual Error	118	3.80921	0.03228		
Total	119	3.81739			

Conclusion: There are no correlation between HGA and HSA preload. So, the in-control changed of HGA preload will not have any effect to HSA preload.

6.4.3 Phase Conclusion

DOE analysis reported 78% R-Squared and FOS bond epoxy impact to HGA preload as a main effect. This leads to a suggestion how to apply epoxy at FOS bond operation in Control phase. Moreover, evaluation of raw suspension preload versus preload _1 before adjustment reported 93.5% R-Squared after suggesting operators to apply epoxy at FOS bond operation. Beside, 0.15 gram of preload at raw suspension should be lower than Preload _1 before adjustment regarding to regression equation.

However, the preload target had been changed during the evaluation due to the Drive issue that required the preload target to be up-gram in order to get the fly height to be on the target. So, the preload target had been changed from 2.65 gram to be 2.75 gram and the incoming flexure preload had been changed from 2.50 gram to 2.65 gram regarding to regression equation.

Finally, the autogrammer adjustment window has been changed from target +/-0.05 to +/-0.12 gram base on the frontline process variation reduction, the preload window adjustment evaluation and correlation between HGA and HSA preload result.

6.5 Control Phase

6.5.1 Metrics to be reported and interval

Preload times adjusted per unit will be reported by weekly, daily and shiftly basis on Microsoft Intranet Explorer.

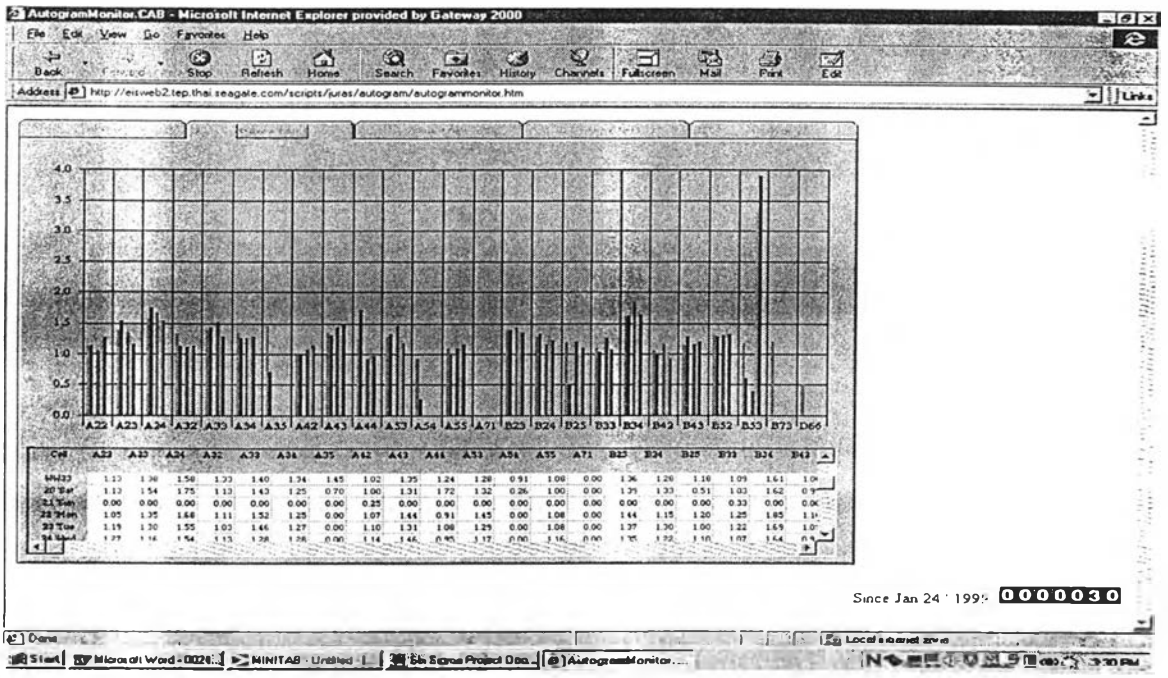
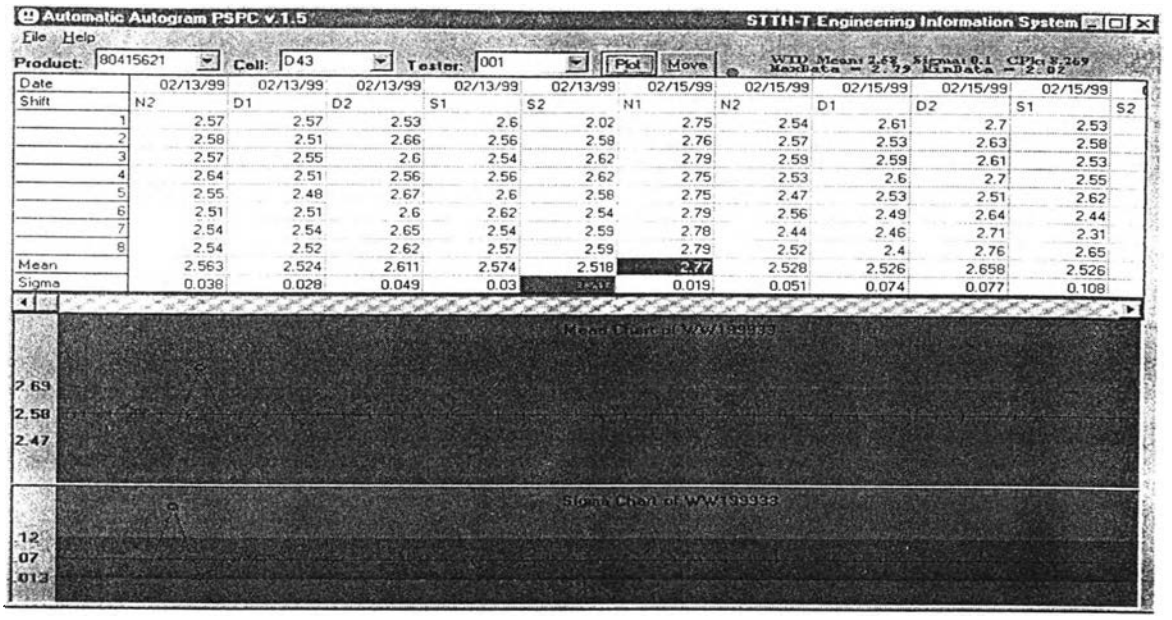


Figure6.5 Report preload by Weekly and daily basis

6.5.2 Product and Tester SPC status by cell

Product and Tester SPC have been set up for each manufacturing cell. Mean, Sigma, Control limits and Input of corrective action when out of control occurred are provided as automatically system. The sample of this is illustrated as below.



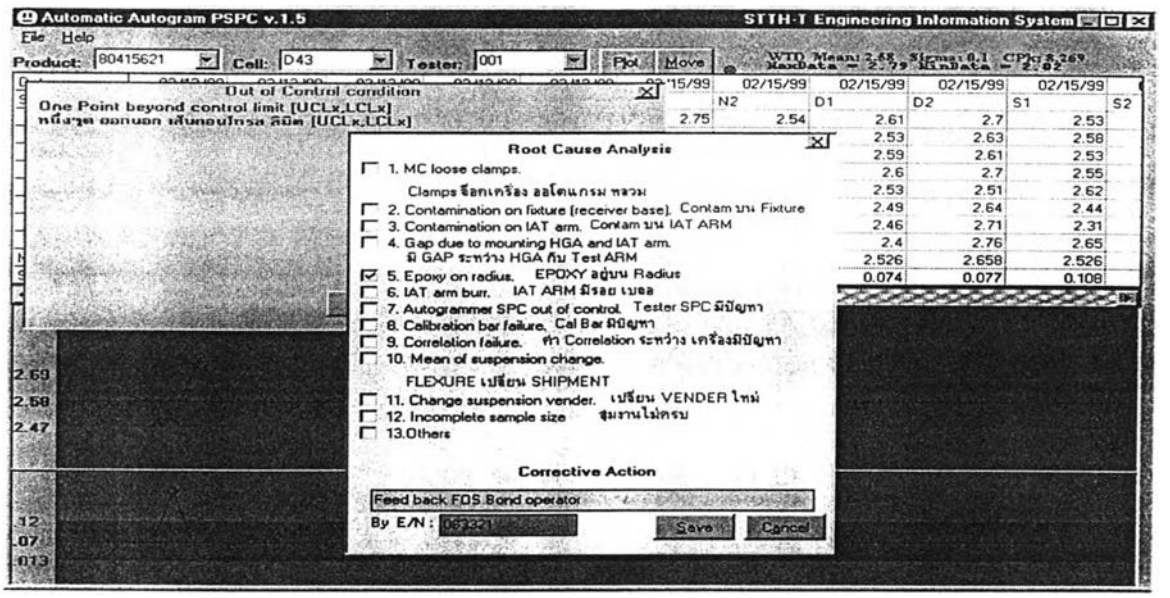
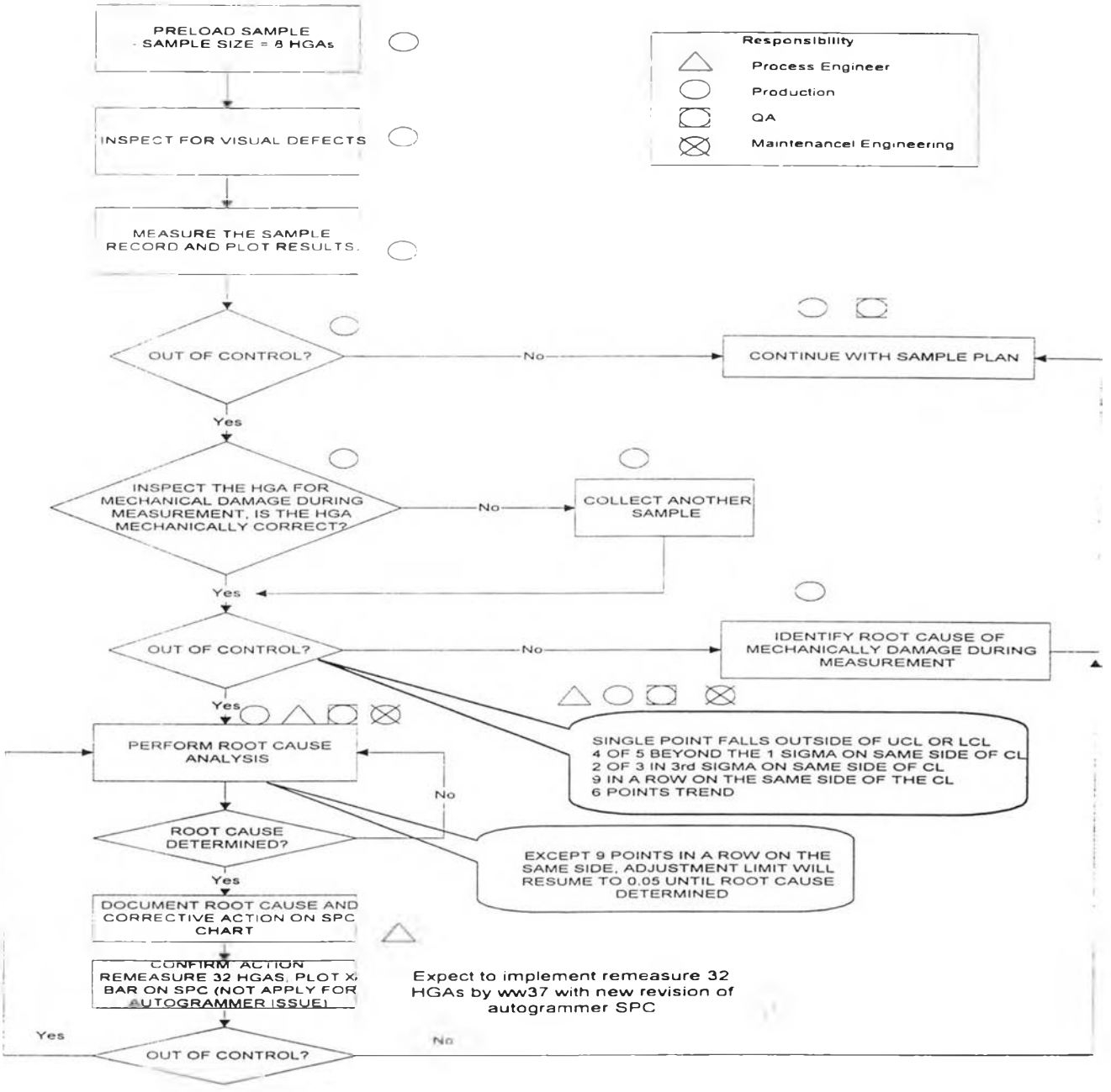
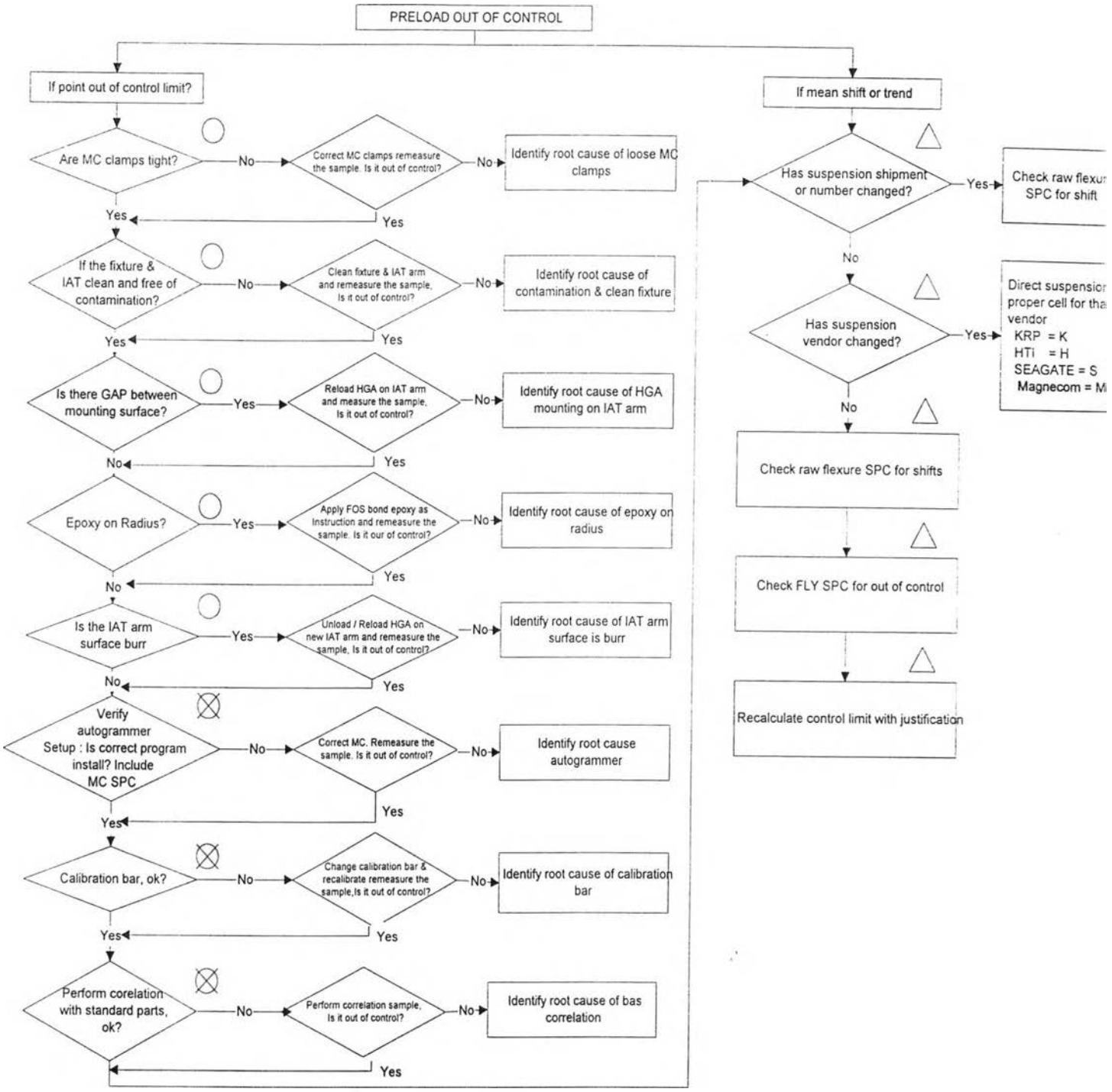


Figure 6.6 Automate PSPC

6.5.3 Preload SPC procedure and root cause analysis[11]





[11]Preload SPC Procedure and Root Cause analysis references from PCA#PEM8145555.

6.5.4 Phase Conclusion

1. Raw suspension preload should have been controlled at vendor. Need vendor control process by using SPC.
2. Train Trainers, Supervisors and Operators about how to apply epoxy at FOS bond operation. In addition, visual aid of this is provided by Process engineer.
3. Tester SPC has been changed from 1 HGA/day to 5 HGAs/shift in order to ensure that autogrammer is under controlled all the time.
4. Preload SPC has been established before adjustment in order to feedback to frontline when process is out of control. In addition, there are few monitoring chart on EIS/WEB such as SPC, Autogrammer Times Adjusted/Unit by cell or by shift and Real time Out of Control monitoring.

6.6 Product Performance

The product performances, include Preload_1 before adjustment and Preload at OQA before and after improvement, have been tracking after implementing all improvement activities which is shown in Figure 6.7, Figure 6.8 and Figure 6.9, respectively.

From Process Capability analysis, we have observed that DPMO has been improved to 180000 DPMO and the percent of First Yield has also improved to 60%. Moreover, The preload OQA performance is maintain as same as before implementing new adjusted window.

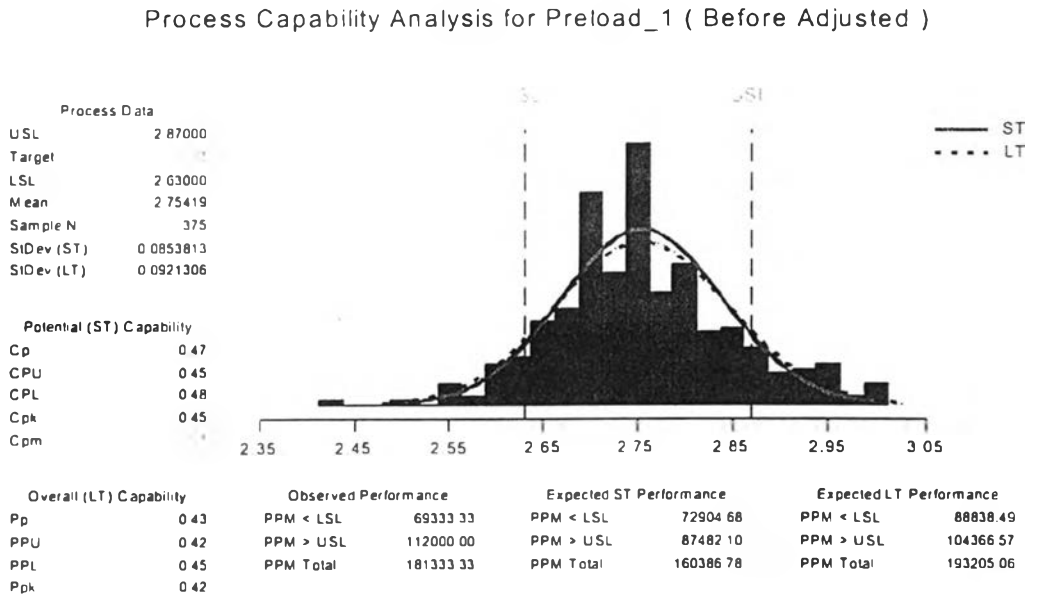


Figure 6.7 Process capability analysis after improvement

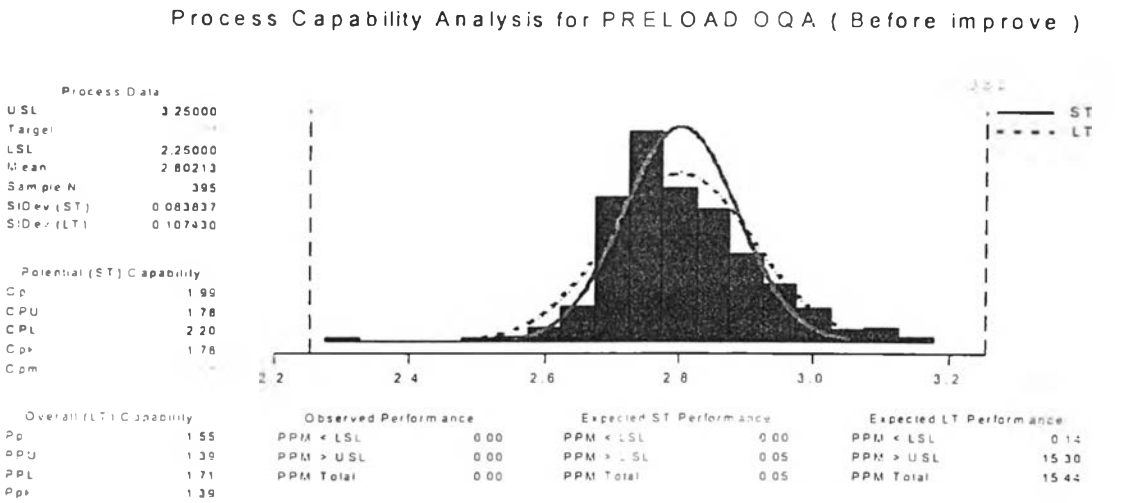


Figure 6.8 Process capability analysis of Preload OQA before improvement

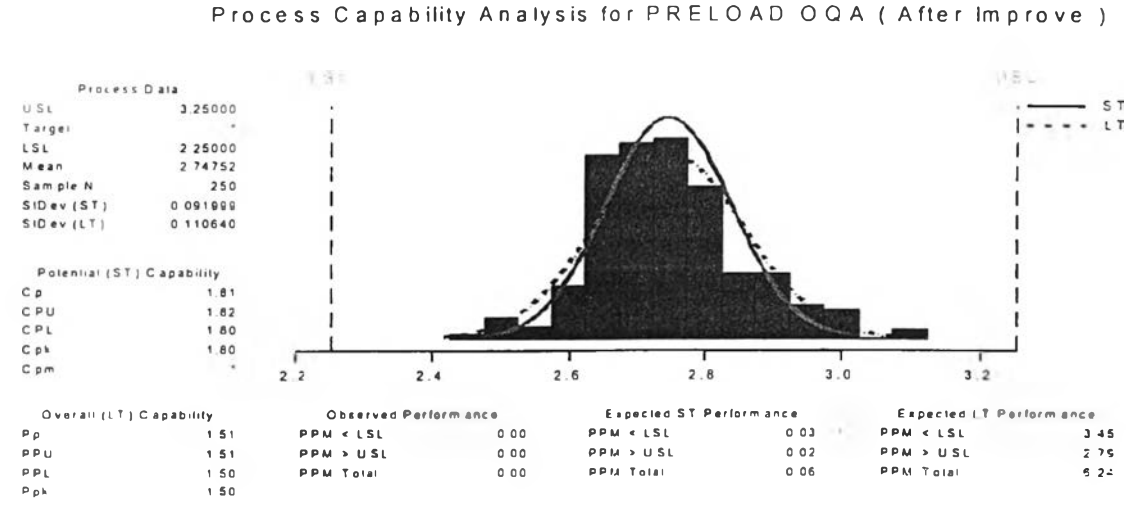


Figure 6.9 Process capability analysis of Preload OQA after improvement